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Research Paper

Determination of the Suitability of the Newly Breed Güz Gülü Grape Cultivar for Cold Storage

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Abstract

In grape production, in order to maintain the competitive power in the domestic and foreign markets and to meet the market needs, it is necessary to have the product in a wide period of time. Especially late and high quality table grape varieties that are suitable for cold storage are needed. In the study, the suitability of Güz gülü grape variety for cold storage was investigated. The study was carried out during the harvest period of 2018 and 2019. The clusters were placed in bags weighing 5 kg and dual releasing SO_2 pads with a dose of 0.9 g kg^{-1} of sulphur dioxide were placed in the bag. Müşküle variety was used as a control. After the applications, the grapes were stored for 90 days at 0-1 °C and 90±5% relative humidity. In order to determine the fruit quality characteristics of the samples at 15-day intervals throughout the storage period; weight loss, total soluble solids, titration acidity, maturity index, berry firmness, the removal force of the berries, cluster rachis color, decay rate, berry cracking rate and sensory analysis values were determined. It has been determined that Güz Gülü grape variety is not suitable for cold storage in Tekirdağ location due to the cracking of the skin. It was determined that the experiment should be done in locations with higher day and night temperature difference, better sun exposure and continental climate. In addition, it is recommended to apply calcium or other support components to increase the resistance of berry skin against cracking.

Introduction

Viticulture has a wide spread area in the world. There is 78 million tons of grape production (FAO, 2020) on 6 950 930 ha in the world, and 3.67 million tons on 390 221 ha in Turkey (TUIK, 2021).

According to the data of 2020, the total production of table grapes in the world is 25.7 million tons. In the production of table grapes, China ranks first with a production of 11 million tons, followed by India with a production of 3 million tons. After India, the world's 3rd largest producer of table grapes is Turkey, with a production of 2 million tons, which has the potential to export table grapes, with increasing storage opportunities (USDA, 2021).

Turkey is one of the main genetic resources of vine and has an important potential with its vineyard regions suitable for table grape cultivation. In order to maintain the competitive power in the domestic and foreign markets and to meet the market needs, it is necessary to have the product in a wide period of time. Therefore, there is a need for especially late and high quality table grape varieties that are suitable for cold storage.

Table grapes, which are stored in a cold room and offered to the market in later periods, find buyers at higher prices. Although some developments have been observed in this regard in recent years, the capacity utilization rate in table grape storage is quite low (Üstün, 2011).

Table grape is a fruit with increasing

interest due to its attributes and nutritional compounds. In recent years, new cultivars such as those without seeds and with new flavors have reached countries around the world. For this reason, postharvest treatments that retain fruit quality need to be improved (Romero et al., 2020).

After harvest, table grapes are highly perishable as they are subjected to important water losses as a result of rachis and pedicel desiccation, causing browning, weight loss and berry softening. Moreover, fungal decay, largely caused by the necrotrophic pathogen Botrytis cinerea also produces big losses (Palou et al., 2010).

Table grapes can be stored at -1°C to 0°C and 90-95% relative humidity (Nelson, 1985; Karaçalı, 2004). Varieties such as Müşküle, Alphonse Lavallée, Hafızali, İrikara, Kozak Siyahı, Ribol and Palieri, which generally mature in the middle or late season, with relatively higher skin thickness and stronger berry stem connections, are suitable for cold storage (Eriş et al., 1988; Özer & Işık., 2002).

In this study, it was aimed to determine the performance of Güz Gülü grape variety, which is a newly breed late variety, for fresh consumption as well as cold storage performance.

Material and Methods

In the study, Güz gülü variety, which was registered in 2011 and located in the production parcel of Tekirdağ Viticulture Research Institute, was used.

Güz Gülü (Kırmızı Şam X Barış): Normally dense clusters are large, weighing 400-450 g on average and branched conical. Grape berries are rose-colored and seedless. It is a late maturing variety. The amount of total soluble solids and titratable acid in mature grapes is relatively low.

Müşküle (Control Variety): The clusters are large, weighing 250-350 g on average and are winged conical. Berries are green-yellow, slightly elliptical and very large (5 g). This seeded variety, which matures in the late season, holds up well on the vine, suitable for transit and long-term storage.

As packaging materials, polyethylene-based modified atmosphere bag (Passive MAP) with a certain rate of gas and water vapor permeability, specially produced for grape storage, and non-permeable/very limited permeable, F2-12 low density, transparent, 0.03 mm thick and unperforated polyethylene bags (PE) were used. UVASYS Dual Release sodium metabisulfite generator pads were used for sulfur dioxide (SO_2) release. Generator pads were 23x33 cm in size and each pad contains 7.5 g of sodium metabisulfite.

