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THE EFFECT OF POMEGRANATE AND GRAPE SEED EXTRACTS ON THE SHELF LIFE OF GOOSE MEAT DURING REFRIGERATED STORAGE

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ABSTRACT
The aim of this study is to investigate the effects of pomegranate and grape seed extracts on the shelf life of goose meat samples stored in refrigerator conditions. Seven different sample groups were created including control (C), pomegranate seed extracts (PSE1, PSE2), grape seed extracts (GSE1, GSE2), and antioxidants (BHA, BHT). Prepared goose meat sample groups were stored under refrigerator conditions for 10 days and lipid oxidation, moisture, pH and color properties were analyzed during this period. The extracts decreased the TBA values of the samples compared to the control group ($P<0.05$). Antioxidative effects of synthetic antioxidants and extracts added to goose meat samples were determined as BHA > GSE2 = GSE1 = PSE2 = BHT > PSE1, respectively. Grape and pomegranate seed extracts have strong antioxidant activity, and it can be recommended that these extracts can be used as natural antioxidants in the preservation of goose meat.
Keywords: Grape seed, shelf life, pomegranate seed, storage stability

NAR VE ÜZÜM ÇEKİRDEĞİ EKSTRAKTLARININ SOĞUK DEPOLAMA SÜRECİNDE KAZ ETİNİN RAF ÖMRÜNE ETKİSİ

ÖZ
Bu çalışmanın amacı, buzdolabı koşullarında saklanan kaz eti örneklerinin raf ömrü üzerine nar ve üzüm çekirdeği ekstraktlarının etkilerinin araştırılmasıdır. Kontrol (C), nar çekirdeği ekstraktları (PSE1, PSE2), üzüm çekirdeği ekstraktları (GSE1, GSE2) ve antioksidanlar (BHA, BHT) içeren yedi farklı örnek grubu oluşturuldu. Hazırlanan kaz eti örnek grupları 10 gün süreyle buzdolabı koşullarında saklandı ve bu sürede lipid oksidasyonu, nem, pH ve renk özellikleri analiz edildi. Ekstraktlar, kontrol grubuna kıyasla örneklerin TBA değerlerini düşürmüştür ($P<0.05$). Kaz eti örneklerine ilave edilen sentetik antioksidan ve ekstraktların antioksidatif etkileri sırasıyla BHA > GSE2 = GSE1 = PSE2 = BHT > PSE1 olarak belirlenmiştir. Üzüm ve nar çekirdeği ekstraktlarının güçlü birer antioksidan aktivite göstermekte olup, kaz etinin muhafazasında doğal antioksidanlar olarak üzüm ve nar çekirdeği ekstraktlarının kullanılması önerilebilir.
Anahtar kelimeler: Üzüm çekirdeği, raf ömrü, nar çekirdeği, depolama stabilitesi

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INTRODUCTION

Goose meat is very appropriate as a nutritional item of sight. It contains all the essential amino acids and a high amount of unsaturated fatty acids (Boz et al., 2019; Guo et al., 2020; Werenska et al., 2021). Goose fat is one of the fittest animal fats, and it is imagined credible for users because of its comparatively low degree of saturated fatty acids (Woloszyn et al., 2020). Goose meat has a higher content of valuable polyunsaturated fatty acids (PUFAs) (Uhlíová et al., 2018; Biesek et al., 2020). As with other types of meat, some negative situations occur during the storage process of goose meat. These include oxidation, color changes, lipolysis, and lipid oxidation. (Li et al., 2022). Lipid oxidations are one of the most significant agents limiting the shelf life of meat (Falowo et al., 2017; Domínguez et al., 2019). Oxidation in meats is affected by the PUFAs present in the phospholipids of the cell membranes of the meats, and they are the basic targets of oxidative rancidity (Ribeiro et al., 2019). Waterfowl meat contains a high rate of UFAs (65–75%). Thus, this meat is more vulnerable to oxidation than the meat of different poultry species (Banaszak et al., 2020; Werenska et al., 2021).

