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The effect of different vine training systems on the shelf life of *Vitis vinifera* cv. Bidane Sefid

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ABSTRACT

In this study, the effect of vine training system and storage time were evaluated on some grape characteristics, such as berry contamination percentage, berry shedding percentage, berry browning rate, titratable acidity, soluble solids, total phenol and the activity of peroxidase, polyphenol oxidase and phenylalanine ammonia-lyase enzymes, in order to maintain the quality of grape during storage time. Factorial experiment was conducted based on completely randomized design with two factors of vine training system (Khazandeh, pergola and cordon) and storage time (zero, 20, 40 and 60 days after storage) with three replications during 2018-2019. After transferring the fruits to the cold storage with temperature of +4°C, relative humidity of 85-90% and storage for two months, some characteristics of grape were examined on different days after storage. The results showed that the level of contamination of the berry increased over time, and during the storage period, the lowest level of contamination (13.706%) was related to the cordon training system. Also, after 60 days of storage, the lowest percentage of berry drop (27.535%) was observed in the fruits harvested from the cordon training system. The amount of berry browning after 60 days of storage was significantly higher than other times. The highest amount of TSS (26.182 degrees Brix) was related to the Khazandeh training system in 40 days after storage, however, a significant decrease in the value of this index was observed during 60 days after storage. The results showed that the amount of phenol increased until the end of the storage period, and the maximum amount of phenol in all three training systems was significantly higher than other days in 60 days after storage. The level of peroxidase enzyme activity in the Khazandeh training system reached its highest level at 20 days after storage, while in the other two training systems, it was significantly higher than the other days at 40 days after storage. Also, the activity of polyphenol oxidase enzyme reached its maximum level in 40 days after storage in Khazandeh and pergola training systems and then decreased. While in cordon training system, the highest activity of this enzyme was observed after 60 days of storage. The activity of phenylalanine ammonia-lyase enzyme increased during the storage period, and 60 days after storage, the highest activity of this enzyme was related to the pergola training system. In general, the results showed that the cordon training system had the best effect in maintaining the characteristics of grape during the storage period compared to other training methods.

1. Introduction

Every year, a significant amount of agricultural products and food items produced at a cost of time, money, and resources go to waste, causing significant damage to global food resources. Among these, fruits, which play a crucial role in providing human nutritional needs and health, are prone to spoilage due to their high moisture content, leading to significant post-harvest losses [1]. Advances in the fields of physiology and technology, both pre and post-harvest, have led to the adoption of appropriate harvesting methods, post-harvest operations, utilization of suitable storage facilities and cold storage, as well as physical and chemical treatments, resulting in a noticeable reduction in this waste.

Grapes are one of the most important and oldest perennial plants globally, having been utilized by humans for centuries [2]. The diversity of consumption and cultivation areas worldwide underscores the importance of this product. Grapes contain compounds such as anthocyanins, flavonols, flavonoids, and resveratrol, known for their antioxidant properties. The biological activities of these compounds, such as anti-cancer, anti-inflammatory, anti-aging, and antimicrobial properties, have been well-documented [3]. According to 2019 statistics from the World Food Program, the global grape cultivation area is 972,925.6 hectares, with Iran ranking eleventh among grape-producing countries with 203,155 hectares under cultivation and an annual production of 930,945.1 tons [4].

Grapes are among the oldest fruits, with wild grape species scattered across all temperate, sub-tropical, and tropical regions [5]. With over 300 seeded and seedless grape varieties, Iran is considered one of the most important centers of diversity for this product globally [6]. Among seedless commercial varieties, the seedless white grape variety stands out as the most prominent globally and occupies the largest cultivated area in the country. The white seedless grape has complete flowers, medium-sized berries, round or oval in shape, with a greenish-yellow color and thin skin. The clusters are large, with medium berry density. This variety is a mid-season crop, usually harvested in the month of Shahrivar [7].

The quality of table grapes during storage can be compromised by factors such as weight loss, softening of berries, berry shattering, and browning, significantly affecting grape storage quality [8]. Implementing certain pre-storage methods can improve fruit quality and prolong storage duration [9]. Product quality depends on various factors, including environmental, agricultural, and genetic factors. Environmental factors such as light, pollination, moisture, pruning, temperature, wind, and training systems play crucial roles [10]. Grape yield and quality are influenced by training and pruning systems [11]. Adequate sunlight and suitable temperatures enhance grape quality [12]. Training systems, such as trellising, can increase yield, prevent rot, and enhance fruit quality [13]. The trellising system directly affects light penetration into the canopy, affecting grapevine photosynthesis. In addition to light penetration, the training system can influence grape water uptake, evaporation, and leaf transpiration. Proper initial training and regular pruning can open up the canopies, improving light penetration, ventilation, and preventing excess moisture accumulation, reducing gray rot [14]. Miller *et al*. (2001) that proper initial training and regular annual pruning lead to the opening of crowns, resulting in improved light penetration, better ventilation, and prevention of excess moisture accumulation inside the crowns. These conditions can reduce gray rot [15]. Asgari *et al*. (2009) after examining the impact of different training methods on grapes, that the Y training system resulted

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in the highest yield, while the traditional (control) system caused the lowest performance [16]. Mahmoudzadeh *et al*. (2009) studied the effect of eight training systems on the performance, vegetative growth, and fruit quality of the white seedless grape variety over two years in Qazvin. The results indicated the relative superiority of the short cordon system in this region compared to other methods [17]. Junior *et al*. (2021) study that the bilateral cordon system improves the chemical quality of grapes, especially the content of anthocyanins and sugars [18].