After the clusters were harvested and sorted, they were placed in bags with an average of 5 kg grapes in each replication. A generator (at a dose of 0.9 g kg^{-1}) was put into MA and PE bags for every 5 kg of product, and the bags were closed. Desiccant paper towels were placed under the clusters, the grapes were placed in the crates by holding the cluster stem, and a generator pad was placed after the paper towel was placed on it again. All packages were stored at 0-1°C and 90±5% relative humidity for 3 months. O_2 and water vapor permeability analyzes of packaging materials were made by The Scientific and Technological Research Council of Türkiye (TUBITAK) MAM Food Institute.

At the beginning of the study and at 15-day intervals; weight loss (%), total soluble solids (TSS) (%), titratable acidity (g L^{-1}), maturity index (total soluble solids/titration acidity), berry firmness (kg), berry removal force (g), decay rate (%), cluster rachis color, berry cracking rate (%) and sensory analyzes were made.

Water-soluble solid content was measured with a hand-held refractometer at 20°C and the % brix degree was determined (Anonymous, 1983).

Titration acidity was determined by adding a few drops of phenolphthalein (1% in ethanol) to 5 ml of grape must and titrated with 0.1 N NaOH solution. The results were calculated in terms of "tartaric acid" (g L^{-1}) (Anonymous, 1983).

The maturity index was obtained by dividing the amount of water-soluble solid by the amount of titratable acidity.

Changes in the cluster rachis of stored grapes due to drying were determined using the following 0-5 scale (Harvey et al., 1988).

0: Fresh, bright green
1: Green
2: Dull matte green
3: Green, light brown
4: Brown
5: Dried grayish brown

In sensory analysis, grapes were evaluated on a 1–9 scale in terms of appearance, taste and texture (firmness of the texture when chewing) (Artes-Hernandez et al., 2004).
According to this scale;
1: Extremely weak or soft texture
3: Weak and soft
5: Medium and limited in marketability
7: Good
9: Excellent

Berry cracking rate was determined as a percent ratio by dividing the weight of the berries with skin cracking to the total weight after the grapes removed from the cold storage were kept at a temperature of 20 °C and 70% humidity for 3 days.

Berry firmness measurements were determined in kg with a PCE PTR-200 handheld digital penetrometer using a 6 mm tip (According to the catalog recommendation of the device). Measurements were made without stripping the skin of grape berries.

The breaking strength of the berries and the force required to separate the grapes from the stem were determined in a modified electronic balance and expressed in grams (Özer and Işık, 2002).

The decay rate was calculated as a percent ratio by dividing the decayed berries weight by the cluster weight.

The study was carried out according to the randomized block design with 3 replications. The data were subjected to statistical analysis in the JMP package program.

Results and Discussion

In the province of Tekirdağ, where the grapes subject to the experiment were harvested, frequent, intense and sometimes 1 week-long rains in the late summer period, which have started to be seen in recent years, cause negativities during the harvest period. As the cloudiness increases, maturation and coloration are adversely affected, and the intensity of fungal diseases increases due to precipitation. Due to these adverse climatic conditions during the harvest periods during the

Table 1. Changes in the amount of weight loss depending on different treatments of Güz Gülü and Müşküle grape cvs. (%)

Weight loss (%)									
Variety			Müşküle (Control)		Güz Gülü		Main effect of the days		Main effect of the year
Application			MAP+SO_2	PE+SO_2	MAP+SO_2	PE+SO_2			
2018	Days	15	0.40	0.70	0.48	0.43	15.day	0.37 d	0.75 A
		30	0.59	0.79	0.60	0.45			
		45	0.75	0.85	0.76	0.52	30.day	0.46 cd	
		60	0.82	0.92	0.87	0.54			
		75	0.85	0.94	0.91	0.87	45.day	0.55 bc	
		90	0.92	0.97	1.03	1.11			
2019	Days	15	0.18	0.32	0.22	0.23	60.day	0.60 b	0.40 B
		30	0.28	0.36	0.23	0.34			
		45	0.36	0.44	0.30	0.44	75.day	0.68 ab	
		60	0.38	0.45	0.35	0.48			
		75	0.39	0.58	0.40	0.47	90.day	0.81 a	
		90	0.41	0.79	0.60	0.65			
VarietyxApp.			0.53 b	0.68 a	0.56 ab	0.54 b			
Main effect of the variety			0.60		0.55				
Main effect of the application			(MAP+SO_2) 0.55		(PE+SO_2) 0.61				

M.E.YearLSD0.05= 0.08. DayM.E.DayLSD0.05= 0.14, Variety x App. A.E.LSD0.05= 0.12

project, there have been situations where it is necessary to harvest early or late. This is especially evident in the results of the analysis conducted in 2018.

