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Research Article

Combined Use of Laurel Essential Oil and Vacuum Packing to Extend the Shelf-Life of Rainbow Trout *(Oncorhynchus mykiss)* Fillets

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Abstract

In this study, the effect of the combined use of different concentrations of laurel essential oil (1%, 2%) and vacuum packing on the shelf-life of rainbow trout during cold storage was investigated. Laurel essential oil was applied on trout fillets by spraying. In 14 days of storage, the changes in the microbiological (total viable counts, total psychrotrophic bacteria, *Pseudomonas,* lactic acid bacteria, *Enterobacteriaceae,* coliforms), chemical (TVB-N, pH) and sensory quality characteristics were observed. Upon microbiological, chemical and sensory analyses, it was found that 2% laurel essential oil delayed microbial spoilage in vacuum-packed rainbow trout, thereby extending shelf-life for approximately 4 days and enhancing sensory characteristics. Therefore, it has been concluded that the combined use of laurel essential oil and vacuum packing is promising in extending the shelf-life of seafood and may be used in food industry. Further, the use of laurel essential oil as an alternative to synthetic additives may be recommended for providing microbial safety hence extending shelf-life of other meat and meat products.

Keywords: *Rainbow trout, Essential oil, Laurel, Shelf-life, Vacuum packing*

Gökkuşağı Alabalığı *(Oncorhynchus mykiss)* Filetolarının Raf Ömrünü Uzatmak İçin Defne Esansiyel Yağı ve Vakum Paketlemenin Birlikte Kullanımı

Öz

Bu çalışmada farklı konsantrasyonlarda defne esansiyel yağı (%1, %2) ve vakum paketlemenin kombine kullanımının soğuk muhafaza boyunca gökkuşağı alabalıklarının raf ömrününe etkisi araştırılmıştır. Defne esansiyel yağı, alabalık filetolarına püskürtme şeklinde uygulanmıştır. 14 günlük depolama süresince mikrobiyolojik (toplam bakteri, toplam psikrotrofik bakteri, *Pseudomonas,* laktik asit bakterisi, *Enterobacteriaceae,* koliform), kimyasal (TVB-N, pH) ve duyusal kalite özelliklerindeki değişiklikler izlenmiştir. Yapılan mikrobiyolojik, kimyasal ve duyusal analizler sonucunda %2 defne esansiyel yağının vakum paketlenmiş gökkuşağı alabalığı filetolarında mikrobiyal bozulmayı geciktirerek raf ömrünü yaklaşık olarak 4 gün uzattığı ve duyusal kalite özelliklerini arttırdığı belirlenmiştir. Bu nedenle defne esansiyel yağı ve vakum paketlemenin kombine kullanımının deniz ürünlerinin raf ömrünün uzatılmasında umut verici olduğu ve gıda endüstrisinde kullanılabileceği sonucuna varılmıştır. Ayrıca diğer et ve et ürünlerinin mikrobiyal güvenliğin sağlanması ve dolayısıyla raf ömrünün uzatılması için sentetik katkı maddelerine alternatif olarak defne esansiyel yağının kullanımı önerilebilir.

Anahtar sözcükler: *Gökkuşağı alabalığı, Esansiyel yağ, Defne, Raf ömrü, Vakum paketleme*

INTRODUCTION

Global fish production peaked at about 171 million tonnes in 2016. With relatively static capture fishery production, decreased wastage and increase in aquaculture, 88% of the total fish production was for direct human consumption. This production reached a record level in 2016 with a consumption rate of 20.3 kg per capita [1].

Fish and fish products are globally appreciated throughout the world due to their high nutritional value and delicious taste. Therefore, it is very important in the international fishing industry to ensure the safety of edible fish [2]. However, due to microbiological growth and lipid oxidation, fish and other seafood are among the most rapidly perishable food products. Combined with consumers' interest in natural products that are free of chemical preservatives,

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it is quite difficult to provide safe and high-quality seafood. Therefore, there has been a growing interest in the antioxidant and antimicrobial effects of natural preservatives such as essential oils as an alternative to synthetic additives to enhance the oxidative and microbial stability of food and to increase shelf-life [3].

Most consumers demand food without artificial and harmful chemicals including those used as antimicrobial substances and preservatives. Therefore, there has been a growing interest in more natural and non-synthesized antimicrobial substances as an alternative to antimicrobial substances conventionally used for extending shelf-life of food and struggling against foodborne pathogens. Aromatic plants and their components have been researched as potential preventors of bacterial growth, and the majority of such properties have been attributed to essential oils and other secondary plant metabolites. Essential oils obtained from different sources are commonly recommended due to their potential antimicrobial properties [4].