As most grapes grown in a sprawled (non-trellised) form are more susceptible to spring frost damage and fruit rot due to late summer rains, it is crucial to consider the impact of different cultivation systems on grape production and storage quality [19]. Studies have shown that two-sided cordon training and bilateral cordon training significantly affect production costs, yields, fruit decay rates, sugar content, and storage duration [19]. Bilateral cordon training resulted in higher grape yield compared to sprawled vines, with increased harvest by 0.08 grams. Additionally, grape shelf life and storage period increased by 25 days, while grape decay decreased by 75% under bilateral cordon training [19].

The current storage methods for most vineyards in Iran, especially in cold regions, are not suitable for modern requirements. These methods not only require maximum labor force but also result in low productivity per hectare, poor fruit quality due to ground contact, and susceptibility to early autumn rains. Considering the challenges faced by the prevalent training system in Iran, it appears that the storage longevity of products under this system is short.

To date, no research has been conducted in Iran or other external sources regarding the impact of grape cultivation systems on post-harvest conditions and crucial storage indicators. Most research has focused on yield and product quality pre-harvest. Therefore, given the economic value of grapes and the added value of off-season fruit supply, this project aims to gain more insights into the factors influencing storage longevity and optimize necessary conditions to maintain fruit quality during the storage period, utilizing the available equipment and resources in the country to reduce waste and consequently increase economic profits for farmers.

2-Materials and Methods

In order to investigate the effect of different training systems on the storage life of grape fruits, during the summer of 1396, grapevines of the seedless white variety trained under three systems including sprawled (bush), pergola, and cordon (Figure 1) were selected from a commercial vineyard located 4 kilometers from the Malayer to Arak road in the Afsarieh region of Malayer County, Hamadan Province, at an altitude of 1721 meters above sea level with a longitude of 48 degrees 49 minutes and 32 seconds and a latitude of 34 degrees 17 minutes. This region has a cold climate with mild summers. The average rainfall in this county is 300 millimeters. This vineyard, chosen as a model grape orchard by the Ministry of Agriculture over the years, had a drip irrigation system for training the cordon (double-decker) and pergola systems, and a furrow irrigation method for the sprawled system, with proper pruning and nutrition of the vines performed annually. In late September, when the grape fruits had reached commercial maturity, they were harvested and transported to the laboratory of the Horticultural Sciences and Engineering Department of the Khuzestan Agricultural Sciences and Natural Resources University, following proper handling procedures. After removing damaged berries, the clusters were surface disinfected with 0.25% chlorax for five minutes. After surface moisture removal, the fruits were placed in single-use transparent plastic containers with lids that partially prevented air from entering the container, then transferred to a cold room with a temperature of five degrees Celsius and 95% relative humidity, and stored for two months. The experiment was conducted in a factorial design with two factors: training system (sprawled, pergola, and cordon) and storage time (0, 20, 40, and 60 days after storage) in three replicates. The evaluated parameters included berry infection percentage, berry drop percentage, browning level of berries, titratable acidity, soluble solids content, total phenols, and the activity levels of peroxidase, polyphenol oxidase, and phenylalanine ammonia-lyase enzymes.

The level of berry contamination was determined by counting the number of contaminated berries in each cluster, and the percentage of berry contamination was calculated based on the following formula [20].

100 × Total number of berries in the cluster / Number of contaminated berries = Percentage of berry contamination (1)

To measure the percentage of berry drop, the clusters were uniformly shaken by hand for five seconds, the number of dropped berries was counted, and the percentage of berry drop was calculated based on the following formula [21].

100 × Total number of berries in the cluster / Number of dropped berries = Percentage of berry drop (2)

The degree of browning of the berries was investigated based on a grading system (1- Completely green, 2- Slightly brown, 3- Average, 4- Severe, 5- Very severe). The solid material in the solution was measured using a manual refractometer (MT-03 model) under laboratory conditions. The titratable acidity was determined by titration with sodium hydroxide using phthalic acid as the indicator [22]. The total phenol content was determined using Folin-Ciocalteu reagent and measuring the absorbance at a wavelength of 725 nanometers with a spectrophotometer (AE-S60-4U model made in China), and the total phenol amount was calculated in milligrams of gallic acid per gram of dry weight [23].

For the preparation of the enzymatic extract, two and a half grams of fresh tissue from six grapes were homogenized with 0.125 grams of polyvinylpyrrolidone and five milliliters of sodium phosphate buffer (100 millimolar; pH 4.6). The resulting mixture was centrifuged at 13000 rpm for 30 minutes at four degrees Celsius using a centrifuge (Eppendorf-5415 model, made in Germany) [24]. The enzymatic extract obtained was used to measure peroxidase and polyphenol oxidase enzymes.

