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Effects of rosehip sauce on chemical, oxidative and sensorial quality of marinated anchovy (*Engraulis Encrasicolus* Linnaeus, 1758)

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Abstract

Marinated anchovies are of economic importance in Turkey. However, natural antioxidants affecting quality of marinated anchovies are rarely addressed. The purpose of this study is to compare olive oil and rosehip sauce as fillers in anchovy marinades. The study investigated the effects of rosehip sauce on the quality of marinated anchovies stored at 4°C. Anchovy were marinated with 4% acetic acid and 12% NaCl, put into plastic jars, filled with either olive oil or rosehip sauce and stored at 4°C. Changes in sensory attributes were determined during the process, and the following chemical parameters were monitored: total phenolic content (mg/100 g GAE), total volatile basic nitrogen (mg/100 g), pH, peroxide value (meq/kg) and thiobarbituric acid (mg MDA/kg). Values of total volatile basic nitrogen (TVB-N), peroxide value (PV) and thiobarbituric acid (TBA) increased during the storage. Higher values of TVB-N, TBA and PV were found in samples with olive oil than those with rosehip sauce. Samples with rosehip sauce demonstrated better oxidative stability. Rosehip sauce samples had higher appearance, odor, color and texture scores than olive oil samples.

Keywords: fish marinades; marinated anchovy; olive oil; quality changes; rosehip sauce; sauces

Introduction

Recently, functional foods or food supplements have attracted global attention because of the relationships between food and health that can protect people from oxidative stress and various diseases (Losso, 2003). The food industry is also focused on developing natural and minimally processed food products that have a positive impact on the nutritional status of the population. Lipid oxidation causes undesirable changes in the taste, texture, smell, and appearance of foods as well as loss of nutritional value (Gallego *et al.*, 2013; Horbanczuk *et al.*, 2019). In addition, oxidative degradation of lipids is a direct threat to human health because it damages biological membranes, enzymes and proteins (Malheiro *et al.*, 2013; Yang, *et al.*, 2016). These quality losses caused by lipid oxidation are prevented in many foods by using synthetic antioxidants, such as butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA) and propyl gallate (PG) because of their low cost and high oxidative stability (Kebede and Admassu, 2019; Yang, *et al.*, 2016). However, concerns about the use of synthetic antioxidants have increased due to their health effects (Cordeiro, *et al.*, 2013; Gallego, *et al.*, 2013; Yang, *et al.*, 2016).

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Owing to their non-potential toxicities, natural antioxidants, which are more reliable and have no side effects, are preferred more than synthetic antioxidants (Demir *et al.*, 2014; Kapadiya, *et al.*, 2016). A great number of herbs and spices have the potential to delay lipid oxidation during food storage, usually mediated by the intrinsic antioxidant activities of their constituents. Lately, the use of natural antioxidants has increased in the food industry, and many studies have been reported on the subject (Delfino *et al.*, 2021; Demir et al, 2014; Mahdavi and Ariaii, 2021; Messina *et al.*, 2021; Özdemir *et al.*, 2022; Rathod *et al.*, 2021; Saati *et al.*, 2022; Sengun *et al.*, 2019; Trabelsi *et al.*, 2021).

As with other food technologies, there has been a growing interest in using natural food additives to improve the flavor and extend shelf life of semi-preserved foods, such as marinades (Ochrem *et al.*, 2021). One of these natural antioxidants is rosehip. It is a fruit and member of the Rosaceae family which contains high amounts of vitamin C, minerals, phenolic compounds, tocopherols, flavonoids as well as carotenoids (Atalar *et al.*, 2020; Demir and Özcan, 2001; Demir *et al.*, 2014; Saricaoğlu *et al.*, 2019). The antioxidant property of rosehips is due to its polyphenols (anthocyanins, ferulic acid, gallotanins, gallic acid and ellagic acid). These polyphenols neutralize free radicals, stop oxidation and microbial growth, and reduce the risk of certain cancers and cardiovascular diseases (Demir *et al.*, 2014; Kilinc *et al.*, 2020; Nadpal *et al.*, 2016; Saati *et al.*, 2022).

Owing to a slightly sour taste of its fresh fruit, rosehip is generally consumed in dried form as well as processed and consumed in tea, jam, nectar, fruit pulp, and marmalade (Ercişli, 2007; Özdemir *et al.*, 2022). In addition, some researchers suggested that rosehip could be used as a functional food and natural colorant in food technology (Rosu *et al.*, 2011).