The O_2 permeability of the MA bag is 8025.5 ml m^{-2} day^{-1}, and the water vapor permeability is 23 g m^{-2} day^{-1}. The O_2 permeability of the PE bag is 3107 ml m^{-2} day^{-1}, and the water vapor permeability is 7.5 g m^{-2} day^{-1}.

Weight loss

Weight loss is an important criterion in the storage of fresh fruits. In the study, weight loss showed an increasing trend during storage (Table 1). "Main Effect of Year (M.E. Year)", Main Effect of Day (M.E. Day) and "Variety x Application interaction" were found to be statistically significant ($p<0.05$). In the study, it is seen that weight loss occurred more (0.75%) in 2018 and Güz gülü cultivar suffered less weight loss than control cultivar.

Grierson and Wardowski (1978) reported that in general, if the weight loss rate exceeds 10% of the total weight of the product, the product may lose its economic marketability. In our study, weight loss rates were determined below 10%.

Amount of Total Soluble Solids

In the study, "M.E. Year" and "M.E. Variety" were found to be statistically significant ($p<0.05$) in TSS ratios. During the storage period, fluctuations were observed in all applications (Table 2). It is seen that the TSS value in 2019 (16.78%) is higher than in 2018. Among the cultivars, a lower amount of TSS was detected in Güz gülü (15.44%), which has a slow sugar accumulation during maturity.

Titratable Acidity

"M.E. Day " and "M.E. Variety" were found to be statistically significant ($p<0.05$) in the amount of titration acidity. During the storage period, lower values were observed in the control cultivar, compared to the beginning, while a fluctuating course was observed in Güz gülü

Table 2. Changes in the amount of TSS depending on different treatments of Güz Gülü and Müşküle grape varieties

Amount of total soluble solids (%)								
Variety			Müşküle (Control)		Güz Gülü		Main effect of the days	Main effect of the year
Application			$MAP+SO_2$	$PE+SO_2$	$MAP+SO_2$	$PE+SO_2$		
2018	Days	0	15,76		15,10		0.day 16.02	15.11 B
		15	15.00	16.37	14.20	14.00		
		30	16.33	16.73	14.63	14.07	15.day 15.51	
		45	15.87	15.83	14.07	14.03		
		60	15.97	15.83	14.27	13.53	30.day 15.86	
		75	15.23	15.57	14.23	14.53		
		90	16.60	16.07	14.60	14.47	45.day 16.13	
2019	Days	0	16.33		16,90			16.78 A
		15	17.03	15.93	15.53	16.03	60.day 15.88	
		30	17.37	16.33	15.53	15.87		
		45	16.97	18.37	17.03	16.87	75.day 16.06	
		60	16.93	17.03	16.57	16.90		
		75	17.50	18.07	16.47	16.90	90.day 16.21	
		90	17.60	16.43	16.80	17.07		
VarietyxApp.			16.46	16.48	15.42	15.45		
Main effect of the variety			16.47 *a*		15.44 *b*			
Main effect of the application			($MAP+SO_2$) 15.94		($PE+SO_2$) 15.96			

M.E.YearLSD0.05= 0.27, M.E.varietyLSD0.05= 0.27

Table 3. Changes in the amount of titratable acidity depending on different treatments of Güz Gülü and Müşküle grape varieties (g L^{-1})

Titrable acidity (g L^{-1})									
Variety			Müşküle (Control)		Güz Gülü		Main effect of the days		Main effect of the year
Application			MAP+SO_2	PE+SO_2	MAP+SO_2	PE+SO_2			
2018	Days	0	5.07		4.41		0.day	4.76 ab	4.60
		15	4.70	4.60	4.30	4.40			
		30	4.30	4.60	4.70	4.70	15.day	4.39 d	
		45	4.90	4.45	4.55	4.40			
		60	4.75	4.85	4.10	4.00	30.day	4.51 cd	
		75	5.15	5.25	4.75	5.05			
		90	4.90	4.80	3.90	4.05	45.day	4.61 bc	
2019	Days	0	5.00		4.55				4.63
		15	4.35	4.95	3.90	3.95	60.day	4.76 ab	
		30	4.70	4.90	4.15	4.05			
		45	4.75	4.75	4.30	4.75	75.day	4.87 a	
		60	5.55	5.40	4.75	4.70			
		75	4.90	4.90	4.40	4.55	90.day	4.48 cd	
		90	4.70	4.50	4.23	4.78			
VarietyxApp.			4.84	4.86	4.36	4.45			
Main effect of the variety			4.85 *a*		4.40 *b*				
Main effect of the application			(MAP+SO_2) 4.59		(PE+SO_2) 4.65				