The peroxidase enzyme activity was determined according to the modified method of Menge and colleagues [25]. To assess the peroxidase enzyme activity, one milliliter of crude enzyme extract was added to two milliliters of sodium phosphate buffer (200 millimolar; pH 4.6), one milliliter of 1.0% guaiacol, and two milliliters of 0.8% hydrogen peroxide. The increase in absorbance at a wavelength of 460 nanometers was measured for seven minutes using a spectrophotometer. The enzyme activity was calculated in enzyme units per gram of tissue weight.

The polyphenol oxidase enzyme activity was determined according to the modified method of Chen and colleagues [24]. One hundred microliters of crude enzyme extract was added to 1400 microliters of assay buffer (consisting of sodium phosphate 200 millimolar with pH 5, sodium citrate 100 millimolar, and catechol 50 millimolar), and the absorbance changes were measured for two minutes at a wavelength of 398 nanometers using a spectrophotometer. Finally, the enzyme activity was calculated in enzyme units per gram of tissue weight.

The phenylalanine ammonia-lyase enzyme activity was determined according to the proposed method of De Oliveira and

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colleagues [26]. Fifteen grams of fresh fruit tissue were homogenized in 15 milliliters of buffer containing: 1.0 molar sodium borate with pH 8.8, 20 millimolar beta-mercaptoethanol, and five percent polyvinylpyrrolidone. The homogenized solution was centrifuged at 12000 rpm for 20 minutes. Then, one milliliter of the prepared enzyme extract was added to a reaction solution containing one milliliter of 2.0 molar sodium borate buffer with pH 8.8 and one milliliter of 1.0 molar L-phenylalanine. After incubating the solution at 30 degrees Celsius for an hour, the reaction was stopped by adding 1.0 milliliter of six normal hydrochloric acid. The absorbance at a wavelength of 290 nanometers was measured every 20 minutes for an hour, and the enzyme activity was calculated in nanograms per gram of tissue weight.

Cordon training system Pergola training system Khazandeh training system

Figure (1) Various training systems

2-1- Statistical analysis

The data obtained from this research were based on a factorial experiment using a completely randomized design with two factors: training system (in three levels: kneeling, pergola, and cordon) and storage time (in four levels: 0, 20, 40, and 60 days after storage) in three replications. Statistical analysis and comparison of treatment means were conducted using the SAS statistical software version 4.9, and the LSD test was performed at a significance level of five percent. The graphs were plotted using Office 2013 software (Excel).

3- Results and Discussion

3-1- Berry decay percentage

The results of comparing the mean interaction effect of training system and storage time on the percentage of grain contamination (Figure 2) showed that the level of contamination increased over time, with the lowest contamination related to the cordon training system, which started after

40 days of storage and the lowest percentage of contamination (13.706%) was observed after 60 days of storage in this training system, showing a significant difference with the other two training systems. The contamination level in the pergola and kneeling training systems was higher. The presence of high moisture in the canopy (in the pergola and kneeling training systems) and the contact of grape clusters with the ground surface (in the kneeling training system) may be the reasons for the higher contamination levels in these two training systems. The results of this study are consistent with the findings of a study in 1399, which stated that in the bilateral cordon training method compared to creeping, the shelf life and storage period of grapes increased by 25 days, and the percentage of grape rot decreased by 75% [19].

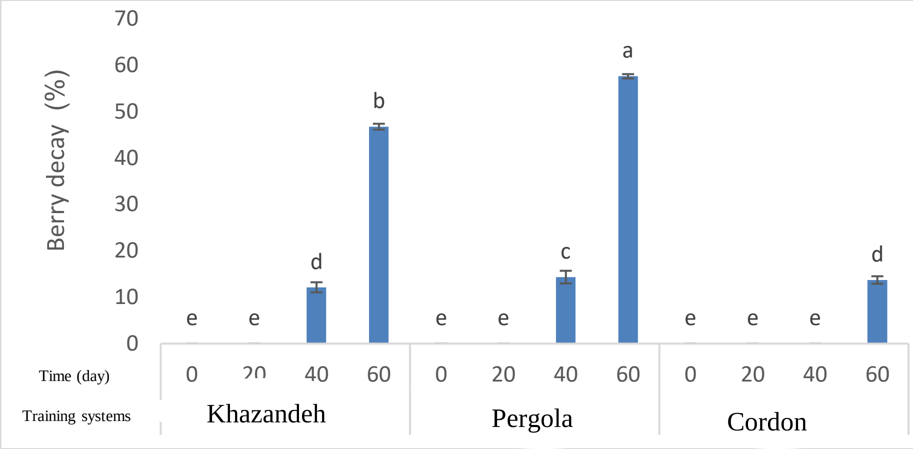

Figure 2- Effect of different training systems and storage time on berry decay percent (The different letters and the error bars on each column show significant difference based on LSD test (P <0.05) and standard error (Mean ± SE))

3-2- Berry abscission percent

According to the results of the analysis of variance, the interaction effect of the training system and storage time on the percentage of grain shedding was statistically significant at a one percent probability level. Furthermore, the examination of the mean interaction effect of the training system and storage time on the percentage of grain shedding in clusters (Figure 3) showed that after 60 days of storage, the lowest percentage of grain shedding (27.535%) was related to the cordon training system, which differed significantly from the kneeling and pergola training systems. Hajji Taqi-Lu stated that possibly the grain shedding is due to the decrease in moisture accompanying ripening, which leads to a reduction in auxin levels and the formation of abscission layers, ultimately stimulating fruit shedding. Additionally, Zuo and colleagues also mentioned that the highest level of grain shedding occurs simultaneously with increased decay in these grains.

