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Use of Antimicrobial Modified Atmosphere Packages Against Postharvest Diseases in Table Grapes*

Sofralık Üzümlerde Hasat Sonrası Hastalıklara Karşı Antimikrobiyal Modifiye Atmosfer Ambalajlarının Kullanımı

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Grape, Storage, Quality, Decay, Antimicrobial MAP

ABSTRACT

Objective: In this study, Sultana and Red Globe grape varieties which produced in Alaşehir region of Manisa were examined in order to determine the effects of 5 differents MAPs and these MAPs combinations with SO2 pad and AM pad in 3ºC and %90-95 humidity.

Material and Methods: The products were stored with 5 different modified atmosphere packings. Before storage, microbiological analysis of the products was carried out. At the end of the storage time, weight loss, decayed berries per kg, quality criteria and microbiological analysis results were determined. In addition, at the end of the storage time, decayed berries per kg of the products were determined and compared with the decay rates of the polyethylene packages and antimicrobial packages which were also used in the study. Also, the quality criteria of the products, rachis browning, berries color changing, taste changing were determined.

Results: The antimicrobial package used in the research and the combination of this package with ¼ SO_2 generator and antimicrobial films have been found to affect the quality criteria assessed in the study at different levels but generally reduce product decay.

Conclusion: As a conclusion of the research, it was determined that packages with antimicrobial capability could be used instead of classic polyethylene SO_2 generator combinations.

ÖZ

Amaç: Bu çalışmada, 2017 yılında Manisa Alaşehir bölgesinde üretilen Sultani ve Red Globe çeşidi üzümler, 5 farklı MAP ve bu paketlerin SO2 ve AM pad'ler ile kombinasyonları 3ºC'de ve %90-95 bağıl nemde etkileri incelenmiştir.

Materyal ve Metot: Hasat edilen ürünler ürünler, 5 farklı modifiye atmosfer paketi ile depolanıp ve depolanmadan önce ürünlerin mikrobiyolojik analizleri yapılmıştır. Depolama sonunda kilo kaybı, kilogram başına çürük dane sayısı, kalite kriterleri ve mikrobiyolojik analiz sonuçları belirlenmiştir. Ek olarak depolama süresinin sonunda, kilogram ürün başına çürümüş dane sayısı belirlenip, çalışmada kullanılan polietilen paketlerin ve antimikrobiyal paketlerin çürüme oranları karşılaştırılmıştır. Ayrıca ürünlerin kalite kriterleri olan salkım iskeleti kararması, meyve renginin değişimi, tat değişimleri belirlenmiştir.

Bulgular: Araştırmada kullanılan antimikrobiyal paketin ve bu paketin ¼ SO_2 jeneratörü ve antimikrobiyal filmlerle kombinasyonunun kalite kriterlerini farklı şekilde etkilediği, ancak genellikle ürün çürümelerini azalttığı görülmüştür.

Sonuç: Araştırma sonucunda klasik polietilen SO_2 jeneratör kombinasyonları yerine antimikrobiyal etkiye sahip ambalajların kullanılabileceği belirlenmiştir.