Antioxidants play an effective role in preventing the formation of rancid taste and odor resulting from oxidation. In industrial processes, synthetic antioxidants are generally used to increase the storage time of foods. However, it has been stated by many researchers that some synthetic antioxidants such as BHT, BHA, TBHQ, and PG used in food processing have carcinogenic and teratogenic effects on living organisms (Kaur et al., 2021; Das et al., 2020; Sen and Mandal 2017). For this reason, users mostly prefer natural antioxidants to synthetic antioxidants (Fernandes et al., 2017; Poojary et al., 2017; Putnik et al., 2016).

Pomegranate (*Punica granatum*) is a perennial herb from the Punicaceae family and is generally grown in tropical and subtropical regions (Rahman and Upadhyaya, 2023). In addition to consuming pomegranate fresh, many products such as juice, sour, and wine are produced from pomegranate fruit (Rastogi and Chaturvedi, 2023). Pomegranate seeds constitute a large part of the pulp remaining after the production of these products. The pomegranate is composed of 48% peel and 52% fruit (Akbari et al., 2023) and the fruit of pomegranate is composed of 78% juice and 22% seeds (Nazoori et al., 2023). Pomegranate peel and seed contain punicalagin and its isomers, ellagic tannins, small amounts of punicalin, gallic acid, ellagic acid and ellagic acid glycosides (Dereli et al., 2023). Pomegranate seeds contain a significant amount of bioactive components such as polyphenols and studies have shown that these polyphenols have antioxidant activity (Okumuş et al., 2015; Jing et al., 2012).

Grapes and grape by-products contain many phenolic compounds with antioxidant activity, mostly flavonoids. As a result of the processing of grapes to produce wine and/or grape juice, 25% of the pulp is the stem, 22.5% is the seed and 42.5% is the skin (Kuzminova et al., 2018). Phenolic compounds in the structure of grape seed and/or pulp; monomeric phenols such as catechin, epicatechin, and epicatechin-gallate, and dimeric, trimeric, and polymeric condensed tannins (proanthocyanidin) (Rajeshwaran et al., 2020). Compared to grape skin in terms of flavanols, the grape seed contains much more monomeric, oligomeric, and polymeric flavanols (Dewi et al., 2021).

Studies on various fruit and plant sources with natural antioxidant properties such as grape and pomegranate peel etc. in meat products are available in the literature (Awad et al., 2022; Carpes et al., 2020; Polat Yemis et al., 2019, Aykurt Oğuz et al., 2019). Although there are studies of grape and pomegranate use in meat products, the effects of pomegranate seed and grape seed extracts on goose meat on lipid oxidation have not been studied before. Therefore, this study aimed to evaluate the effects of grape seed extracts from wine, vinegar, and molasses industry wastes and pomegranate seed extracts from pomegranate juice/pomegranate syrup industry wastes on antioxidant and chemical

effects of goose meat during refrigerated storage for 10 days.

MATERIALS AND METHODS

Materials

Goose meat was purchased from a local butcher in Konya, Türkiye. The pomegranate seed (*Punica granatum L.*) and grape seed (*Vitis vinifera L.*) used for the preparation of extracts were purchased from a local market in Konya, Türkiye. BHA (Butylated hydroxyanisole B1253) and BHT (Butylated hydroxytoluene B1215000) were purchased from Sigma Aldrich Chemical Co. St. Louis, (USA).

Methods

Preparation of extracts

The extracts were prepared by methanol–water extraction following the method of Rodríguez-Carpena et al. (2012) with a slight modification. 1500 ml of methanol-water (80:20 v/v) was added to 100 g seeds ground into a powder with the help of a grinder. The mixture was kept at room temperature in a shaking water bath at 150 rpm for 48 hr. It was filtered separately through filter paper (Whatman no.1), and the supernatants were evaporated with a rotary evaporator to remove methanol. Then the extracts were kept in a small (50 ml) sterile bottle at −18 °C until use.