Bay laurel *(Laurus nobilis)* essential oil (EO) has been acknowledged to have a broad range of potential application areas including health and food, as an antiseptic, antidiarrheal, antimycotic, antimicrobial, antiinflammatory, antioxidant and anticarcinogenic substance [5]. Microbial spoilage is very fast and easy in fresh and slightly processed food products such as fish and meat. There has been a growing demand for natural products as an alternative to synthetic food additives [6]. Preservation methods employing natural products have become a focus of interest for researches, thus many studies have been conducted especially to extend the shelf-life of fish and other seafood [6-11].

Vacuum packing involves placing a product into a film with low permeability, removing the air from the package and applying a hermetic seal. It has been shown that vacuum packing extends the shelf-life of food for six days or longer. On the other hand, although rancidity does not develop due to extended period of storage, undesired smell and taste due to bacterial activity may occur [12]. Therefore, this study investigates the potential use of laurel EO in varying concentrations (1%, 2%) for extending the shelf-life of vacuum-packed rainbow trout.

MATERIAL and METHODS

Plant Material

Laurel leaves were freshly collected at Samandağ district, Hatay, Turkey and dried. The dried laurel leaves were ground in a mechanical grinder for extracting the EO. The laurel oil was obtained by performing water steam distillation on ground leaves in a Clevenger apparatus (Wisd-Wise Therm). For this aim, 50 g grinded sample was placed in a round bottom flask and 500 mL distilled water was added, which was then placed in the Clevenger apparatus. The EO obtained after a 3-h distillation process was preserved in closed dark colored bottles at 4°C until use in the tests.

Determination of Volatile Components

Gas Chromatography-Mass Spectrometer (GC-MS) Analysis was conducted in East Anatolia High Technology Application and Research Center, Atatürk University. The analysis of the EO was performed using a Thermo-Finnigan Trace GC/ Trace DSQ /A1300 (EI quadrapole) (Thermo-Finnigan, San Jose, CA) equipped with an SGE-BPX5 MS capillary column (Scientific Instrument Services Inc., Ringoes, NJ) (30 m x 0.25 mm i.d., 0.25 ím). For GC-MS detection, an electron ionization system with an ionization energy of 70 eV was used. Helium was the carrier gas, at a flow rate of 1 mL/min. Injector and MS transfer line temperatures were set at 220 and 290°C, respectively. The program used was 50-150°C at a rate of 3°C/min, held isothermal for 10 min, and finally raised to 250°C at 10°C/min. Diluted samples (1/100, v/v, in methylene chloride) of 1.0 microliter were injected and in the splitless mode. The components were identified on the basis of the comparison of their relative retention time and mass spectra with those of standards, Wiley7N, TRLIB library data of the GC-MS system, and literature data [13]. The quantitative data were expressed as area percent. The results were also confirmed by comparison of the compounds elution order with their relative retention indices on nonpolar phases reported in the literature [13].

Sampling and Packing

Rainbow trout fillets each weighing approximately 100 g were supplied from a local sales center in Kars. The samples were brought into the laboratory under cold chain conditions and immediately taken into cold storage in a cooled incubator and the packing process was initiated immediately. A total of 3 testing groups were formed in this study. In order to form the control group, the fillets were packed in a vacuum machine (Henkelman, mini Jumbo, Istanbul-Turkey) in polyamide film bags (BC Vakum Ambalaj, Istanbul) without any treatment. For the laurel group, 5 mL laurel EO in concentrations of 1% and 2% in distilled water with 0.2% Tween 80 was applied on the fillets by spraying, which were then vacuum packed in the same way as the control group. The entirety of the samples was stored at 4°C, and the microbiological, chemical and sensory analyses were conducted on days 0, 2, 4, 6, 8, 10, 12, 14 of cold storage.

Microbiological Analysis

For microbiological analyses, 10 g of each sample was collected and weighed under aseptic conditions and transferred into stomacher bags, 90 mL sterile physiologic saline solution was added and homogenized in the stomacher for 2 min. After preparing the decimal dilutions of the samples, the inoculation was made to microorganism-specific media by pour plate and streak plate methods.

For total viable counts, plate count agar (Oxoid CM 325) was incubated at 30°C for 48 h; for total psychrotrophic bacteria, plate count agar (Oxoid CM 325) was incubated at 7°C for 10 days; for *Pseudomonas* spp, pseudomonas agar base (Oxoid CM 559) and C-F-C supplement (Oxoid SR 103) were incubated at 30°C for 48 h; and for lactic acid bacteria (LAB), de man rogosa sharpe agar (Oxoid CM 361) was incubated at 30°C for 3-5 days; for *Enterobacteriaceae*, violet red bile glucose agar (Oxoid CM 485) was incubated at 35°C for 48 h; for coliform group bacteria, violet red bile lactose agar (Oxoid CM 107) was incubated at 37°C for 24 h; and for fecal coliform group bacteria, violet red bile lactose agar (Oxoid CM 107) was incubated at 44.5°C for 24-48 h [14].