Anahtar Sözcükler:
Üzüm, Depolama, Kalite, Çürüme, Antimikrobiyal MAP

INTRODUCTION

In products, postharvest losses occur due to physiological deterioration and pathological diseases and these losses cause significant economic losses (Kasım et al., 2007). A considerable part of these losses occur during storage. Two important factors are limiting the storage period of table grapes. The first of these is water loss of grapes. The water loss of product causes rachis browning and thus the loss of freshness. However, with high relative humidity during storage, the loss of freshness can be significantly reduced. Moisturizing the storage atmosphere or creating a modified atmosphere (MA) using a suitable cover material is an effective method for this problem. The second important reason for the quality losses of table grapes is that grape berries are susceptible to pathogens. The most important reason for the postharvest quality loss and decay of table grapes is the fungal agents such as *Aspergillus niger*, *Rhizopus stolonifer* (Ehrenb.:Fr.) Vuill, *Penicillium spp*., *Alternaria alternata* (Fr.) Keissler and *Botrytis cinerea* (Pers:Fr.) (Akbudak and Karabulut, 2002). MAPs are used commercially to prevent these losses. It is known that MAPs used in grape preservation, prevent pathological and physiological losses and it affects fruit quality. MAP reduces the weight loss of the product and delays aging by changing the gas composition in the package. Because of these advantages, the MAP is used in the storage process to extend the postharvest life of many fruits and vegetables (Kader, 2002; Thompson, 2003; Hardenburg et al., 2004; Porat et al., 2009; Sabir and Agar, 2010; Laribi et al., 2012). However, the moisture permeability of MAPs may be different for the products, and if not suitable, intense moisture may form in the package, thus increasing the fungal diseases (Shin et al., 2007; Nunes, 2008). In MAP, the decrease of O_2 concentration to a certain level and the increase of CO_2 concentration to a certain level, ensure the protection of the quality of grapes. However, if the gas concentration is above or below the acceptable values, it causes physiological deterioration (Karaca et al., 2014). Because of these reasons, it is very important to select the MAPs correctly for the grapes storage. Otherwise, depending on the storage period, pathological and physiological deterioration can be very significant.

The standard practice to control postharvest decay of grapes worldwide is to fumigate the fruit after harvest with sulfur dioxide gas, either by repeated application of gas in storage rooms or to fumigate packed fruit in polyethylene-MAPs with continuous-release sulfur dioxide generator pads (Karabulut et al., 2004). Problems associated with sulfur dioxide usage are bleaching and other injuries of the rachis and berries. Also, excessive sulfite residues can accumulate in berries after prolonged and frequent fumigation, and issues of gas storage, corrosion of equipment within storage facilities, worker safety, and air quality (Smilanick et al., 1990; Crisosto and Mitchell., 2002). SO_2 applications cause serious residual problems in grapes and it causes various negative effects on people. For this reason, limitations have been placed on SO_2 applications in many countries. Therefore, in the last few years, the search for alternative applications has come to the forefront (Nigro et al., 1998).

This study was carried out in order to determine the effects of 5 different MAPs, one of which is with AM properties and a film with AM properties combined with some MAP implementations on the changes in physiological and pathological deterioration and quality criteria of two different grapes varieties during storage.

MATERIAL and METHODS

Material

Grapes were harvested at the maturity period of the product in Manisa Province, Alaşehir District where the grape production was made intensely and the same day grapes were brought Uludag University Faculty of Agriculture Department of Plant Protection. The grapes were spread on a sterile surface and sunburnt, decayed and injured berries were separated from the healthy grapes. Healthy grapes were randomly packaged.

Five different MAPs were used as study material and these MAPs were used in combination with different sizes of SO_2 and AM pads (Table 1). The SO_2 generator used in the study is Chilean production and the brand name is Proteku. The SO_2 generator measures 33x46 cm and contains 7 grams of sodium metabisulfite ($Na_2S_2O_5$).

Method

Pre-storage microbiological analysis was determined by taking samples before carrying out any treatment. The randomized grapes were placed in perforated pouches, each 1 kg. Five of these randomly selected pouches were placed in MAPs capable of receiving 5 kg of product and placed in a plastic case. Pre-cooled with air until fruit temperature reached 3 °C after the pre-cooling process was finished, the packages were closed with ties. Grapes were stored at 3±0.5 °C and 90-95% relative humidity depending on grape type (43 days for

Table 1. Applications in the study, abbreviations of applications and features of packages
Çizelge 1. *Araştırmadaki uygulamalar, uygulamaların kısaltmaları ve paketlerin* özellikleri