M.E.DayLSD0.05= 0.20, M.E.VarietyLSD0.05= 0.11

cultivar (Table 3). Titratable acidity values were found to be close to each other between years. When analyzed on a variety basis, it is seen that the acidity of Güz gülü (4.40 g L^{-1}) variety is lower. When the main effects of the day are examined, it is seen that the acidity has decreased significantly compared to the beginning on the 15th day of storage.

Although the most abundant organic acid in grapes is tartaric acid, malic acid and citric acid can also be found in amounts that could affect the acid content of the must (Buhurcu, 2004). Organic acids can turn into organic sugars by hydrolysis during storage (Çelik, 2011). This result was in agreement with the findings of previous studies, which showed that titratable acidity loss was reduced during cold storage in 'Red Globe' (Özdemir and Dündar, 2002), 'Alphonse Lavallée' and 'Sultani Çekirdeksiz' (Eriş et al., 1995), 'Alphonse Lavallée' (Sabir et al., 2006) and Razaki (Sabir et al., 2011) varieties.

Maturity Index

In terms of maturity index values, "M.E. Year" and "M.E. Day" were found to be statistically significant ($p<0.05$). During the storage period, higher values were generally observed in the control variety compared to the beginning, while a decreasing trend was observed towards the end of the storage period in Güz gülü variety (Table 4). There was a significant decrease in acidity values of Güz gülü variety in 2018 compared to the samples taken on 75th and 90th day. This situation was directly reflected in the maturity index values.

When analyzed on a yearly basis, the maturity index of 2019 (36,64) was found to be higher. Climatic conditions in 2019 were more favorable in terms of maturity. On the cultivar basis, it is seen that Güz gülü (35,30) cultivar has a higher maturity index than the Müşküle cultivar.

Table 4. Changes in the amount of maturity index depending on different treatments of Güz Gülü and Müşküle grape varieties (g)

Maturity Index								
Variety			Müşküle (Control)		Güz Gülü		Main effect of the days	Main effect of the year
Application			MAP+SO_2	PE+SO_2	MAP+SO_2	PE+SO_2		
2018	Days	0	31.16		34.64		0.day 33.94 bcd	33.08 B
		15	31.96	35.92	33.26	32.15		
		30	38.00	36.45	31.26	30.00	15.day 35.72 ab	
		45	32.46	35.70	30.96	31.95		
		60	33.66	32.71	34.86	33.81	30.day 35.49 abc	
		75	29.58	29.69	30.10	28.79		
		90	33.97	33.92	37.49	35.75	45.day 35.13 abcd	
2019	Days	0	32.70		37.24			36.64 A
		15	39.39	32.46	39.99	40.59	60.day 33.67 cd	
		30	37.89	33.70	37.45	39.18		
		45	35.82	38.71	39.75	35.72	75.day 33.23 d	
		60	30.51	32.84	34.91	36.07		
		75	35.72	36.82	37.43	37.68	90.day 36.39 a	
		90	37.47	36.99	39.76	35.74		
VarietyxApp.			34.31	34.27	35.65	34.95		
Main effect of the variety			34.29		35.30			
Main effect of the application			(MAP+SO_2) 34.98		(PE+SO_2) 34.61			

M.E.YearLSD0.05= 1.06 M.E.DayLSD0.05= 1.99

Table 5. Changes in the amount of berry firmness depending on different treatments of Güz Gülü and Müşküle grape varieties (kg)

Berry Firmness (kg)								
Variety			Müşküle (Control)		Güz Gülü		Main effect of the days	Main effect of the year
Application			MAP+SO_2	PE+SO_2	MAP+SO_2	PE+SO_2		
2018	Days	0	3.80		4.02		0.day 3.70 a	3.44 A
		15	3.44	3.25	4.16	3.98		
		30	3.49	3.29	3.74	3.68	15.day 3.49 b	
		45	3.49	3.48	3.43	3.37		
		60	2.88	2.83	3.60	3.58	30.day 3.36 b	
		75	3.30	3.36	3.47	3.58		
		90	2.88	3.10	3.10	3.07	45.day 3.26 bcd	
2019	Days	0	3.78		3.20			3.18 B
		15	3.45	3.45	3.04	3.14	60.day 3.09 d	
		30	3.58	3.37	2.99	2.75		
		45	3.20	3.67	2.70	2.73	75.day 3.34 bc	
		60	3.33	3.35	2.58	2.57		
		75	3.68	3.78	2.67	2.89		
		90	3.87	3.58	2.85	2.55	90.day 3.13 cd	
VarietyxApp.			3.44	3.44	3.25	3.22		
Main effect of the variety			3.44 *a*		3.24 *b*			
Main effect of the application			(MAP+SO_2) 3.35		(PE+SO_2)3.33			