Anchovy (*Engraulis encrasicolus*), a pelagic fish species belonging to the Engraulidae family, is an important economic resource for the Mediterranean as well as Turkey. In 2020, anchovy, with 171.253 tons, ranking first among the species, was obtained by hunting, and is of great importance in Turkey's fisheries (General Directorate of Fisheries and Aquaculture [GDFA], 2022). Most of the anchovy captured are used for human consumption in fresh, salted, marinated and frozen states. Some reports have been published on marinated anchovy (Fıçıcılar and Genccelep, 2020; Gökoğlu *et al.*, 2009; Olgunoğlu *et al.*, 2009; Testa *et al.*, 2019; Topuz *et al.*, 2014). However, no study has been conducted on the effect of rosehip sauce on anchovy. The main objective of the present study was to study the effect of rosehip sauce on chemical, oxidative, and sensorial quality of marinated anchovy fish fillet during refrigerated storage.

Material and Methods

Raw material

Frozen anchovy (*Engraulis encrasicolus* Linnaeus, 1758) was purchased at the fish market of Elazığ city in Turkey and transported to the laboratory in ice. The fish were thawed in water. The temperature of the water was controlled at 20 ± 1°C. The head, bones and internal organs were removed and fillets obtained. The fillets were washed under tap water and drained.

Rosehip sauce preparation

The rosehip sauces were obtained from rosehip fruit *(Rosa canina* L.), picked manually in the region of Southeastern Anatolia (Elazığ, Turkey) and brought to the laboratory; the fruits were washed and drained. The covers of the drained fruits were peeled manually, and ½ L of water was added for every 1 kg of rosehips and boiled for 30 min. The rosehip fruits were taken in a strainer and macerated manually. The mixture was boiled until the densest puree consistency was obtained. The hot rosehip sauce was transferred and stored in tightly closed sterile glass bottles. The bottles were left to cool and stored at room temperature until used in the next experimental stage.

Marination and sauce process

Fish fillets were marinated using 4% acetic acid and 12% NaCl. The fillets were placed in plastic containers and marinade solution was added till the fillets were fully immersed in a fish fillets–marinade solution ratio of 1:1.5. The fillets were kept in marinade solution for 72 h at 4 ± 1°C to complete the marinating process.

After the marinating stage was completed, the fillets were removed from the solution, filtered, divided into two batches of 50 g each, and packed in sealed plastic containers. To the first batch (OO batch), 20 mL of virgin olive oil was added, and 60 g of rosehip sauce was added to the second batch (RS batch). The samples were then stored at 4 ± 1°C and analyzed on the 0, 7th, 14th, 28th, 42nd, and 56th days to determine changes in product quality.

Physical and chemical analysis

All measurements were made in duplicate and analyzed on the 0, 7th, 14th, 28th, 42nd and 56th day to determine changes in product quality. On day 56, physical and chemical analysis was not performed because sensory deterioration occurred in the olive oil group. The pH values of the samples were determined by using a digital pH meter

(EDT GP 353) after being homogenized in distilled water in the ratio 1:10 (w/v) according to the method described by Association of Official Analytical Chemists (AOAC, 1990). The total phenolic content (TPC) was determined according to the method described by Duan *et al.* (2006), which used Folin–Ciocalteu reagent. Total phenolics were estimated as gallic acid equivalent (GAE). The total volatile basic nitrogen (TVB-N) was determined by the distillation method described by Antonacopoulos and Vyncke (1989) and expressed as mg TVB-N per 100-g muscle. The value of thiobarbituric acid (TBA) was determined simple spectrophotometric method reported by Tarladgis *et al.* (1960) and the results were expressed as milligram of malondialdehyde per kilogram of flesh. Peroxide value (PV) analysis was achieved by the method described by the American Oil Chemists Society (AOAS, 1994) and expressed in milliequivalent of peroxide oxygen per kilogram of fat.

Sensory analysis

The sensory quality of the marinated fish was evaluated by eight experienced panelists. Panelists scored the products for sensory characteristics, such as appearance, odor, color, texture, and general acceptability, using a 5-point hedonic scale, with the following quality scores: 5 indicated 'very good' quality, 4 indicated 'good' quality, 3 for 'acceptable', and a score of 1–2 indicated "spoiled" fish (Kurtcan and Gönul, 1987).