Applications	Abbreviations	Application Format and Feature
MAP PE	PE	Commercially used modified atmosphere (MA) polyethylene (PE) package - Oxygen Gas Permeability (OGP*): 7000 cm^3 m^{-2} 24h
MAP PE + Fruit Bottom-Top AM Film	PE + Bottom-Top AM Film	Antimicrobial (AM) film (with AM effect) 30x40cm sized was placed at the top and bottom of the fruits that inside the MAP PE package.
MAP PE + ¼ SO_2 Generator	PE + ¼ SO_2	¼ sized SO2 generator was placed at the top of the fruits that inside the MAP PE package.
MAP PE +Tam SO_2 Generator	PE +Tam SO_2	1/1 sized SO2 generator was placed at the top of the fruits that inside the MAP PE package (commercial application).
MAP AM	AM	MAP with AM effect. OGP: 1200 cm^3 m^{-2} 24h
MAP AM + Fruit Top AM Film	AM + Top AM Film	AM film (with AM effect) 30x40cm sized was placed at the top of the fruits that inside the MAP AM package.
MAP AM + Fruit Bottom-Top AM Film	AM + Bottom-Top AM Film	AM film (with AM effect) 30x40cm sized was placed at the top and bottom of the fruits that inside the MAP AM package.
MAP TR	TR	MAP - commercial name TR OGP: 4200 cm^3 m^{-2} 24h
MAP PREMIER	PR	MAP - is commercial name PREMIER. OGP: 3500 cm^3 m^{-2} 24h
MAP POINT	PO	MAP - is commercial name POINT. OGP: 3000 cm^3 m^{-2} 24h

*OGP: Oxygen Gas Permeability (cm3 m-2 24h)

Sultana, 72 days for Red Globe). There were 2 studies of Sultana grapes. The first study was established with the products harvested on 20.08.2017 and the second study with the products harvested on 17.09.2017. At the end of the storage time, weight loss, microbiological analysis, decayed berries per kg, quality criteria were determined.

One plastic case (30x50 cm) contains 1 MAP and 1 MAP includes 5x1 kg grapes perforated pouches. Three cases are used for each application.

Weight loss

The weight loss of the applications was determined in the study. For this purpose, the applications which weights were determined before storage were weighed again at the end of the cold storage and their weight loss was determined as a percentage (%).

Before storage, 5000±100gr of net fruits were placed on each case. The applications which weight was determined before storage was weighed after storage and their weight loss was determined as a percentage (%).

Decay development

In the detection of decay, clusters of grapes were removed from the perforated pouches and examined. The decayed berries were separated and counted (number of decayed berries kg^{-1}).

Sensory analysis

Four panelists trained in the discriminative evaluation of table grapes conducted the sensory analysis and 5 perforated pouches in each case were evaluated separately by 4 panelists.

Berry color: Visual index of grapes in perforated pouches: Scale 0-3; %100 white=0 , slightly more than %50 white=1, less than %50 white= 2, %0 white=3 (cause of whiteness index SO_2). The scala was modified from Karabulut et al (2004).

Taste changes: Likes scale 0-3 (0: completely different 1: change exists 2: slight change 3: no change).

Rachis appearance: Likes scale 0-5 (fresh and green=0, green=1, %25 dry=2, %50 dry=3, %75 dry:4 completely dry=5). The scala was modified from Karabulut et al (2004).

Microbiological Analysis

Microbiological analysis of the products used in the experiment was carried out twice for each product (before and after storage). Microbiological analysis of each application was done separately and the aim of this study was to determine the effect of packages, AM films and SO_2 generators on microbial development.

Before storage, 20 berries from Sultana varieties, 10 berries from Red Globe variety were randomly selected and put into the sterile locked bags using sterile gloves, and put into a sterile chamber. 200 ml of sterile distilled water was added to the bags, they were sealed and then shaken at 150 rpm for 15 min. Finally, the bags were opened inside the sterile chamber and 1000 µl samples were taken from the liquid using eppendorf tubes. Serial decimal dilutions were carried out and 100 µl were added to related petri plates.

Potato Dextrose Agar (PDA, Oxoid) was used for the detection of total microorganisms; PDA+ 0.1 g L^{-1} streptomycin sulfate (Oxoid, Sigma-Aldrich) for the detection of total yeast and fungal population; and Tryptone Soy Agar (TSA, Difco)+0.2 g L^{-1} cycloheximide (Actidione, Fluka) for the detection of bacterial population . Petri dishes of 6 cm diameter were used. The 100 µl liquids taken in the eppendorf tubes were placed in petri dishes and then put in the sterile chamber. The petri dishes were incubated at 24 °C for 5-7 days for the total and fungal population; 2-4 days for the bacterial population at 24 °C in the incubator then the microbial populations of samples were determined.

Populations were expressed as colony forming units per fruit (CFU $berry^{-1}$).