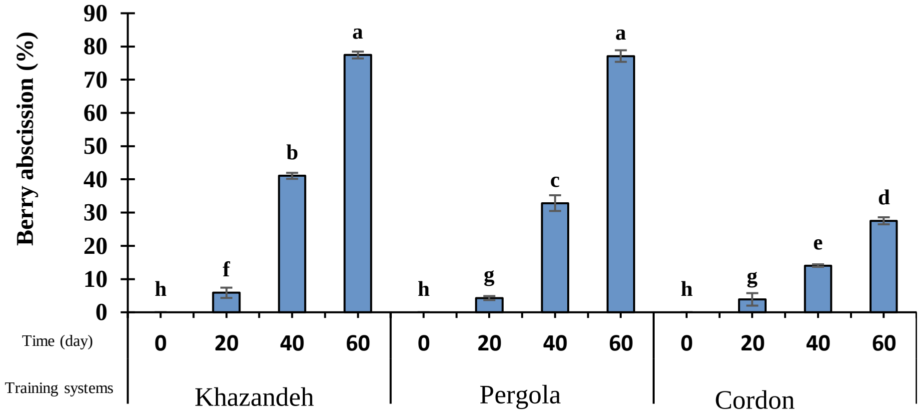

Figure 3- Effect of different training systems and storage time on berry abscission percent (The different letters and the error bars on each column show significant difference based on LSD test (P <0.05) and standard error (Mean ± SE))

3-3-Browning level of berries

The results did not show a significant effect of the three types of grape training systems investigated in this study on the browning level of berries. On the other hand, the examination of the mean comparison results of the storage time treatment effect on the browning level of berries in grape

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fruits (Figure 4) indicated that the browning level of berries increased over time. The browning level of berries was evaluated on a scale of 1 to 5 (1- completely green, 2- slightly brown, 3- moderate, 4- severe, 5- very severe). The browning level of berries after 60 days of storage was significantly higher than other times, so that codes 3 to 3.5 (moderate to severe browning) (Figure 4) corresponded to this period of storage. Enzymatic browning may occur due to the activity of phenol oxidizing enzymes, including polyphenol oxidase and peroxidase. Considering that in the current study, the activity of these two enzymes showed an increasing trend and the activity of polyphenol oxidase was higher compared to peroxidase, it is likely that this enzyme played a more significant role in the oxidation of phenols and enzymatic browning compared to peroxidase .

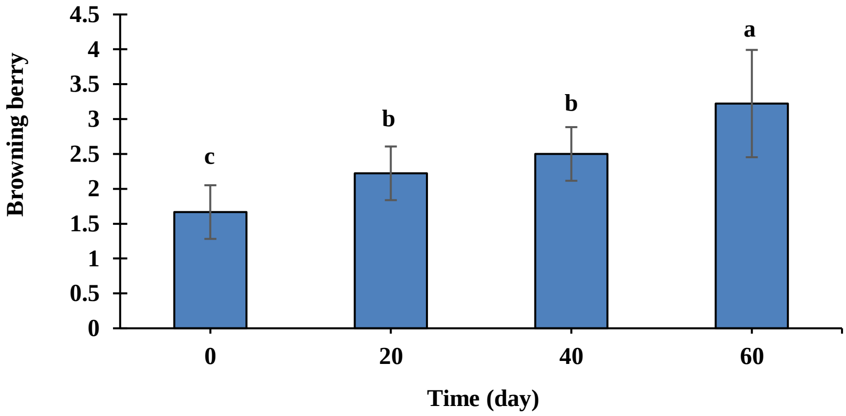

Figure 4- Effect of different training systems and storage time on browning berry (The different letters and the error bars on each column show significant difference based on LSD test (P <0.05) and standard error (Mean ± SE))

3-4- Total soluble solids (TSS)

Comparison of the mutual effect of training system and storage time on solid soluble content (Figure 5) showed an increasing trend in solid soluble content. However, due to the non-porous nature of grape fruits, there were slight changes in the level of solid soluble content, which were not statistically significant. The highest level of solid soluble content (26.182 degrees Brix) was related to the sprawl training system 40 days after storage. The increase in solid soluble content may be due to the reduction of fruit water content, breakdown of complex sugars into simple sugars, and digestion of cell walls that occur during fruit ripening. A decrease in the total solid soluble content after 60 days of storage in the sprawl training system could indicate high respiration due to potential early aging of fruits in this training system compared to the other two training systems and the consumption of these substances in the respiratory process .