Statistical analyses

All measurements were performed in duplicate. Data were subjected to analysis of variance (ANOVA) using the SPSS statistical package version 22.0 (IBM, USA). All data were expressed as mean ± standard deviation (mean ± SD). Duncan's multiple range test was used for comparison of mean values. Differences between the mean values of treatments and storage period were determined by the least significant difference (LSD) test, and statistical significance was defined as $p < 0.05$.

Results and Discussion

Changes in Total Phenolic Content

Phenolic compounds have antioxidant properties (Castelo-Branco and Torres, 2011). The quantity of phenolic compounds is used as a parameter for determining antioxidant activity (Williams *et al.*, 2004). The TPC of each sample was estimated, and contributed significantly to the overall antioxidant activity. Changes in the TPC of samples are shown in Figure 1. Rosehip sauce had a higher TPC (105.98±1.96 mg/100 g GAE) than olive oil (42.60±0.55 mg/100 g GAE). In this study, a significant difference ($p < 0.05$) in TPC values was observed between rosehip sauce and olive oil samples during storage. Although there was a decrease in the total amount of phenolic compounds in both groups during storage, no measurement was made because sensory deterioration occurred in the olive oil (OO) group on 56th day. A significantly ($p < 0.05$) lower antioxidant activity was observed in olive oil, while the highest antioxidant activity was observed in rosehip sauce (RS) group. It was observed that the addition of rosehip sauce formulation increased TPC and antioxidant activity values of marinated anchovy.

TVB-N and pH Changes in Marinated Anchovy

Total volatile basic nitrogen is a traditional chemical method used widely for evaluating the degree of

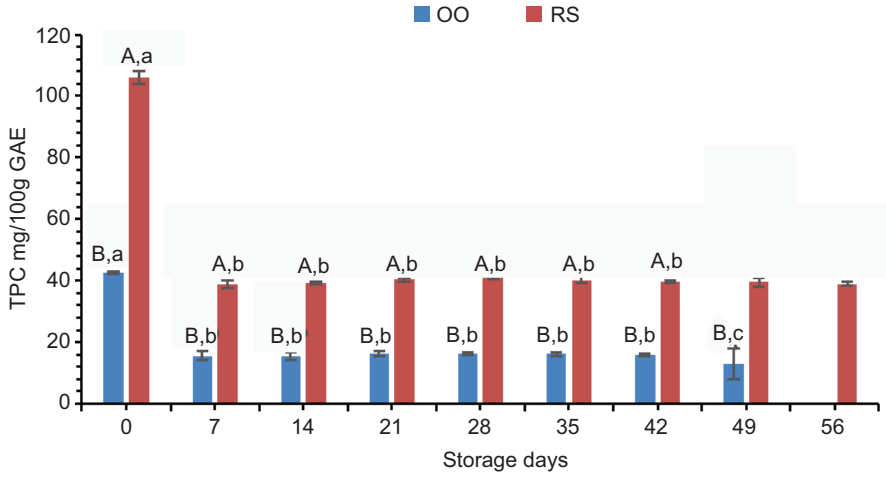

Figure 1. Changes in the total phenolic content of anchovy marinades preserved in rosehip sauce and olive oil. Values labeled with upper letters are significantly different ($p < 0.05$) between groups, and those labeled with lower letters are significantly different ($p < 0.05$) between days (OO: olive oil; RS: rosehip sauce).

microorganism spoilage in seafood (Sallam *et al.*, 2007). Although the concentration of TVB-N in fresh fish is typically between 5 and 20 mg/100 g, the general limit of acceptability is 30–35 mg/100 g flesh (Connell, 1990; Huss, 1988; Kim *et al.*, 2002; Lopez-Caballero *et al.*, 2000). These values can vary greatly depending on whether the fish is fresh or processed (Dalgaard, 2000). The TVB-N values of marinated anchovy fillets treated with olive oil (OO) and rosehip sauces (RS) are shown in Figure 2. TVB-N value was 7.33±0.41 mg/100 g at the end of marinating process in both groups, and an increase ($p < 0.05$) depending on time in both groups during storage is shown in Table 1. Higher TVB-N values were found in control samples, compared to those treated with sauce during the storage.