Statistical analysis

The study was designed as 3 replications based on the Coincidence Plots Experiment Design and each plastic case was accepted as a replication. The performance of each variety was evaluated during storage separately. The data was subjected to analysis of variance by JMP7 statistical software (SAS Institute Inc. Cary, NC, USA) and differences between means at each sampling data were determined by Duncan's multiple range test ($p \leq 0.05$).

Microbiological analysis incidence data were transformed (square root of the proportion of affected fruit) before analysis.

RESULTS

Weight Loss

Five different MAPs and their applications had different effects on weight loss in grapes during storage. The weight losses are shown in Figure 1 and PE application had the least weight loss in the range of 0.45-1.78% and PO and PR applications had the most weight loss in the range of 2.03-3.71% when all applications were compared. However, despite weight loss, no product had lost its market value.

Decay

After storage, the two different grape varieties (Sultana, Red Globe) were examined. Significant differences were observed of the decayed berries per kg (number of decayed berries kg^{-1}), in MAPs and their applications. The decay levels are given in Figure 2. In all applications, the most frequently detected decayed berries were in PE application, the least decayed berries were in applications that used SO_2 generator.

Figure 1. Weight loss at the end of storage of different grape varieties (%)

Figure 2. Determined decayed berries of different grape varieties (decayed berries kg^{-1})

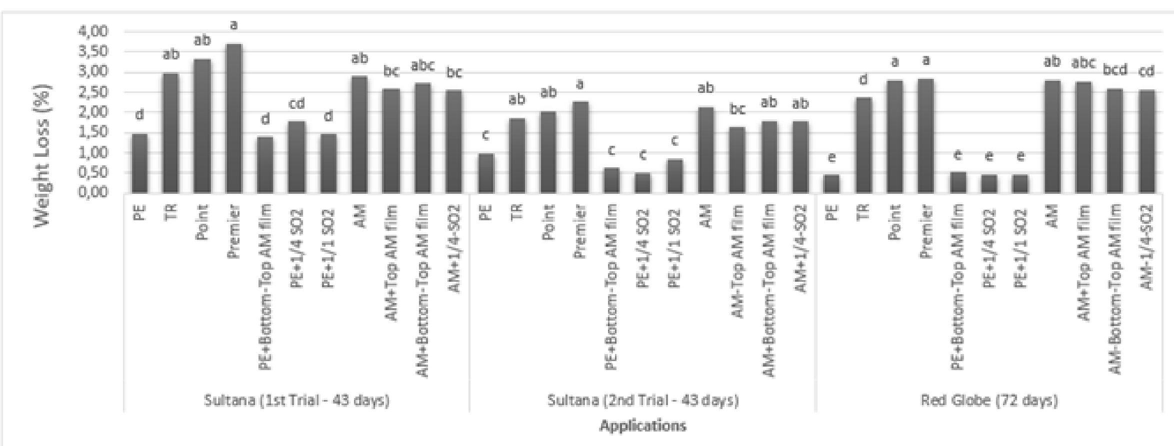

Figure 1. Weight losses at the end of storage time (%)