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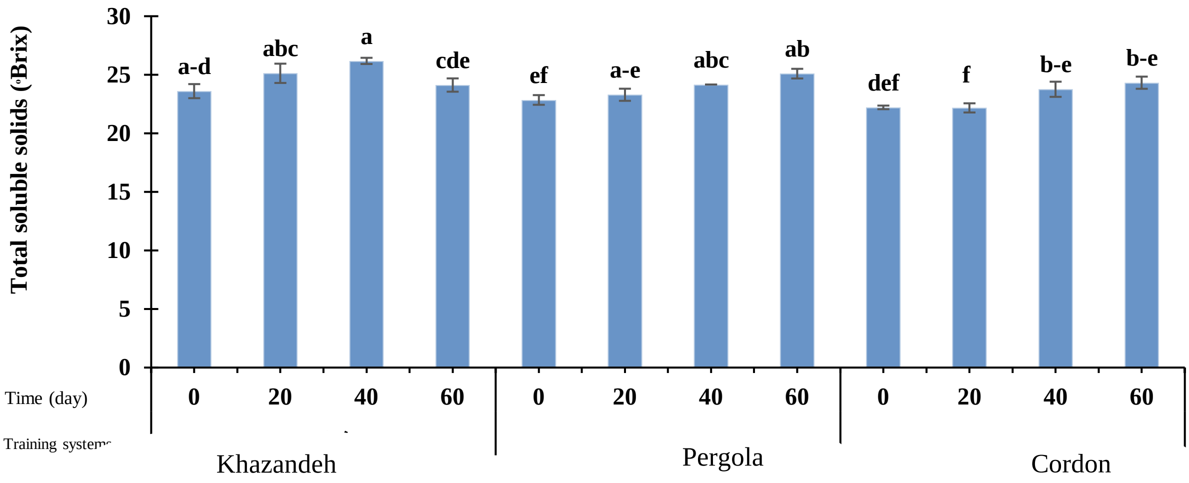

Figure 5- Effect of different training systems and storage time on total soluble solids (TSS) (The different letters and the error bars on each column show significant difference based on LSD test ($P < 0.05$) and standard error (Mean ± SE))

3-5- Titratable Acidity (TA)

The results of comparing the mutual effect of training system and storage time on titratable acidity (Figure 6) showed that the level of titratable acidity had a slight increasing trend. The highest level of titratable acidity (0.202 percent) was observed in the sprawl training system 40 days after storage, which had a significant difference compared to the other two training systems, and then the titratable acidity in the sprawl and pergola training systems decreased. Since the titratable acidity of fruits in the sprawl training system was higher 40 days after storage and decreased 60 days after storage, it seems that fruits harvested from sprawl and pergola-trained vines consumed organic acids sooner, and this did not happen in fruits harvested from cane-pruned vines 60 days after harvest. The decrease in titratable acidity at the end of storage may be due to metabolic changes in the fruit, consumption of organic acids in the respiratory process, or fungal contamination. Therefore, the decrease in titratable acidity in grape fruits from the sprawl and pergola training systems may be due to high fungal contamination and consequently high respiration in samples from these two training systems. As for the increase in acidity of fruits harvested from the sprawl system 40 days after harvest, since the berries at the top of the cluster were sweeter and more mature compared to the end of the cluster, the selected berries for measurement were probably more than those at the end of the cluster. Also, since the harvesting and measurements were done randomly in this study, there could be another reason for this trend.

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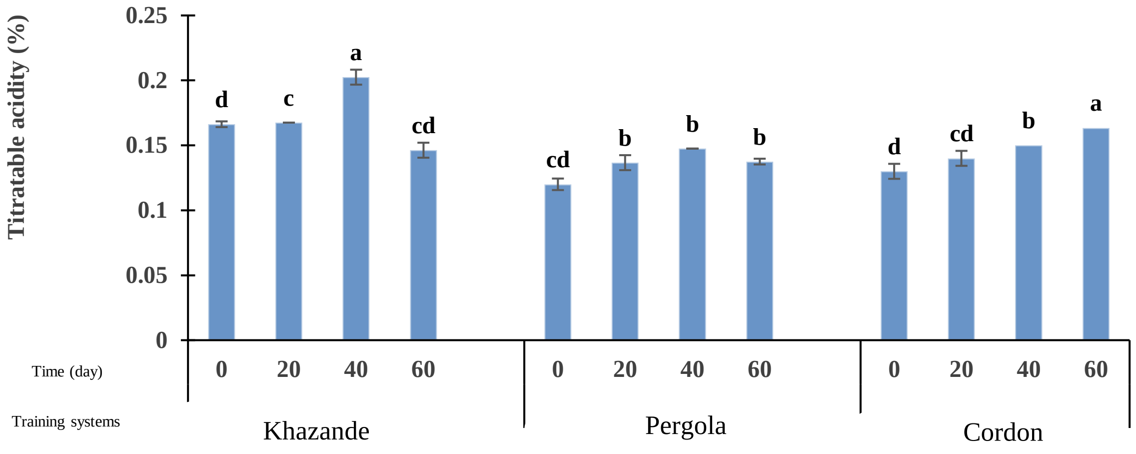

Figure 6- Effect of different training systems and storage time on titratable acidity (TA) (The different letters and the error bars on each column show significant difference based on LSD test (P <0.05) and standard error (Mean ± SE)