Rosehip sauce had the highest effect on the reduction of TVB-N production. Although the control sample reached the maximum acceptable freshness limit of 35 mg/100 g fish fillets on the 49th day of storage, other samples with rosehip sauce were still below this limit. This indicated that rosehip sauce had significant effect on decrease of TVB-N content in marinated fish. This could be due to phenolic content or acidic property of rosehip sauce (Demir *et al.*, 2014; Nadpal *et al.*, 2016; Özdemir *et al.*, 2022; Saricaoğlu *et al.*, 2019; Stralsjö *et al.*, 2003; Uggla *et al.*, 2003; Wenzig *et al.*, 2008). Similar increase during storage was reported in the previous studies as well (Aksu *et al.*, 1997; Essid *et al.*, 2020; Gökoğlu *et al.*, 2009; Korkmaz *et al.*, 2021; Topuz *et al.*, 2014). It was reported that the TVB-N value of 8.97 mg/100 g in marinated anchovy increased to 36.27 mg/100 g during the storage of 100 days (Topuz *et al.*, 2014). In another report, TVB-N value in marinated anchovy increased from 9.8 mg/100 g to 14 mg/100 g during storage of 8 months at 4°C (Dokuzlu, 2000).

Changes in the pH values of marinated samples are shown in Figure 3. At the beginning of storage period (day 0), pH of marinated anchovy was 4.13±0.04 and increased during storage in parallel with time in both olive oil- and rosehip sauce-treated samples. Significant differences ($p < 0.05$) were observed between both olive oil and rosehip sauce treatments. At the end of 56 days of storage, pH was determined as 5.56±0.20 for RS group. However, since sensory deterioration occurred in olive oil-treated anchovy fish, no measurement was conducted.

Changes in lipid oxidation products

The oxidative quality of marinated anchovy was determined by peroxide value (PV) and thiobarbituric acid (TBA) analysis. Hydroperoxides, known as primary oxidation products, were determined by PV analysis. PV, which is an indicator of oxidation in oils, is a measure of the amount of active oxygen in oils (Farag *et al.*, 2021; Gordon, 2004; Zhang *et al.*, 2021). Changes in PV of the marinated samples are shown in Figure 4. Within the scope of this study, PV on day 0 for both groups was 2.14±0.07 meg/kg, with a significant rise with time, particularly in the olive oil (OO) group ($p < 0.05$). At the end of storage, PV was observed as 9.60±0.29 meg/kg in the rosehip-treated group, but the analysis was not performed because sensory deterioration occurred in the olive oil-treated group. Although an increase was observed in the peroxide value of both groups during storage, comparative increase in the rosehip sauce group

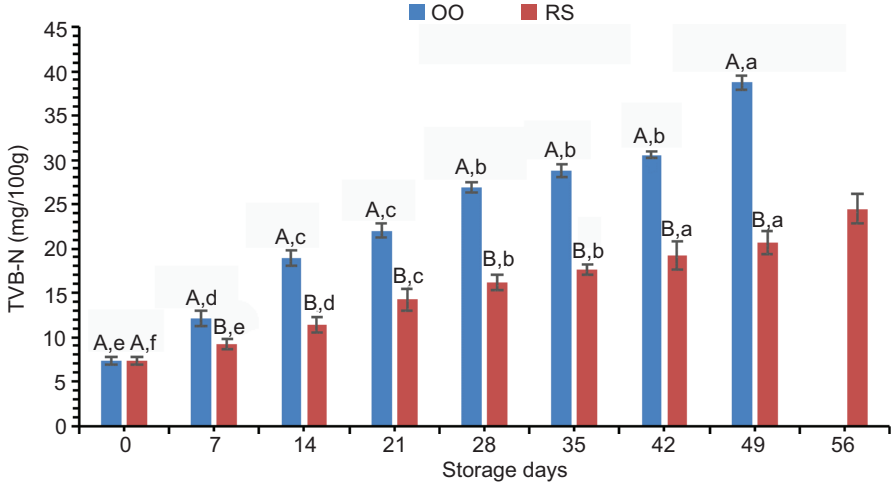

Figure 2. Changes in TVB-N values of anchovy marinades preserved in rosehip sauce and olive oil. Values labeled with upper letters are significantly different ($p < 0.05$) between groups, and those labeled with lower letters are significantly different ($p < 0.05$) between days (OO: olive oil; RS: rosehip sauce).