Şekil 1. *Depolanma sonundaki ağırlık kayıpları (%)*

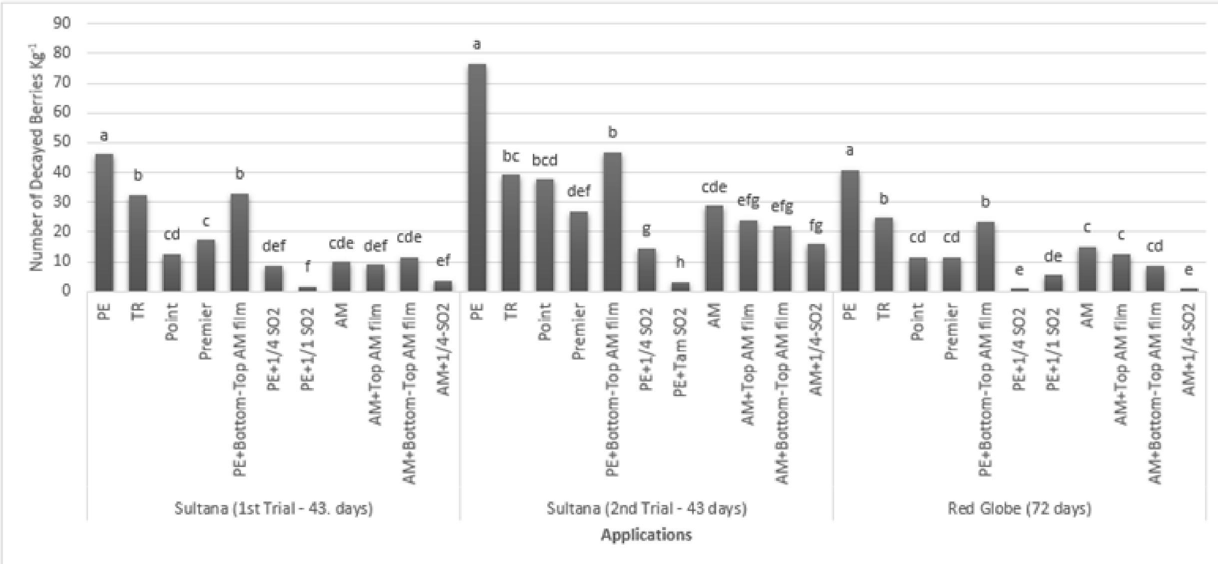

Figure 2. Determined decayed berries at end of the storage (number of decayed berries kg^{-1})
Şekil 2. *Depolama sonunda belirlenen çürümüş dane sayıları (çürük dane kg^{-1})*

Quality Criteria

Grape berries colors

The effects of applications on color change of berries during storage are given in Table 2. The effects of the applications during the storage showed similarity and the effects of berries color were quite limited.

In the first trial of Sultana grapes, there were statistically significant differences in berries colors in TR (2.97), AM+Top AM film (2.90) and AM+Bottom-Top AM film (2.87) applications, in the second trial of Sultana grapes, there were statistically significant differences on berries colors in PE (2.97), PO (2.93), PR (2.97), and AM (2.90) applications.

In Red Globe variety, there were statistically significant differences on berries colors in PE+Bottom-Top AM film (2.97) and AM+Bottom-Top AM film (2.93) applications. In the PE+1/1 SO_2 (2.65) application, the color change was determined more clearly than other applications. Applications other than PE+1/1 SO_2 are not at a level to reduce the market value and quality criteria of the products.

The effects of applications on the taste of the berries during storage are given in Table 2. The effects of different MAPs on fruit tastes were similar and effects have been limited except on the applications that used SO_2. A strong sulfur taste was detected on the applications that used SO_2.

PE+¼ SO_2, PE+1/1 SO_2 and AM+¼ SO_2 applications showed statistically significant differences in change of fruit taste in all two different grapes varieties.

Red Globe grape variety was also found to be statistically different in AM+Bottom-Top AM film (2.47) application.

It was determined that the changes in grape taste was caused by SO_2 generator and that this was at a level that decreased the market value and quality criteria of the product.

Rachis browning

The effects of applications on rachis browning at the end of the storage time are given in Table 2. The effect of the applications on the rachis browning was statistically significant.

In the two grape varieties, statistically, the best result was in PE+1/1 SO_2 application. There were statistically significant differences in the PO, PR, PE+Bottom-Top AM film, AM, AM+Top AM film.

In the first trial of Sultana grapes, there were statistically more occurrences of rachis browning in TR (1.70), AM (1.80) applications. In the second trial of Sultana grapes, there were statistically significant differences in rachis browning in PO (0.80) application.

There was a statistically significant difference in rachis browning in AM+Top AM film (1.23) application in Red Globe variety of grapes.

Table 2. Berries colors, taste change (0-3 scale)* and rachis browning (0-5 scale)** at the end of storage time

Çizelge 2 . *Depolama sonundaki meyve renk, tat değişimi (0-3 skalası)* ve salkım kararması (0-5 skalası)***