3-6- Total phenol

The results of comparing the average interactive effect of training system and storage time on the total phenol content (Figure 7) showed that the total phenol content had an increasing trend until the end of the storage period, with the highest level of phenols in all three training systems significantly higher at 60 days after storage compared to other days. This relative increase in phenol content may be due to stress caused by aging. The increase in total grape phenol content could be attributed to the loss of chlorophyll and the beginning of phenolic compound synthesis, which coincides with the period of berry color change. Topalovic and Micolucci stated that during the ripening stage, the total phenol content of grape fruits increases. Phenolic compounds in grapes are secondary metabolites that play a role in plant resistance to non-biological stressors. The phenylalanine ammonia-lyase enzyme is induced by non-biological stressors, resulting in the accumulation of phenolic compounds. Therefore, the phenylalanine ammonia-lyase enzyme likely induces resistance to stress-induced contamination by regulating the biosynthesis of phenolic compounds at the end of the storage period.

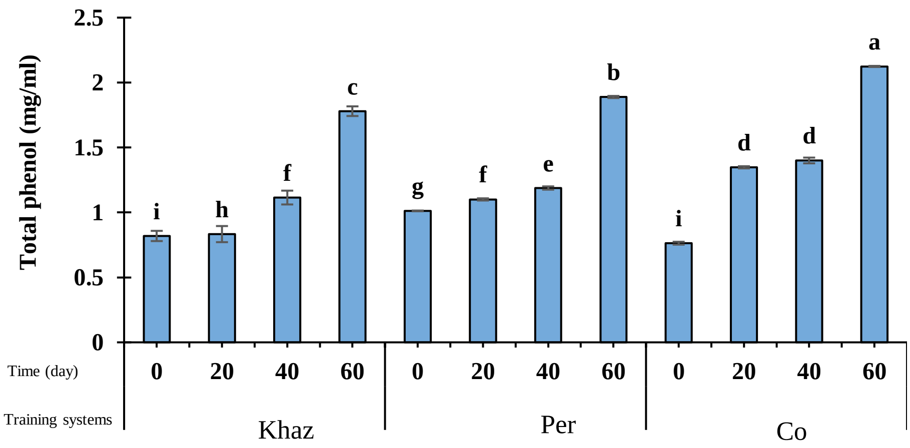

Figure 7- Effect of different training systems and storage time on total phenol (The different letters and the error bars on each column show significant difference based on LSD test (P <0.05) and standard error (Mean ± SE))

3-7- Peroxidase Enzyme

The results of comparing the mutual effect of training system and storage time on the level of peroxidase enzyme activity (Figure 8) showed that the activity of this enzyme initially increased and then decreased. The activity of this enzyme reached its highest level in the

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sprawl training system 20 days after storage, while in the other two training systems, it was significantly higher at 40 days after storage. The highest level of enzyme activity was observed 40 days after storage in the pergola training system. Nat et al. reported that the activity of peroxidase enzyme increased during pathogen activity. These results indicate that peroxidase genes may be induced in response to disease resistance and during the disease period. The results obtained are consistent with the findings of Nat et al. in 2015 regarding the increase in peroxidase enzyme activity with the increase in pathogens [33].

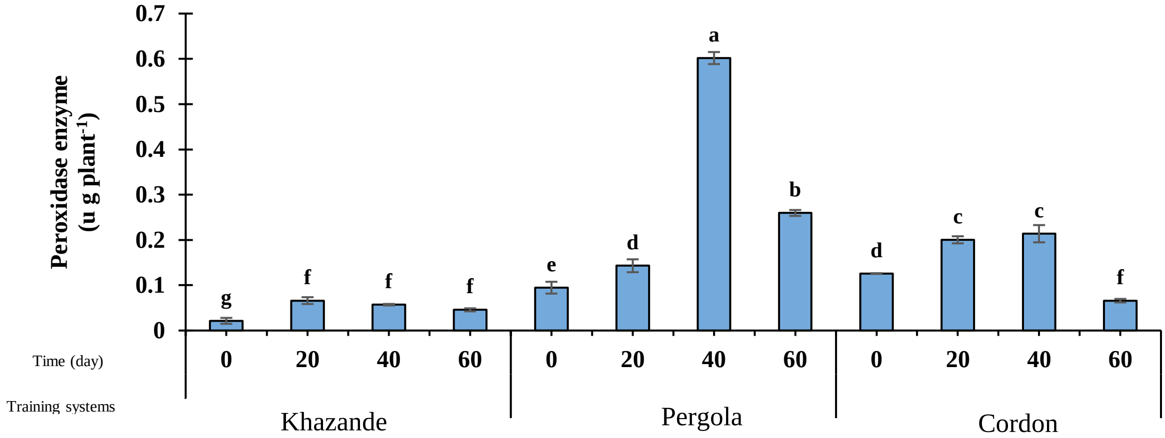

Figure 8- Effect of different training systems and storage time on peroxidase enzyme (The different letters and the error bars on each column show significant difference based on LSD test (P <0.05) and standard error (Mean ± SE))