M.E.YearLSD0.05= 0.12 M.E.DayLSD0.05= 0.23 M.E.VarietyLSD0.05= 0.12

Berry firmness

In the measurement of berry firmness, "M.E. Year", "M.E. Day" and "M E. Variety" were found to be statistically significant ($p<0.05$) (Table 5). There was a decreasing trend in both applications during storage period. In terms of years, the firmness value of 2019 (3.18 kg) was found to be lower than in 2018. It was observed that the firmness value was slightly lower towards the end of the storage period compared to the beginning in 2018 and the amount of decrease was more limited in 2019. On the cultivar basis, it is seen that the firmness value of Güz gülü (3.24 kg) cultivar is lower than the control.

Our results are also in line with Pretel et al. (2006) who reported that grape firmness decreases slightly at the end of the storage period and this decrease is related to the degradation of pectic polymers over time (Artes-Hernandez et al., 2004). also stated that the firmness values in grapes decreased during storage and shelf life compared to the initial values. Further, Martinez-Romero et al. (2003) reported that MAP prevent the reduction of fruit firmness in the storage of grapes and that KA is more effective than the use of SO_2 in maintaining firmness.

Resistance to Berry Rupture from Stem

"M.E. Year", " M.E. Day" and "M.E. Variety" were found to be statistically significant ($p<0.05$) in the measurement of the resistance to berry rupture from the stem. (Table 6).

It is observed that the berry-stalk connection weakens in general towards the end of the storage period. In terms of years, the firmness value of 2019 (296.89 g) was found to be higher than in 2018. On the cultivar basis, it is seen that the the resistance to berry rupture from the stem value of Güz gülü (319.20 g) cultivar is higher than the control.

Compared to Müşküle variety, which is known as one of the most suitable varieties for storage, the fact that Güzü gülü variety has more berry-stalk connection is an important

Table 6. Changes in the amount of berry stem breaking resistance depending on different applications of Güz Gülü and Müşküle grape varieties (g)

The resistance to berry rupture from stem (g)								
Variety			Müşküle (Control)		Güz Gülü		Main effect of the days		Main effect of the year
Application			MAP+SO_2	PE+SO_2	MAP+SO_2	PE+SO_2			
2018	Days	0	279.17		389.08		0.day	320.30 a	280.71 B
		15	213.58	263.93	330.04	300.51			
		30	258.33	219.20	351.49	336.56	15.day	295.15 b	
		45	258.82	262.36	274.24	305.62			
		60	258.96	231.87	273.93	331.48	30.day	299.53 b	
		75	252.91	231.76	286.22	302.24			
		90	250.76	241.73	294.82	298.85	45.day	284.18 bc	
2019	Days	0	266.64		346.32				296.89 A
		15	288.69	307.09	318.64	338.71	60.day	286.76 bc	
		30	290.11	266.87	340.24	333.40			
		45	279.16	286.56	312.22	294.44	75.day	282.14 bc	
		60	283.07	272.16	330.33	312.29			
		75	264.98	280.02	317.51	321.49	90.day	269.28 c	
		90	253.47	253.09	269.84	291.67			
VarietyxApp.			264.19	261.60	316.78	321.62			
Main effect of the variety			262.90 *b*		319.20 *a*				
Main effect of the application			(MAP+SO_2) 290.48		(PE+SO_2) 291.61				

M.E.YearLSD0.05= 11.25. M.E.DayLSD0.05= 21.04. M.E.VarietyLSD0.05= 11.25

advantage in terms of suitability for storage.

Cluster Skeleton Color

"M.E. Day" and "M.E. Variety" were found to be statistically significant ($p<0.05$) in cluster skeleton colour. (Table 7). While the closest value to the baseline was found in the control with 1.40, it was determined as 2.08 in Güz gülü variety. In the study, there is an increasing changes in the color of cluster skeleton throughout storage period and a rapid increase in color change is observed on 75th and 90th day.