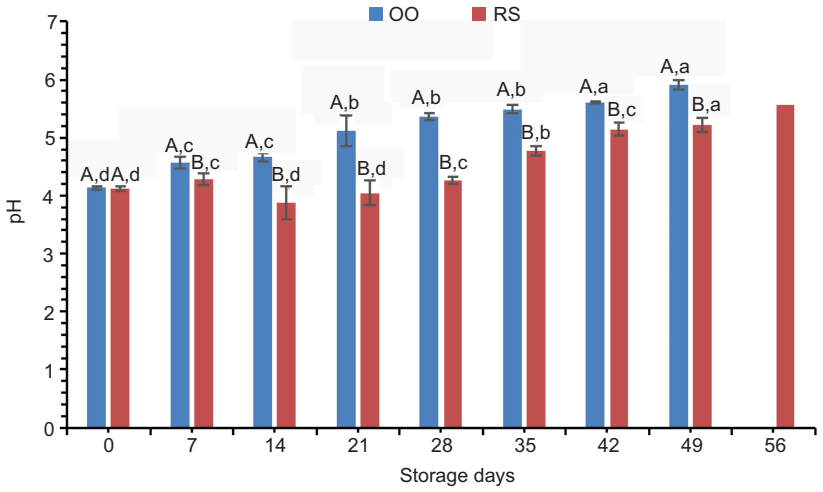

Figure 3. Changes in pH values of anchovy marinades preserved in rosehip sauce and olive oil. Values labeled with upper letters are significantly different ($p < 0.05$) between groups, and those labeled with lower letters are significantly different ($p < 0.05$) between days (OO: olive oil; RS: rosehip sauce).

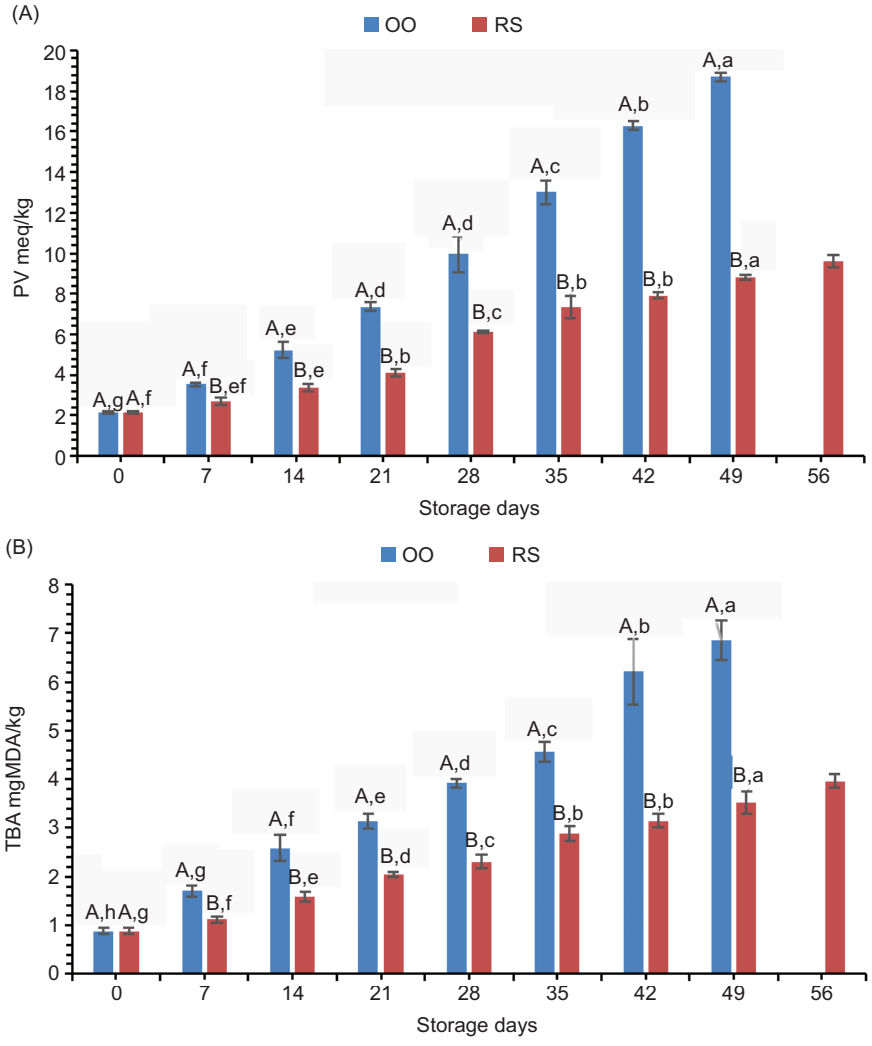

Figure 4. Changes in PV and TBA values of marinated anchovy fillets treated with olive oil–rosehip sauces during refrigerated storage at 4°C. Values labeled with upper letters are significantly different ($p < 0.05$) between groups, and those labeled with lower letters are significantly different ($p < 0.05$) between days (OO: olive oil; RS: rosehip sauce).