3-8- Polyphenol Oxidase Enzyme

The results of comparing the mutual effect of training system and storage time on the level of polyphenol oxidase enzyme activity (Figure 9) showed that the activity of this enzyme reached its highest level in the sprawl and pergola training systems 40 days after storage and then decreased. While in the cordon training system, the highest level of enzyme activity was observed after 60 days of storage. The activity of this enzyme increases during the storage period due to the fruit aging [32]. Nat et al. reported that the activity of polyphenol oxidase enzyme increased in bananas infected with *Botryodiplodia theobromae* fungus [33]. In the current study, with the increase in storage time and sample contamination, the activity of this enzyme also increased. The results obtained were consistent with the findings of Pileh *et al.* in 1394 and Nat et al. in 2015 [32]. In the sprawl and pergola training systems, contamination of the fruits was observed 20 days after storage, browning started after 40 days of storage, and complete browning was visible after 60 days of storage, which seems to be related to the activity of polyphenol oxidase enzyme.

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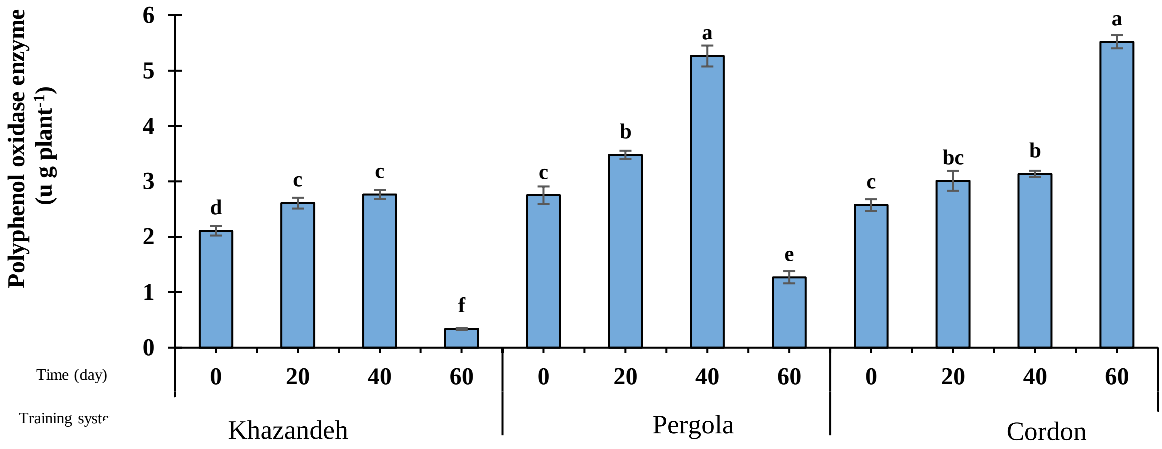

Figure 9- Effect of different training systems and storage time on polyphenol oxidase enzyme (The different letters and the error bars on each column show significant difference based on LSD test (P <0.05) and standard error (Mean ± SE))

3-9- Phenylalanine Ammonia-Lyase Enzyme

The results of comparing the mutual effect of training system and storage time on the level of phenylalanine ammonia-lyase enzyme activity (Figure 10) indicated an increasing activity, with the highest level of enzyme activity related to the pergola training system observed 60 days after storage. Overall, the highest level of enzyme activity was observed in the pergola training system. The activity of the phenylalanine ammonia-lyase enzyme changes under the influence of growth stage, cell differentiation, and various biotic and abiotic stresses. Factors such as pathogen contamination, mechanical damage, UV radiation, drought, salicylic acid, and methyl jasmonate can increase the activity of this enzyme [34]. The results obtained from this study were consistent with the findings of Nat et al. in 2015 on bananas and Mohammadhani and Abbaspour in 1394 on grapes, indicating that pathogens and contamination lead to an increase in the activity of this enzyme [33 and 35]. In the cordon and pergola training systems, the activity of the phenylalanine ammonia-lyase enzyme increased, with the highest amount observed in the sprawl training system 40 days after storage, which was associated with an increase in contamination.

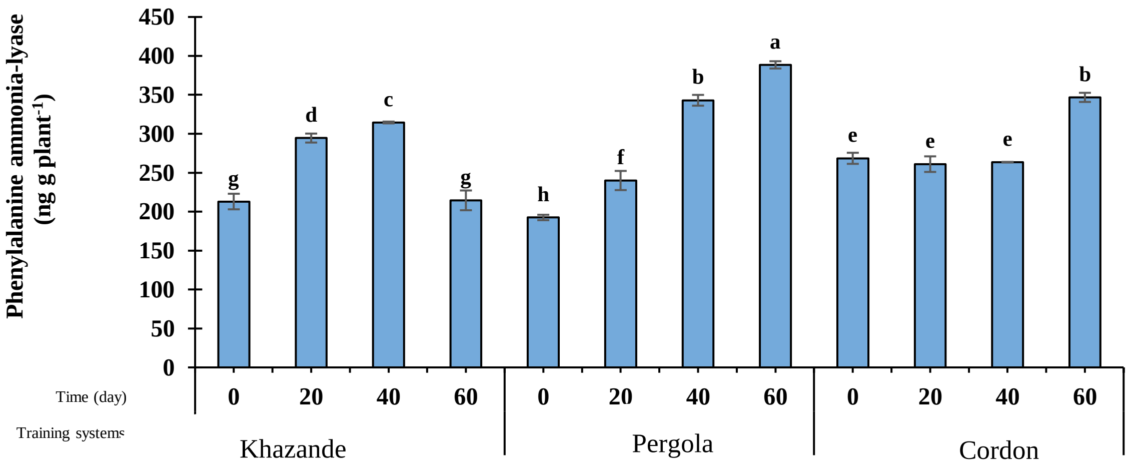

Figure 10- Effect of different training systems and storage time on phenylalanine ammonia-lyase (The different letters and the error bars on each column show significant difference based on LSD test (P <0.05) and standard error (Mean ± SE))