Preparation of goose meats for analysis

The goose meats were minced using a 3-mm plate in a meat grinder (Kitchen Aid, Classic Model, USA). Seven different goose meat treatments were prepared depending on antioxidant addition; Control, no added antioxidant; BHA, including 200 ppm Butylated hydroxyanisole; BHT, including 200 ppm Butylated hydroxytoluene; PSE1, including 500 ppm extract of pomegranate seed; PSE2, including 1000 ppm extract of pomegranate seed; GSE1, including 500 ppm extract of grape seed and GSE2, including 1000 ppm extract of grape seed. For homogeneous mixing of the antioxidant material and goose meat, 5 ml soybean oil + 5 ml distilled water was added to each of the antioxidant material groups separately and mixed with goose meat. The prepared goose meats were wrapped in polystyrene trays with a PVC film (moisture permeability: 8 g/m^2 day; oxygen permeability: 15 cm^3/m^2 day atm) (Cook, Ankara, Türkiye) and stored for 10 days at + 4 °C in a refrigerator. Moisture (%), color, pH, thiobarbituric acid (TBA), and a_w analyses were performed on the 1st, 3rd, 7th, and 10th days of storage.

Moisture analysis

Moisture (%) was determined using the AOAC (2000) methods. A 5 g sample was dried (Nüve EN 500, Türkiye) at 105 ºC for 18 h until constant weight.

pH analysis

pH values were determined with a pH meter (pH 3110/SET WTW, Germany) after blending 10 g of samples with 100 ml of distilled water for 60 sec. in a homogenizer (Homogenizer HG-15D, Wisd, Germany) (Lambooij et al., 1999).

Thiobarbituric acid (TBA) analysis

Lipid oxidation was assessed in goose meat during refrigerated (4 ºC) storage under retail conditions; the oxidative rancidity of meat was determined by measuring thiobarbituric acid. The results were expressed as mg malondialdehyde/ kg extract (AOAC, 2000).

Color measurement

The exterior surface color of all samples was measured using a chromameter (Hunterlab Colourimeter Colourflex) according to the CIELab system. Measurements were made by reading from three different points per sample on each measurement day. The average score of two experiments is recorded. CIE *L**, *a**, and *b** were determined by the method described by Hunt et al. (1991).

Determination of water activity (a_w)

The water activity (a_w) values of the samples were measured using a water activity device (AquaLab Series 3TE, Germany). The samples were placed in the chamber of the device, and the values shown on the monitor were recorded.

Statistical analysis

All the analyses were performed in two repetitions and three parallels. The results were expressed as

means ± standard deviation. The statistical interpretation of results was performed by an analysis of variance (Two-way ANOVA). The statistical analyses were performed by using the MINITAB release 16.0 program. Duncan Multiple Comparison Tests were used to determine the differences among the means at a 95% significance level (Snedecor and Cochran, 1980).

RESULTS AND DISCUSSION

Proximate composition

Used in this study the meat has a total protein content of 18.97% fat content of 29.0% and a moisture level of 48.0%. It was determined that the effects of extracts (Table 1) and storage time (Table 2) on the chemical properties of goose meats. The moisture content of goose meats varied between 48.00% and 49.13%. The results of the effects of storage on moisture were not statistically important (Table 2) (P>0.05). Moisture results related to storage were indicated at 48.02 and 49.41. It was found that there was no statistically significant difference (P>0.05) in moisture content between day 1st and day 10th of storage. Similarly, the a_w of goose meat did not change depending on storage and extracts, and the difference was not statistically significant (P>0.05). This can be explained by the fact that seed extracts can protect muscle fibers and reduce moisture loss.