Rachis lacks the thick epidermis and cuticular wax depositions that protect berries against dehydration. In this sense, it has been observed that storage at 0–1°C and a relative humidity of 95% is not enough to control water loss from bunches, with this being linked to an increase in rachis browning (Romero et al., 2020). Crisosto et al. (2001) reported that the amount of water loss varies according to cultivars, but is associated with the darkening of the cluster skeleton. On the other hand, Çakır (2010) reported that the stem browning of grapes (Red Globe cv.) stored in MAP condition after 30 days was at a level that could significantly affect the marketability of the fruits, and that the higher scores of grapes stored under MAP+SO_2 conditions could be attributed to the fact that SO_2 prevented darkening and the bleaching effect.

Decay Rate

The sensitivity to rot in fruits is the most important factor affecting storage and the market value of the product.

In the decay rate values, " M.E. Year", " M.E. Day" and " M.E. Variety" were found to be statistically significant ($p<0.05$). (Table 8). Depending on the storage period, an increase in the rate of decay is observed. Especially in 2018, the decay rates (3.49%) were higher. When analyzed on the basis of cultivar, a higher decay rate was detected in Güz gülü variety (2.80%) than the control. In the rainy 2018, the decay rate of MAP+SO_2 application in Güz gülü variety was 9.66% on the 75th day, while 3-4% rot in the

Table 7. Changes in the color of cluster skeleton depending on different treatments of Güz Gülü and Müşküle grape varieties

Cluster skeleton colour									
Variety			Müşküle (Control)		Güz Gülü		Main effect of the days		Main effect of the year
Application			MAP+SO_2	PE+SO_2	MAP+SO_2	PE+SO_2			
2018	Days	15	1.00	1.00	1.00	1.00	15.day	0.75 d	1.74
		30	1.00	1.00	1.33	1.33			
		45	1.33	1.33	1.33	1.33	30.day	1.17 c	
		60	2.00	2.00	1.67	1.33			
		75	2.33	2.67	2.33	2.67	45.day	1.67 b	
		90	2.33	2.67	2.67	3.00			
2019	Days	15	0.00	0.00	1.00	1.00	60.day	1.88 b	1.75
		30	1.00	1.00	1.33	1.33			
		45	1.00	1.00	3.00	3.00	75.day	2.38 a	
		60	1.00	1.00	3.00	3.00			
		75	1.67	1.33	3.00	3.00	90.day	2.63 a	
		90	2.00	2.00	3.00	3.33			
VarietyxApp.			1.39	1.42	2.06	2.11			
Main effect of the variety			1.40 *b*		2.08 *a*				
Main effect of the application			(MAP+SO_2) 1.72		(PE+SO_2) 1.76				

M.E.DayLSD0.05= 0.31. M.E.VarietyLSD0.05= 0.18

Table 8. Changes in decay rate depending on different applications of Güz Gülü and Müşküle grape varieties (%)

Decay Rate (%)									
Variety			Müşküle (Control)		Güz Gülü		Main effect of the days		Main effect of the year
Application			MAP+SO_2	PE+SO_2	MAP+SO_2	PE+SO_2			
2018	Days	15	0.00	0.00	0.00	0.00	15.day	0.00 d	3.49 A
		30	0.94	1.44	1.67	0.83			
		45	2.21	1.83	1.99	1.61	30.day	0.68 cd	
		60	2.65	1.95	3.92	2.88			
		75	2.42	2.25	9.66	4.33	45.day	1.23 c	
		90	4.05	3.19	17.83	16.10			
2019	Days	15	0.00	0.00	0.00	0.00	60.day	1.58 bc	0.40 B
		30	0.00	0.35	0.00	0.18			
		45	0.25	0.40	0.83	0.71	75.day	2.77 b	
		60	0.39	0.20	0.37	0.27			
		75	0.21	0.81	1.55	0.92	90.day	5.40 a	
		90	0.09	0.45	0.83	0.68			
VarietyxApp.			1.10	1.07	3.22	2.38			
Main effect of the variety			1.09 *b*		2.80 *a*				
Main effect of the application			(MAP+SO_2) 2.16		(PE+SO_2) 1.72				

M.E.YearLSD0.05= 0.70, M.E.DayLSD0.05= 1.20. M.E.VarietyLSD0.05= 0.70

Müşküle cultivar was detected on the 90th day. However, in 2019, when the climatic conditions were better, it was observed that the decay remained at an acceptable level with 0.83% and 0.68% for Güz gülü at the end of the storage period.