was lower. It was emphasized by Hras *et al.* (2000) that rancidity in oils starts when their peroxide value exceeds 20 meq/kg. In the light of these results, it was determined that the rosehip sauce-treated samples had a consumable value of 56 days whereas the olive oil-treated samples could be consumed up to the 49th day. Similarly, Olgunoğlu *et al.* (2009) and Topuz *et al.* (2014, 2016) reported that peroxide values of anchovy marinades increased during storage.

Secondary oxidation products generated by hydroperoxide decomposition were determined by TBA measurement. It has been suggested that a maximum TBA value, indicating the good quality of the fish, is 5 mg MA/kg, while the maximum allowable TBA level is considered as 7–8 mg MA/kg (Sallam *et al.*, 2007). Changes in the TBA values of treatment groups are shown in Figure 4. On the first day of marination, the TBA values of anchovy fillet were 0.88±0.07 mg MA/kg. The TBA values of all samples increased gradually during the 56 days of storage. The TBA value of the control sample varied between 0.88 mg MA/kg and 6.85 mg MA/kg ($p < 0.05$), while the TBA value of the rosehip sauce-treated sample varied between 0.88 mg MA/kg and 3.97 mg MA/kg ($p < 0.05$). The data demonstrated that TBA values of rosehip sauce-treated anchovy marinades were within the limits of good quality after 56 days of storage whereas the TBA values of olive oil-treated anchovy marinades were within consumable limits only up to 49 days.

Rosehip is widely used as a natural antioxidant substitute because of anthocyanins, ferulic acid, gallotanins, gallic acid, and ellagic acid (Atalar *et al.*, 2020; Demir *et al.*, 2014; Nadpal *et al.*, 2016; Özdemir *et al.*, 2022; Su *et al.*, 2007; Yi *et al.*, 2007).

Sensory attributes

Effects of rosehip sauces on the sensory properties of marinated anchovy are presented in Table 1 Sensory scores of both samples decreased significantly ($p < 0.05$) throughout the storage period. The sensory evaluation of marinated samples in terms of appearance, odor, color, texture, and general acceptability was conducted by panelists. Although the panelists gave good scores at the first evaluation of both samples after maturation, all sensory properties demonstrated a decreasing trend with storage time. However, higher valuation in terms of appearance, odor, color, and taste for the rosehip sauce-treated samples ($p<0.05$) was observed, compared to the olive oil-treated samples. On the last day of storage (56th day), the rosehip sauce group retained its good quality characteristics, while sensory deterioration was observed in the olive oil-treated group. The results of the present study demonstrated that rosehip sauce had positive effects on

Table 1. Changes in sensory scores of marinated anchovy during storage at 4°C.