Table 1. Effect of extracts on *L*, a*, b**, pH, moisture, TBA and a_w

Factor	*L**	*a**	*b**	*pH*	*Moisture (%)*	*TBA (mg MA/kg)*	a_w
Control	58.90^{ab} ± 2.84	13.07^{abc} ± 2.77	12.16 ± 1.06	6.19 ± 0.19	48.00±0.89	0.14^{a}± 0.05	0.98± 0.01
BHA	59.49^{a} ± 2.56	12.31^{c} ± 2.28	13.25 ± 1.03	6.22± 0.39	48.90±1.95	0.11^{d}± 0.03	0.96± 0.01
BHT	58.80^{ab} ± 3.03	13.49^{a}± 3.05	12.75 ± 0.97	6.21± 0.18	48.96±1.13	0.12^{c}± 0.03	0.98± 0.01
PSE1	54.10^{b}± 3.78	12.21^{c} ± 2.31	13.21± 1.37	6.13± 0.19	49.13±1.85	0.12^{b}± 0.03	0.98± 0.01
PSE2	58.35^{ab} ± 1.41	13.38^{ab}± 2.77	12.08± 1.01	6.14± 0.20	48.70±1.23	0.12^{c}± 0.04	0.99± 0.01
GSE1	57.86^{b} ± 2.98	12.43^{bc}± 0.09	14.01 ± 9.72	6.13± 0.20	48.79±1.76	0.11^{c}± 0.04	0.99± 0.01
GSE2	58.45^{ab}± 3.16	12.60^{abc} ± 1.95	11.93 ± 1.42	6.08± 0.14	48.94±0.76	0.11^{c}± 0.03	0.99± 0.01

$^{a–c}$ Means within columns with different superscript letters are significantly different (P<0.05).
(BHA: Butylated hydroxyanisole (200 ppm); BHT: Butylated hydroxytoluene (200 ppm); PSE1: Pomegranate seed extract (500 ppm); PSE2: Pomegranate seed extract (1000 ppm); GSE1: Grape seed extract (500 ppm); GSE2: Grape seed extract (1000 ppm).

Sengun et al., (2021) found that vinegar from grapes has a devastating impact on meat proteins and reason decrement in moisture from meat structure. Serdaroglu et al., (2015) used various fruit extracts as marinates for fish margination, and the moisture of the samples marinated with pomegranate juice was detected as the lowest during the preservation time. It has been found in studies that fruit vinegar causes moisture changes in meat caused by acidity. Since fruit juice affects pH, it can be said that it has an effect on the amount of moisture. However, since the fruit seed extracts did not differ in terms of pH in this study, they had no effect on the moisture of the meat.

Lipid oxidation (TBA)

Lipid oxidation is a highly complex set of free radical reactions that occur between fatty acids and oxygen, resulting in oxidative degradation of lipids, also known as rancidity. Lipid oxidation or rancidity means that hydroperoxides are formed. Different oxygenated products are produced during lipid oxidation, which may have a significant impact on the quality of meat products during storage (Alirezalu et al., 2019). The TBA tests define the grade of the secondary oxidation products produced by lipid oxidation (Lorenzo et al., 2018). It was determined the effect of extracts and storage day on TBA results was statistically important (P<0.05) (Tables 1 and 2). The highest TBA level (0.14± 0.05 mg malonaldehyde/kg sample) belongs to the control. PSE and GSE decreased the TBA level. The minimum TBA level (0.11 mg malonaldehyde/kg sample) belonged to samples that had GSE1, GSE2, and

BHA. Table 1 shows that the extracts used reduce lipid oxidation like artificial antioxidants.

Table 2. Effect of storage day on *L**, *a**, *b**, pH, moisture, TBA, and a_w

Storage days	*L**	*a**	*b**	*pH*	*Moisture (%)*	*TBA (mg MA/kg)*	a_w
1st	58.20^{b} ± 1.83	11.08^{d} ± 1.44	13.10 ± 1.01	6.09^{b}± 0.03	49.41± 1.47	0.08^{c}± 0.01	0.98^{b}± 0.01
3rd	58.29^{a} ± 2.16	12.11^{c} ± 2.01	13.69 ± 7.35	6.10^{b}± 0.04	48.95± 1.81	0.11^{b}± 0.01	0.99^{b}± 0.01
7th	55.27^{c}± 2.32	14.83^{a} ± 1.69	12.50 ± 1.27	6.07^{b}± 0.20	48.71± 1.02	0.16^{a}± 0.02	0.98^{c}± 0.01
10th	60.22^{a} ± 2.10	13.11^{b}± 2.92	11.79 ± 0.98	6.37^{a}± 0.31	48.02± 1.62	0.16^{a}± 0.03	0.99^{a}± 0.01

$^{a–d}$ Means within columns with different superscript letters are significantly different (P<0.05).