Prevention of decay by SO_2 treatment was also reported by Fourie (2008), Yazar (2013), Kaşka (1992), Özer and Ayman (1997), Agosto (1998), Özdemir and Dündar (2002) and Castro (2003). Karaçalı (2006) stated that SO_2 application is the most important application in preventing the spread of Botrytis cinerea damage, which causes significant damage to grapes even at low temperatures. He also explained that SO_2 was effective by binding to the proteinic structures in the cells and preventing the growth and proliferation of the agent on the berry surface, but it did not save the contaminated berry.

Berry cracking rate

In the study, it was tried to determine whether the structure of the grapes, which came out of the cold storage with the cracking rate of the berry skin, was deteriorated due to the temperature increase while waiting at room temperature again. Likewise, this situation is important in terms of whether the grapes stored in the cold storage can preserve the integrity of berries after the storage conditions and directly affects their marketability. This is especially important in newly breed varieties with unknown cold storage capability.

As a result of the analysis, " M.E. Year", " M.E. Day" and " M.E. Variety" were found to be statistically significant ($p<0.05$) (Table 9). Variable cracks were observed in Güz gülü variety during the storage period. It is observed that cracking is higher due to the unfavorable climate in 2018. When analyzed on the basis of "M.E. Year", it is seen that the cracking rate in 2018 was higher (4.44%). Although there was no statistical difference between the applications, a lower (2.99%) cracking rate was detected in the PE+SO_2 application numerically. When analyzed on the basis of variety, Güz gülü variety was exposed to cracking in the bark in both years. While it was observed in a very low amount, such

Table 8. Changes in decay rate depending on different applications of Güz Gülü and Müşküle grape varieties (%)

Decay Rate (%)									
Variety			Müşküle (Control)		Güz Gülü		Main effect of the days		Main effect of the year
Application			MAP+SO_2	PE+SO_2	MAP+SO_2	PE+SO_2			
2018	Days	15	0.00	0.00	0.00	0.00	15.day	0.00 d	3.49 A
		30	0.94	1.44	1.67	0.83			
		45	2.21	1.83	1.99	1.61	30.day	0.68 cd	
		60	2.65	1.95	3.92	2.88			
		75	2.42	2.25	9.66	4.33	45.day	1.23 c	
		90	4.05	3.19	17.83	16.10			
2019	Days	15	0.00	0.00	0.00	0.00	60.day	1.58 bc	0.40 B
		30	0.00	0.35	0.00	0.18			
		45	0.25	0.40	0.83	0.71	75.day	2.77 b	
		60	0.39	0.20	0.37	0.27			
		75	0.21	0.81	1.55	0.92	90.day	5.40 a	
		90	0.09	0.45	0.83	0.68			
VarietyxApp.			1.10	1.07	3.22	2.38			
Main effect of the variety			1.09 *b*		2.80 *a*				
Main effect of the application			(MAP+SO_2) 2.16		(PE+SO_2) 1.72				

M.E.YearLSD0.05= 0.70, M.E.DayLSD0.05= 1.20, M.E.VarietyLSD0.05= 0.70

Table 9. Berry cracking rates in SO_2 application of Güz Gülü and Müşküle grape varieties (%)

Berry cracking rate (%)									
Variety			Müşküle (Control)		Güz Gülü		Main effect of the days		Main effect of the year
Application			MAP+SO_2	PE+SO_2	MAP+SO_2	PE+SO_2			
2018	Days	15	0.00	0.00	0.00	0.00	15.day	1.50 d	4.44 A
		30	0.00	0.00	6.74	6.46			
		45	0.00	0.00	14.81	7.93	30.day	2.78 bcd	
		60	0.00	0.00	7.40	9.14			
		75	0.00	0.00	4.50	4.52	45.day	3.85 b	
		90	5.68	3.18	19.25	16.85			
2019	Days	15	0.00	0.00	7.54	4.42	60.day	3.47 bc	2.45 B
		30	0.00	0.00	2.80	6.24			
		45	0.00	0.00	5.67	2.39	75.day	2.19 cd	
		60	0.00	0.00	6.19	5.04			
		75	0.00	10.00	6.49	2.00	90.day	6.86 a	
		90	0.00	0.00	6.32	3.63			
VarietyxApp.			0.47	0.27	7.31	5.72			
Main effect of the variety			0.37 *a*		6.51 *b*				
Main effect of the application			(MAP+SO_2) 3.89		(PE+SO_2) 2.99				

M.E.YearLSD0.05= 0.87, M.E.DayLSD0.05= 1.51, M.E.VarietyLSD0.05= 0.87

Table 10. Changes in sensory evaluation depending on different treatments of Güz Gülü and Müşküle grape varieties