Storage time (day)	Appearance		Odor		Color		Texture		Overall acceptability	
	OO	RS	OO	RS	OO	RS	OO	RS	OO	RS
0	$5.00\pm0.00^{A,a}$	$5.00\pm0.00^{A,a}$	$5.00\pm0.00^{A,a}$	$5.00\pm0.00^{A,a}$	$5.00\pm0.00^{A,a}$	$5.00\pm0.00^{A,a}$	$5.00\pm0.00^{A,a}$	$5.00\pm0.00^{A,a}$	$5.00\pm0.00^{A,a}$	$5.00\pm0.00^{A,a}$
7	$5.00\pm0.00^{A,a}$	$5.00\pm0.00^{A,a}$	$5.00\pm0.00^{A,a}$	$5.00\pm0.00^{A,a}$	$4.70\pm0.00^{B,b}$	$5.00\pm0.00^{A,a}$	$4.80\pm0.45^{B,a,b}$	$5.00\pm0.00^{A,a}$	$4.88\pm0.21^{A,a}$	$5.00\pm0.00^{A,a}$
14	$4.80\pm0.55^{B,b}$	$5.00\pm0.00^{A,a}$	$4.80\pm0.45^{B,b}$	$5.00\pm0.00^{A,a}$	$4.40\pm0.45^{B,a,b}$	$5.00\pm0.00^{A,a}$	$4.80\pm0.45^{B,a,b}$	$5.00\pm0.00^{A,a}$	$4.70\pm0.33^{B,a,b}$	$5.00\pm0.00^{A,a}$
21	$4.40\pm0.15^{B,b}$	$5.00\pm0.00^{A,a}$	$4.20\pm0.55^{A,b,c}$	$4.70\pm0.15^{A,a}$	$4.30\pm0.5^{B,b}$	$4.80\pm0.45^{A,b}$	$4.40\pm0.55^{B,b}$	$5.00\pm0.00^{A,a}$	$4.33\pm0.45^{B,b}$	$4.87\pm0.12^{A,a,b}$
28	$4.20\pm0.84^{A,c}$	$4.40\pm0.55^{B,b}$	$4.00\pm1.00^{A,c}$	$4.40\pm0.55^{A,b}$	$4.00\pm0.00^{A,c}$	$4.40\pm0.55^{B,b}$	$3.60\pm0.19^{A,c}$	$4.40\pm0.55^{B,a,b}$	$3.95\pm0.13^{B,c,d}$	$4.40\pm0.19^{A,b}$
35	$4.00\pm0.71^{A,c}$	$3.80\pm0.45^{B,b,c}$	$3.40\pm0.15^{A,d}$	$3.80\pm0.45^{B,b,c}$	$4.00\pm0.00^{B,c}$	$4.00\pm0.71^{A,b,c}$	$3.20\pm0.15^{B,d}$	$4.00\pm0.00^{A,b}$	$3.65\pm0.45^{B,c}$	$3.90\pm0.33^{A,c}$
42	3.20 ± 0.05^{Bd}	3.40 ± 0.55^{Ac}	3.00 ± 0.00^{Be}	3.20 ± 0.45^{Ac}	3.40 ± 0.15^{Bd}	3.80 ± 0.84^{Ac}	$2.80\pm0.15^{B,e}$	$3.20\pm0.45^{A,c}$	$3.00\pm0.15^{B,d}$	$3.40\pm0.55^{A,d}$
49	$2.00\pm0.15^{B,e}$	$3.00\pm0.05^{A,d}$	$2.00\pm0.11^{A,B,f}$	$3.00\pm0.00^{A,d}$	$2.40\pm0.55^{B,e}$	$3.40\pm0.55^{A,d}$	$2.10\pm0.05^{B,f}$	$3.00\pm0.45^{A,c}$	$2.13\pm0.5^{B,e}$	$3.10\pm0.45^{A,e}$
56	SS	2.10 ± 0.15^{e}	SS	2.00 ± 0.00^{e}	SS	2.00 ± 0.00^{e}	SS	2.00 ± 0.15^{d}	SS	2.02 ± 0.15^{f}

N = 8; the values represent±standard errors.
OO: olive oil; RS: rosehip sauce; SS: sensory spoilage.
Values labeled with upper letters are significantly different ($p < 0.05$) between groups, and those labeled with lower letters are significantly different ($p < 0.05$) between days.

the sensory criteria of marinated anchovies. Decrease in the sensory scores of marinated anchovies with increase of storage period was also reported by Gökoğlu *et al.* (2009), Topuz *et al.* (2014) and Trabelsi *et al.* (2021).

Conclusıon

Our results clearly demonstrated that deterioration in oxidative and chemical quality was significantly delayed in marinated anchovy treated with rosehip sauces, compared to the control sample. Rosehip sauce prevented loss in chemical quality and lipid oxidation of marinated anchovy. It was also observed that rosehip sauce was able to delay chemical changes, and had a positive effect on the appearance, odor, color, texture, and general acceptability of fillets, and extended their shelf life. Thus, considering that the consumer preference is for natural antioxidants and preservatives, rosehip sauce, being a natural antioxidant, could be used as a preservative, antioxidant, and flavoring additive in fish marinades, such as anchovy marinades. The study established the potential benefits of using rosehip sauce as a natural antioxidant in the preservation of different marinated seafood to meet both consumer preferences for natural additives and need of the food industry for effective preservation methods.

Conflict of Interest

The authors declared no conflict of interest for this article.

Author Contributions

Gülderen Kurt Kaya: investigation, methodology, project administration, software and writing of original draft. Özlem Emir Çoban: investigation, methodology, software and writing of original draft. Reşit Bilici: investigation, methodology, software, and writing of original draft.

Data Availability

The data that supported the findings of this study are available from the corresponding author upon reasonable request.

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