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4- Conclusion

Although no research has been conducted within the country on the effect of training system on important indicators after grape harvest, the results of this study showed that the cordon training system with better control over the visual traits and some biochemical indicators of grape clusters, including berry contamination, berry drop, soluble solids, titratable acidity, along with increased peroxidase enzyme activity and control of polyphenol oxidase and phenylalanine ammonia-lyase enzymes significantly increased the storage life of seedless white grape variety. While there was not much difference observed in terms of berry browning quality between the training systems based on scoring, field observations and the condition of harvested fruits from the cordon training system showed better conditions and the possibility of storing them for a longer period, compared to samples from the sprawl and pergola training systems, which could not be stored for more than 60 days. However, the one-year data from this study was not sufficient for a strong conclusion on the effects of training system on the storage life of grape fruits, and further investigation over several years and evaluation of more storage-related traits is needed.

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تأثیر سیستم‌های مختلف تربیت تاک بر عمر انبارمانی میوه انگور رقم سفید بی‌دانه

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چکیده

در این پژوهش به‌منظور حفظ کیفیت میوه انگور در دوره انبارمانی، اثر سیستم تربیت تاک و زمان انبارمانی بر برخی صفات ظاهری و بیوشیمیایی خوشه انگور در دوره انبارمانی مورد بررسی قرار گرفت. آزمایش به‌صورت فاکتوریل در قالب طرح کاملاً تصادفی با دو عامل سیستم تربیت تاک در سه سطح (خزنده، پرگولا و کوردون) و زمان انبارمانی در چهار سطح (صفر، ۲۰، ۴۰ و ۶۰ روز پس از انبارمانی) با سه تکرار در سال ١٣٩٦ انجام شد. پس از انتقال میوه‌ها به سردخانه با دمای ٥+ درجه سلسیوس و رطوبت نسبی ۹۵ درصد و نگهداری به مدت دو ماه برخی صفات میوه انگور طی روزهای مختلف پس از انبارمانی مورد بررسی قرار گرفتند. نتایج نشان داد میزان آلودگی حبه‌ها به مرور زمان افزایش یافت و در طی دوره انبارمانی کم‌ترین میزان آلودگی (١٣/٧٠٦ درصد) مربوط به سیستم تربیت کوردون بود. همچنین پس از ٦٠ روز انبارمانی کم‌ترین درصد ریزش حبه (٢٧/٥٣٥ درصد) در میوه های برداشت شده از سیستم تربیت کوردون مشاهده گردید. میزان قهوه‌ای شدن حبه پس از ٦٠ روز انبارمانی به‌طور معنی‌داری بیش‌تر از سایر زمان‌ها بود. بیش‌ترین میزان مواد جامد محلول (٢٦/١٨٢ درجه بریکس) مربوط به سیستم تربیت خوابیده در ٤٠ روز پس از انبارمانی بود با این حال کاهش قابل ملاحظه ای طی ٦٠ روز پس از انبار مانی در مقدار این شاخص مشاهده گردید. نتایج نشان داد که میزان فنل تا پایان دوره انبارمانی روند افزایشی داشت و بیش‌ترین میزان فنل در هر سه سیستم تربیت در ٦٠ روز پس از انبارمانی به‌طور معنی‌داری بیش‌تر از سایر روزها بود. میزان فعالیت آنزیم پراکسیداز در سیستم تربیت خوابیده در ٢٠ روز پس از انبارمانی به بالاترین میزان فعالیت خود رسید درحالی که در دو سیستم تربیت دیگر در ٤٠ روز پس از انبارمانی و با اختلاف معنی‌داری بیش‌تر از سایر روزها بود. همچنین فعالیت آنزیم پلی فنل اکسیداز در سیستم تربیت خوابیده و پرگولا در ٤٠ روز پس از انبارمانی به بیش‌ترین میزان خود رسید و سپس کاهش یافت. در حالی که در سیستم تربیت کوردون پس از ٦٠ روز انبارمانی بیش‌ترین میزان فعالیت این آنزیم مشاهده گردید. فعالیت آنزیم فنیل آلانین آمونیالیاز طی دوره انبار مانی افزایشی بود و ٦٠ روز پس از انبارمانی بیش‌ترین میزان فعالیت این آنزیم مربوط به سیستم تربیت پرگولا بود. به‌طورکلی نتایج نشان دادند که سیستم تربیت کوردون بهترین اثر را در حفظ صفات میوه انگور در طی دوره انبار مانی نسبت به سایر روش های تربیت داشت.

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