As seen in Figure 1, while the highest TBA was observed in the control group on the 1 day of storage, the lowest TBA was determined in the sample groups treated with PSE2 and GSE2. TBA counts of all samples increased on the 3rd day of storage and the highest TBA was observed in the control group, the difference between TBA counts of the other samples was not statistically significant (P>0.05). On the 7th day of storage, the highest TBA was again observed in the control group, and the lowest TBA was observed in the sample group treated with BHA and GSE1. The highest TBA was observed on day 7th of storage in sample groups treated with BHT, PSE1, PSE2, and GSE2. On the 10th day of storage, the highest TBA was observed in the control group, while the lowest TBA was observed in the sample groups treated with BHA and GSE2. After the TBA of the sample groups treated with BHT, the TBA of the sample groups treated with PSE1, PSE2, and GSE1 come. The difference between the TBA of these groups was not statistically significant (P>0.05). The degree to which antioxidants prevent oxidation of goose meat samples was determined as BHA > GSE2 = GSE1 = PSE2 = BHT > PSE1, respectively. These findings are in agreement with previous results using plant extracts in meat products regarding the decrease of lipid oxidation during storage (Chauhan et al., 2019; Bellucci et al., 2021; Jayawardana et al., 2019).

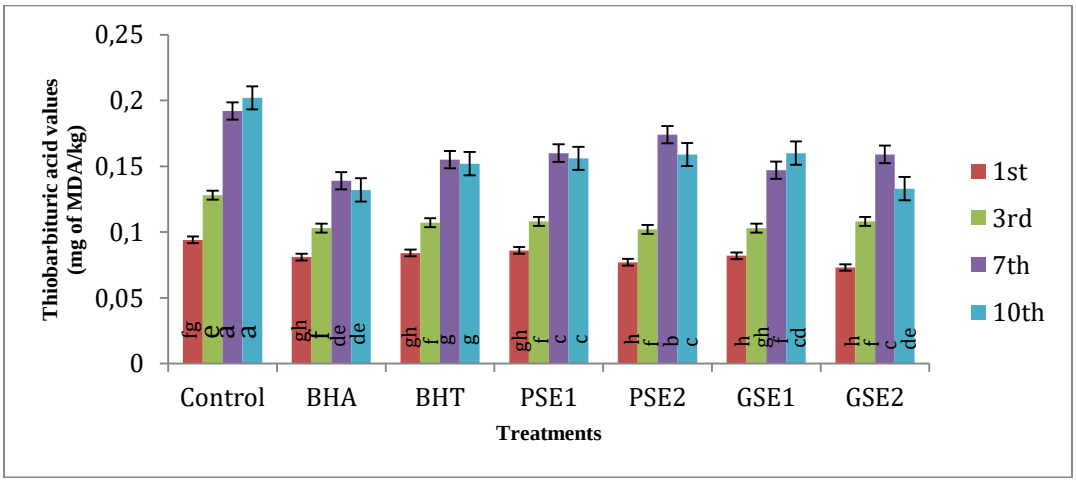

Figure 1. Different treatment x storage interaction of TBA (mg of MDA/kg) values of goose meat samples. The letters on the bars show significantly different (P<0.05) between means. BHA: Butylated hydroxyanisole (200 ppm); BHT: Butylated hydroxytoluene (200 ppm); PSE1: Pomegranate seed extract (500 ppm); PSE2: Pomegranate seed extract (1000 ppm); GSE1: Grape seed extract (500 ppm); GSE2: Grape seed extract (1000 ppm).

In a study conducted by Yerlikaya and Şen Arslan (2021), the oxidation of samples that had propolis and lavender was lower than the control sample and this result shows that propolis and lavender can be used to decrease or prevent lipid oxidation in chicken sausages. Peanut skin extracts minimized lipid oxidation in chicken patties on 15th days of storage at 1 °C (Munekata et al., 2015). Extracts of grape pomace obtained from the winemaking industry incorporated in chicken patties have a lower TBA than control samples (Carpes et al., 2020). Pomegranate extract treatments in chicken meat reduced lipid oxidation by up to 7th days better than the product with ascorbic acid (Ordaz-Rodríguez et al., 2022). Green tea extract reduced lipid oxidation and discoloration without deteriorating the sensory attributes of chicken patties (Passos et al., 2022).