Applications	Berries Colors Change			Taste Change			Rachis Browning		
	1. Sultana	2. Sultana	Red Globe	1. Sultana	2. Sultana	Red Globe	1. Sultana	2. Sultana	Red Globe
	(43 days)	(43 days)	(72 days)	(43 days)	(43 days)	(72 days)	(43 days)	(43 days)	(72 days)
PE	3.00 a[x***]	2.97 ab	3.00 a	3,00 a	3,00 a	3,00 a	1.23 bc	0.53 abc	0.33 cde
TR	2.97 ab	3.00 a	3.00 a	3,00 a	3,00 a	3,00 a	1.70 a	0.63 ab	0.80 b
PO	3.00 a	2.93 bc	3.00 a	3,00 a	3,00 a	3,00 a	1.57 ab	0.80 a	0.70 b
PR	3.00 a	2.97 ab	3.00 a	3,00 a	2,93 a	3,00 a	1.27 bc	0.63 ab	0.40 cd
PE+Bottom-Top AM film	3.00 a	3.00 a	2.97 b	3,00 a	2,90 a	3,00 a	1.17 bc	0.57 ab	0.40 cd
PE+¼ SO_2	3.00 a	3.00 a	3.00 a	2,70 b	2,20 c	1,93 c	0.37 ef	0.20 de	0.10 ef
PE+1/1 SO_2	3.00 a	3.00 a	2.65 c	1,43 c	1,70 d	1,47 d	0.00 f	0.05 e	0.00 f
AM	3.00 a	2.90 c	3.00 a	2,8 b	3,00 a	3,00 a	1.80 a	0.27 cde	0.57 bc
AM+Top AM film	2.90 bc	3.00 a	3.00 a	3,00 a	2,93 a	3,00 a	0.93 cd	0.57 ab	1.23 a
AM+Bottom-Top AM film	2.87 c	3.00 a	2.93 b	3,00 a	2,87 a	2,47 b	1.13 c	0.67 ab	0.60 bc
AM+¼ SO_2	3.00 a	3.00 a	3.00 a	2,77 b	2,47 b	1,93 c	0.56 de	0.46 bcd	0.26 def

* Scale of Berries Colors Change; 0-3 (0: 100% white, 1: 50-99% white, 2: 1-49% white 3: No whitening). Scale of Taste Change; 0-3 (0: Taste completely different, 1: Taste high level different, 2: Low level taste different, 3: No taste change).

**Scale of Rachis browning; 0-5 (0: Green and fresh - no drying, 1: Green and matte - no drying, 2: up to 50% brown and no drying, 3: up to 50% brown and dry, 4: 50% More than brown - dry 5: 100% brown and dry)

[x]LSD Test: (P <0.05) There is no statistically significant difference between the same letters at significance level.

*** In each statistical analysis, each column is evaluated according the coincidence plots experiment design

Microbiological Analysis

As the population of microorganism increases during the storage, the amount and percentage of decay increases so microbiological analysis was performed before and after storage for 2 different grapes varieties. The results of the microbiological analysis for two different table grapes varieties are given in Table 3. After storage, the most microorganisms and fungi were detected in PE application and the least microorganisms were detected in which applications were used SO_2 generator (PE+1/1 SO_2, PE¼ SO_2, AM¼ SO_2). The intensity of fungi populations on the surface of the product increases fruit decay during the storage and causes loss of market value.

DISCUSSION

The most common method used for grape storage is fumigation with SO_2 after harvest, in order to prevent the activities of organisms that cause degradation (Söylemezoğlu, 2001). However, SO_2 applications create serious residues on grapes and this leads to various allergic effects in humans. For this reason, SO_2 applications have been limited in many countries. Therefore, in recent years, the study of alternative applications to reduce degradation has come to the fore (Bal, 2011). In this study, different MAPs were compared to the reference product SO_2 generator, some combinations of these packages with AM films and SO_2 generators were tested (Table 1). The results show that AM MAP shows similar values to the commercially used PE package+SO_2 generator combination and AM MAP can be improved further. Regarding weight loss criteria: The most weight loss occurred in PO and PR applications (Figure 1). The least weight loss occurred in PE packaging and combinations. According to Retamales et al (2003) study, the Sultana grape variety was kept at 0 °C for 40 days and it was reported that 1.1% weight loss occurred when the application was PE+SO_2 generator. This result supports the current findings.

Regarding the colors criterion, the effects of the type of packaging used were generally insignificant (Table 2). However, in the applications using the SO_2 generator, bleaching (whitening) was determined on the surface of the berries. The grapes near the SO_2 generator were found to be cracked due to excessive sulfur. SO_2 may cause changes in color and cracks on the berries by entering grape tissues (Crisosto and Mitchell, 2002; Crisosto and Smilanick, 2004; Karaçalı, 2012).