Sensory analyzes									
Variety			Müşküle (Control)		Güz Gülü		Main effect of the days		Main effect of the year
Application			MAP+SO_2	PE+SO_2	MAP+SO_2	PE+SO_2			
2018	Days	15	9.00	9.00	9.00	9.00	15.day	9.00 a	8.58
		30	9.00	9.00	9.00	9.00			
		45	9.00	9.00	9.00	9.00	30.day	9.00 a	
		60	9.00	9.00	9.00	9.00			
		75	9.00	9.00	8.33	9.00	45.day	9.00 a	
		90	7.00	7.00	6.33	6.33			
2019	Days	15	9.00	9.00	9.00	9.00	60.day	8.92 a	8.67
		30	9.00	9.00	9.00	9.00			
		45	9.00	9.00	9.00	9.00	75.day	8.75 a	
		60	9.00	8.33	9.00	9.00			
		75	9.00	8.33	8.33	9.00	90.day	7.08 b	
		90	7.00	7.00	8.33	7.67			
VarietyxApp.			8.67	8.56	8.61	8.67			
Main effect of the variety			8.61		8.64				
Main effect of the application			(MAP+SO_2) 8.64		(PE+SO_2) 8.61				

M.E.DayLSD0.05= 0.28

as 0.37%, in the control variety Müşküle, 6.51% cracking was detected in Güz gülü variety. This situation emerges as the determining factor in determining the preservation performance of Güz gülü variety. Although the flesh of the Güz gülü variety is firm, the very thin structure of the skin, especially in the region around the berry stem, is thought to cause cracking.

Sensory Analyzes

In sensory evaluation, "M.E. Day" was found to be statistically significant ($p<0.05$). The "M.E. Day" remained constant for 45 days as the retention period progressed, and then decreased slightly; It was observed that the sensory analysis scores decreased significantly on 90th day (Table 10). It is seen that the values for 2019 (8.67) are higher. No significant difference was detected in terms of varieties.

Conclusion

In this study, which was carried out in Tekirdağ Viticulture Research Institute, Güz Gülü grape variety was stored in a cold room for 90 days.

As expected, the weight loss increased during the storage period, but did not reach very high levels. Fluctuations were observed in all applications in terms of TSS. In the titration acidity analysis, lower values were observed in the control variety during the storage period, while a fluctuating course was observed in Güz gülü variety. In terms of maturity index, during the storage period, higher values were observed in the control variety compared to the beginning, while a decreasing trend was observed towards the end of the storage period in Güz gülü variety.

In terms of fruit firmness and berry-stalk breaking resistance, decreases were observed in both applications and cultivars compared to the initial values.

When the cluster skeleton color was examined, the closest value to the beginning values at the end of the storage period was seen in the control, while the color change was more in Güz gülü variety. Considering the sensory analysis values, there is a decreasing trend compared to the baseline and the scores between the cultivars are close to each other. In the study, increases in decay rate were observed

during the storage period, and a higher decay rate was detected in Güz gülü variety than in the control. The decay rate of Güz gülü grapes, which were affected by precipitation in 2018, is slightly higher than the decay rates of Müşküle grapes in the first 60-day period. In 2019, both packaging types exhibited a decay rate of less than 1% at the end of the storage period. Therefore, care should be taken in the cold storage of Güz gülü grapes, which are affected by bad climatic conditions in cultivation.

In the study, the berry cracking rate was observed only on the 90th day in 2018 in the control variety, while cracking occurred in Güz gülü variety in both years. It is seen that especially the adverse climatic conditions in 2018 increased the cracking even more. This situation emerges as the determining factor in determining the preservation performance of Güz gülü variety. Regarding the cracking of the skin, it is thought that although the berry of Güz gülü variety is firm, the very thin structure of the skin causes cracking. While there was no significant difference between packaging materials in general, lower values were found in PE packaging in terms of decay and cracking. As a result, it has been determined that Güz gülü grape variety is not suitable for long-term storage due to the cracking of the skin after cold storage in Tekirdağ ecological conditions, and it is affected by adverse climatic conditions such as heavy summer rains and cloudiness. In order to increase the resistance of the berry skin against cracking, it is recommended to apply calcium or berry skin supportive applications. It is thought that it would be useful to examine the changes in market conditions after cold storage, especially in new grape varieties.

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Conflicts of Interest

The authors declare no conflict of interest.

Author Contribution

Author AİT planned conceptualization, data acquisition, laboratory analysis and methodology, C. Ö. contributed to translations, interpretation and editing, G. U. S. carried out laboratory analysis, translations and editing, E. B. contributed to supervision, interpretation and editing. All authors read and approved the final manuscript.

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