There are many studies on meat and meat products. However, studies on goose meat are limited. For this reason, studies on chicken meat, which is the closest sample to goose meat, were compared. Extracts from grape and pomegranate seeds are thought to show strong antioxidant activity.

Hunter color and pH determination

Color values and color stability are significant sensory parameters of meat and meat products that affect all relevance of consumers (Zhang et al., 2022). According to Table 1, the highest *L** value was observed in the samples treated with BHA, while the lowest *L** value was observed in the goose meats treated with PSE1 and GSE1. During storage, the highest *L** values were observed on the 3rd and 10th days of storage, while the lowest *L** values were observed on the 7th day.

The highest *a** values were observed in the samples treated with BHT while the lowest *a** values were observed in the groups treated with BHA and PSE1 (Table 1). During storage, the highest *a** value was observed on the 7th day of storage, while the lowest *a** value was observed on the 1st day (Table 2). The *b** values do not have statistical significance ($P>0.05$) depending on the storage and extracts.

According to Figure 2, *L** values of all sample groups; showed a slight increase overall on the 3rd day of storage except for BHT-treated sample groups. The lowest *L** values of all sample groups were measured on the 7th day of storage, and the highest *L** values were measured on the 10th day of storage. When the *a** values of the sample groups were examined during the storage period, the highest *a** values for all sample groups were observed on the 7th day of storage, the groups except the control group and the treated BHT sample. The highest *a** values were measured on the 10th day of storage in the control group and BHT-treated sample groups. The *a** values of all sample groups were higher than on the 10th day of storage, except for the PSE1-treated sample groups. In the sample group treated with PSE1, the lowest *a** value was observed on the 10th day of storage. It is not desirable for goose meat to change in color depending on storage. Therefore, the treatment with the least variation provides a positive effect. Therefore, PSE 2, GSE2 for *L** closest to control among treatments; PSE2 for *a**; for *b**, all treatments were given (Table 1).

Unal et al. (2022) marinated chicken meat with citric acid, lemon, and grapefruit reported that the *L** and *b** values increased significantly ($P<0.01$) compared to the control group. Unal et al. (2020) marinated chicken and turkey meat with diverse juices and observed that the highest *L** and *b** parameters for chicken breast meat were in the pomegranate juice group, at 51.21 and 16.01, respectively. The highest *a** value was in the group marinated with black mulberry juice, at 15.53. Kim et al. (2014) reported that chicken breast treatment with soy sauce solution showed lower *L** and higher *a** and *b** due to the color of the soy sauce. Serdaroglu et al. (2007) reported that the highest *L** and *b** values were 63.1 and 9.2 for the group using 100% grapefruit juice, respectively; the *a** value was 2.3 for the group using 0.5 M citric acid. In literature and this study, the difference in color values was thought to be due to the difference in pigments from the fruits and fruit seeds.

As shown in Table 1, the pH of the control sample was 6.19 and the sample had BHA the

highest pH value of 6.22. The pH differed from 6.07 to 6.37 in storage days. The highest pH can be seen on day 10th of storage (Table 2). GSE reduced the pH of goose meat (Table 2).