Table 3. The growth of microorganisms at before and end of storage of Sultana (1st and 2nd Trails) and Red Globe varieties
Çizelge 3. *Sultani (1. ve 2. Denemeler) ve Red Globe* çeşidinin *depolanmasından* önce *ve sonrasında mikroorganizma gelişimi*

	cfu berry^{-1}								
	1st Sultana Trail			2st Sultana Trail			Red Globe		
Applications	Total Microorganisms	Fungi	Bacteria	Total Microorganisms	Fungi	Bacteria	Total Microorganisms	Fungi	Bacteria
Before Storage	$8.78x10^{4}$ c^{x*}	$6.39x10^{4}$ c	$1.80x10^{4}$ a	$2.95x10^{4}$ e	$2.18x10^{4}$ e	$1.05x10^{4}$ a	$7.03x10^{4}$ e^{x*}	$4.41x10^{4}$ e	$6.88x10^{3}$ c
PE	$2.34x10^{5}$ a	$2.18x10^{5}$ a	$1.38x10^{4}$ b	$9.75x10^{4}$ b	$1.07x10^{5}$ a	$3.50x10^{3}$ c	$2.09x10^{5}$ a	$1.88x10^{5}$ a	$1.25x10^{4}$ a
TR	$3.68x10^{4}$ d	$2.95x10^{4}$ d	$6.15x10^{3}$ c	$3.10x10^{4}$ e	$2.60x10^{4}$ d	$1.50x10^{3}$ e	$9.75x10^{4}$ c	$6.30x10^{4}$ c	$5.25x10^{3}$ d
Point	$5.55x10^{4}$ cd	$5.15x10^{4}$ cd	$2.60x10^{3}$ fg	$4.75x10^{4}$ c	$3.65x10^{4}$ c	$1.50x10^{3}$ e	$7.90x10^{4}$ d	$5.68x10^{4}$ d	$9.25x10^{3}$ b
Premier	$6.15x10^{4}$ cd	$4.07x10^{4}$ cd	$5.43x10^{3}$ cd	$3.75x10^{4}$ d	$2.15x10^{4}$ e	$2.25x10^{3}$ d	$6.49x10^{4}$ f	$4.08x10^{4}$ e	$3.35x10^{3}$ e
PE+Bottom-Top AM film	$1.34x10^{5}$ b	$1.18x10^{5}$ b	$4.55x10^{3}$ cde	$1.03x10^{5}$ a	$8.85x10^{4}$ b	$4.50x10^{3}$ b	$1.08x10^{5}$ b	$9.55x10^{4}$ b	$4.45x10^{3}$ d
PE+¼ SO_2	$5.88x10^{3}$ e	$5.45x10^{3}$ e	$2.28x10^{3}$ g	$1.08x10^{4}$ ı	$8.40x10^{3}$ h	$1.00x10^{3}$	$5.70x10^{3}$ ı	$1.08x10^{3}$ h	$5.92x10^{2}$ gh
PE+1/1 SO_2	$4.33x10^{3}$ e	$3.38x10^{3}$ e	$9.25x10^{2}$ h	$1.05x10^{3}$ k	$1.50x10^{2}$ j	$5.50x10^{2}$ g	$4.40x10^{3}$ ı	$7.75x10^{3}$ g	$4.40x10^{2}$ gh
AM	$5.00x10^{4}$ d	$4.75x10^{4}$ cd	$3.55x10^{3}$ efg	$1.50x10^{4}$ h	$1.10x10^{4}$ g	$2.00x10^{3}$ d	$4.55x10^{4}$ h	$3.33x10^{4}$ f	$2.18x10^{3}$ f
AM+Top AM film	$4.78x10^{4}$ d	$4.49x10^{4}$ cd	$4.05x10^{3}$ def	$1.90x10^{4}$ g	$1.25x10^{4}$ f	$2.50x10^{3}$ d	$5.35x10^{4}$ g	$4.20x10^{4}$ e	$1.30x10^{3}$ fg
AM+Bottom-Top AM film	$6.43x10^{4}$ cd	$4.53x10^{4}$ cd	$3.55x10^{3}$ efg	$2.35x10^{4}$ f	$1.20x10^{4}$ fg	$2.00x10^{3}$ d	$5.03x10^{4}$ gh	$3.55x10^{4}$ f	$3.10x10^{3}$ e
AM+¼ SO_2	$9.58x10^{2}$ e	$3.65x10^{2}$ e	$3.55x10^{2}$ h	$1.70x10^{3}$ j	$2.30x10^{3}$ ı	$7.00x10^{2}$ fg	$4.10x10^{3}$ ı	$1.08x10^{3}$ h	$2.13x10^{2}$ h