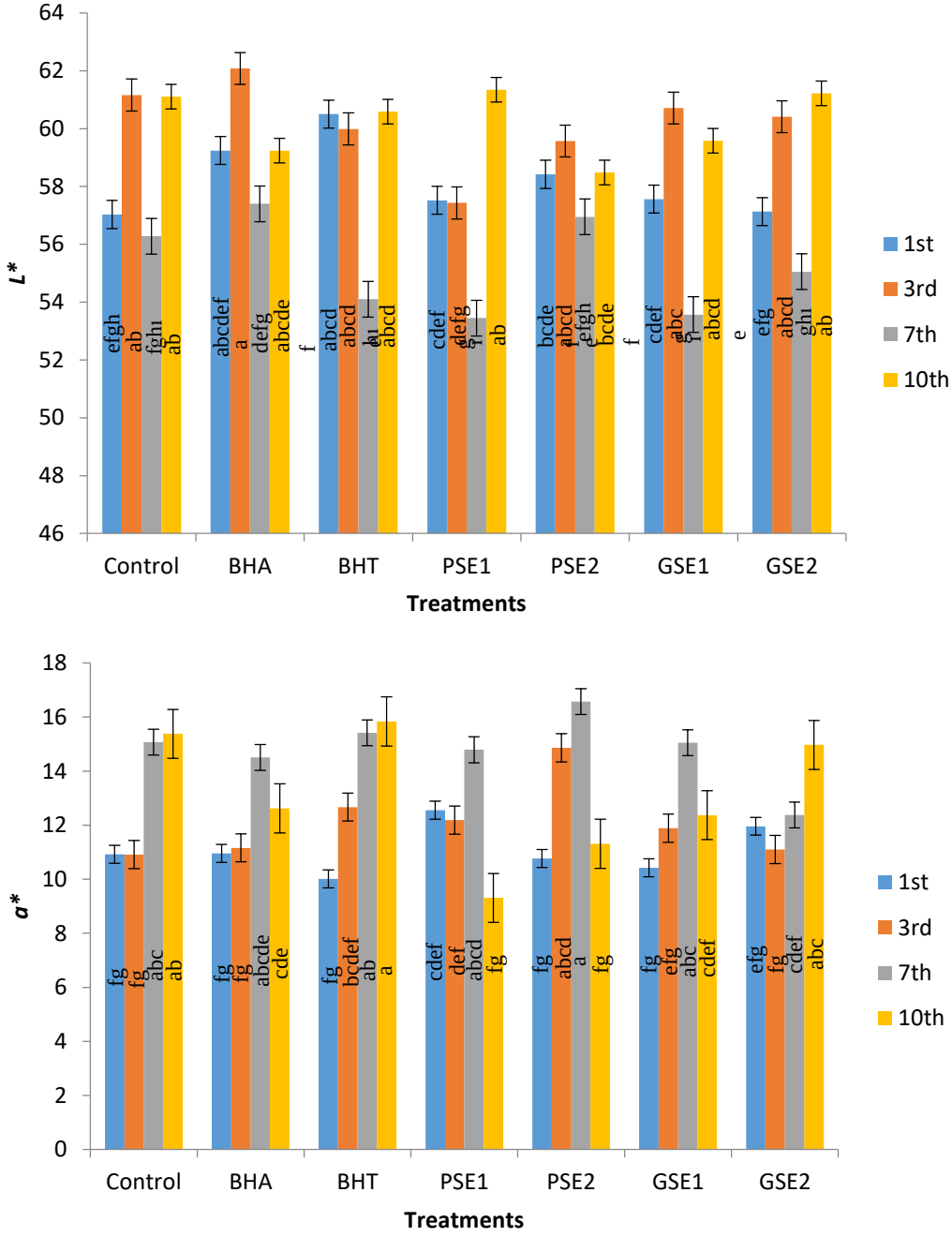

Figure 2. Different treatment x storage interaction of *L** and *a** values of goose meat samples. The letters on the bars show significantly different ($P<0.05$) between means. BHA: Butylated hydroxyanisole (200 ppm); BHT: Butylated hydroxytoluene (200 ppm); PSE1: Pomegranate seed extract (500 ppm); PSE2: Pomegranate seed extract (1000 ppm); GSE1: Grape seed extract (500 ppm); GSE2: Grape seed extract (1000 ppm).

According to Figure 3, pH values of all sample groups, except PSE2 and GSE2 treated sample groups, showed a high increase overall on day 10 of storage. In addition, the pH of the samples treated with PSE2 and GSE2 was not affected much by the storage period. The highest pH was measured during the 10th day of storage in the BHA-treated sample groups. In the sample group treated with BHA, the lowest pH was observed during the 7th day of storage.