^{x} LSD Test: ($P < 0.05$) There is no statistically significant difference between the same letters at significance level
* In each statistical analysis, each column is evaluated according the coincidence plots experiment design

In the taste criterion, detected sulfur taste in the applications which used the SO_2 generator is a negative factor for the consumer. In grapes which were stored with AM MAP a little taste change was detected. However, it was observed that the taste change disappeared in several minutes after the package was opened. The rachis browning was scaled as 1 (best)-4 (worst) by Retamales et al. (2003) and in Red Globe grapes, which were stored using an SO_2 generator, the mean value was found to be 1.8 in Retamales et al. (2003) study. In the our study, Red Globe grapes which were stored with an SO_2 generator the mean value was found to be 0.33 according to the scale 0: Best, 5: Worst (Table 2). In the two different studies, the results are quite good and support each other. In addition, it has been observed that the rachis browning was prevented in applications which used SO_2 generators. In the rachis browning criterion, it is noted that an SO_2 generator made a positive contribution.

When decay rates were examined, the most decay was determined in PE packaging and the least decay in PE+SO_2 generator combinations and in AM+SO_2 generator combination (Figure 2). AM and AM+Film combinations were found to be better than PE and TR packages in all trials. Microbiological analysis results support these results. In Yalav (2011) study SO_2 generator, thymol, menthol, and UV light were applied to Red Globe variety grapes. The best result in terms of percentage of decay was given by the SO_2 generator application. The percentage of decay in the SO_2 generator application was determined as 5% at the end of the 45th day and 15% at the end of 90th day. Comparing these results with the present study, PE + SO_2 and AM+¼ SO_2 applications showed better results than Yalav (2011) study. We claim that AM+¼ SO_2 application is more effective than thymol, menthol, and UV applications. In the study of Yaldız and Şen (2015) which used the Sultana grape, they tried three different MAPs. The first was SmartPac MAP (containing 4.5 g active $Na_2S_2O_5$); and the second was SO_2 generators placed both under and over the polyethylene packages. The products were stored at -0.5±0.5 °C with 90% relative humidity for 60 days. At the end of 60 days, no decay was observed. According to our study, Yaldız and Şen (2015) study obtained better results but considering the storage temperatures, it is thought that the differences in results were caused by this. It is also important to consider the use of sodium metabisulphite as an antimicrobial substance.

The results of the microbiological analysis, show that in general, combinations of PE package with SO_2 generators, and combinations of AM package with ¼ SO_2 generator or microbial films produced similar results in the 2 grape varieties (Table 3). The population of microorganisms detected in the products which were stored in AM packages were similar to those which were stored with an SO_2 generator.

RESULT

If it is acceptable for users, there will be an extra 1-1.5% weight loss compared to PE package by the end of the storage time, AM package can be used alone or combined with ¼ SO_2 instead of PE package for the storage of Sultana variety for 1 month and for the storage of Red Globe grapes for 2 months. The rate of decay in the AM package and it's combinations is very low compared to the stored grapes without using the SO_2 generator. In this way, the SO_2 generator, which is risky for human health, is not used or only ¼ dose of SO_2 is used in the storage of the products. In addition, in the grapes which used an SO_2 generator during storage, cracking and color changing on berries occured in regions close to SO_2 generator. Use of AM package or films does not cause any cracking or color change.

Safer alternative control methods are needed due to restrictions or prohibitions of chemicals such as SO2 (Wilson et al.1994; Nigro et al. 1998). AM packages and films can also be used for the storage of organically produced products.

This study shows that AM package can be used for the specified time but this could be improved for usage over a more extended period of time in the future.

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