In a study conducted by Tänavots et al., (2018), four different treatments on the pork were prepared using white wine vinegar, apple vinegar, mustard honey, and kefir, and the pH values were determined as 3.0, 3.1, 3.9, and 4.5, respectively. Kargiotou et al., (2011) reported that the pH values of raw beef prepared with soy sauce and red wine were ranging between 3.60 and 4.74. These studies indicated that the pH and total acidity of meats might change depending on the treatment matter.

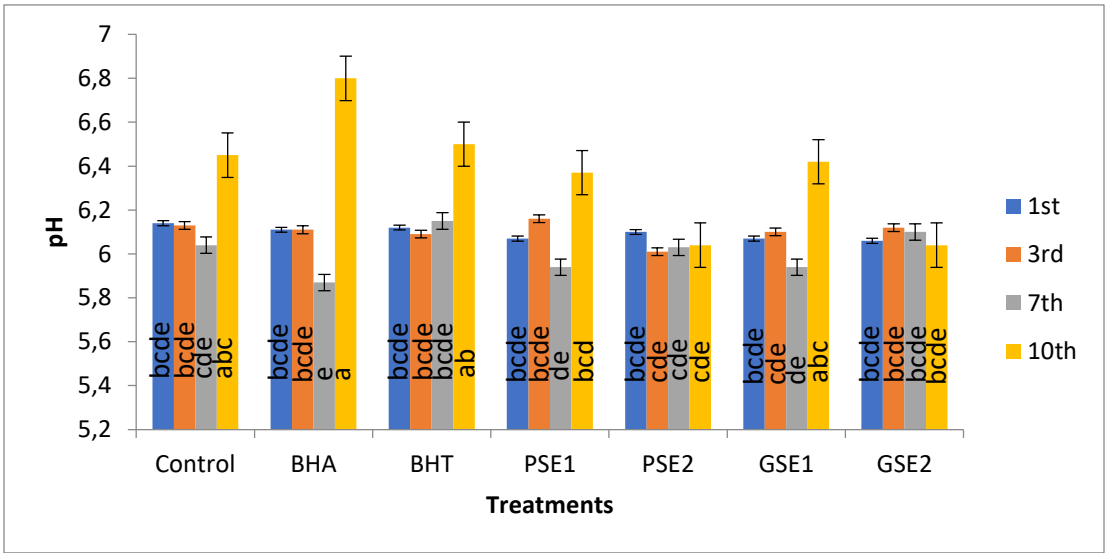

Figure 3: Different treatment x storage interaction of pH values of goose meat samples. The letters on the bars show significantly different (P<0.05) between means. BHA: Butylated hydroxyanisole (200 ppm); BHT: Butylated hydroxytoluene (200 ppm); PSE1: Pomegranate seed extract (500 ppm); PSE2: Pomegranate seed extract (1000 ppm); GSE1: Grape seed extract (500 ppm); GSE2: Grape seed extract (1000 ppm).

CONCLUSIONS

The study indicated that pomegranate seed and grape seed extracts improved the storage quality of goose meats during refrigerated storage for the 10th day. The extract dealing did not influence the moisture and b^* values of the samples. The lowest TBA values were found in the samples with the grape seed extracts. The seed extracts had a significant effect on the lipid oxidation of goose meats over the 10th day. It could be suggested that grape seed and pomegranate seed, which are industrial residuals, are used as a native safeguard in meats, but also studies are needed on extracts, acquired by distinct extraction methods, and used with diverse supplement grades and forms (essential oil, powder, etc.), to obtain better conclusions in meat products.

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CONFLICTS OF INTEREST

The authors have declared no conflicts of interest in this article.

AUTHOR CONTRIBUTIONS

Fadimana Arı: Investigation; Methodology, Analysis. Cemalettin Sarıçoban: Conceptualization; Investigation; Funding

acquisition; Methodology; Writing – review & editing; Formal analysis; Data curation; Supervision; Resources. Hulya Sen Arslan: Writing – original draft, Validation; Visualization; Analysis, Writing – review & editing.

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