Chemical Analysis

Determination of Total Volatile Basic Nitrogen (TVB-N): Determination of TVB-N was performed according to the method of Antonocopoulus [15]. For this aim, approximately 10 g homogenized sample was weighed in 0.1 mg sensitive analytical balance and transferred into the tubes of the Kjeldahl apparatus, and approximately 1 g magnesium oxide and 100 mL distilled water were added. In an Erlenmeyer flask, 10 mL 3% boric acid and eight drops of methyl-red were added, then completed with an average of 100 mL distilled water and placed on the distillate collection section of the distillation unit. The distillation was continued until 200 mL liquid accumulated. Then, the distillate collected was titrated with 0.1N hydrochloric acid until color change.

pH Measurement: 10 g fish sample of each group was weighed and homogenized with 100 mL distilled water. The pH value of the homogenizate was measured by a digital pH meter (Thermo-Orion 3 Star).

Sensory Analysis

The sensory assessment of the fish fillets was performed by 4 academics at the Kafkas University, Department of Food Hygiene and Production, and the Department of Food Engineering in the Faculty of Engineering and Architecture. The sensory analysis was performed on days 0, 2, 4, 6, 8, 10, 12 and 14 of storage by modifying *(Table 1)* the Quality Index Method (QIM) recommended by Bonilla et al.[16]. In the sensory analysis table, 0 indicates very fresh fish whereas gradually increasing values indicate spoilage based on the period of storage.

Statistical Analysis

The tests were repeated three times and the averages were calculated and transformed into the $\log_{10}$ base. The data obtained was examined by one-way analysis of variance (ANOVA). In the evaluation of the differences among the groups, the Least Significant Difference (LSD) test was used. The statistical analyses were performed in the SPSS 20 software package.

Table 1. *Quality index method scheme*

Quality Parameter			
Skin	Brightness	Bright, shining	0
		Slightly dull	1
		Dull	2
	Mucus	Thin, transparent	0
		Slightly thick, dull	1
		Thick, yellowish	2
Meat	Texture	Firm	0
		Slightly soft	1
		Very soft	2
	Blood	Bright red, none	0
		Pale red, dull	1
		Clouded, brown	2
	Smell	Fresh	0
		Seaweed	1
		Sour milk	2
		Acetic /Ammonia	3
		Laurel oil smell	Yes/No
	Color	White, greyish	0
		Slightly yellowish, slightly pinkish	1
		Yellow, completely pink	2
	Brightness	Transparent	0
		Dull	1
		Milky	2
	Breakdown status	No breakdown	0
		Slightly broken down but intact	1
		Slightly broken down, not completely intact	2
		Intensely broken down	3

RESULTS

The GC-MS analysis of laurel EO revealed 92.98% of the components. The main components of laurel EO were determined as 1,8-cineole (62.36%), a-terpinyl acetate (10.54%) and sabinene (8.44%). *Table 2* shows the main components of laurel EO as analyzed by GC-MS.

The results of the microbiological analyses conducted at different days of cold storage on control (vacuum-packed group), 1% and 2% laurel EO-treated vacuum-packed samples are shown in *Fig. 1a,b,c,d,e,f*. In the control group samples, the initial total viable count (day 0) was determined as 4.14 log cfu/g, and in the samples involving 1% and 2% laurel oil, it was determined as 4.07 and 3.50 log cfu/g, respectively. On day 14 of cold storage, the total viable count in the control samples and 1% and 2% laurel oil-involving samples were 9.98, 9.93 and 7.83 log cfu/g, respectively. It was determined that there was no

significant difference between the control and 1% laurel oil group (P>0.05), however there was a significant difference with the 2% laurel oil group (P<0.05).

The initial (day 0) total psychrotrophic bacteria count in the control, 1% and 2% laurel oil groups were determined as 4.10, 4.06 and 3.36 log cfu/g, respectively (P>0.05). On day 14 of cold storage, the total psychrotrophic bacteria count of the control, 1% and 2% laurel oil-involving samples was determined to be 9.87, 9.74 and 7.64 log cfu/g, respectively. It was determined that there was no significant difference between the control and 1% laurel oil group (P>0.05), however there was a significant difference with the 2% laurel oil group (P<0.05). The initial (day 0) *Pseudomonas spp* count in control, 1% and 2% laurel oil groups were determined as 4.09, 4.01 and 3.26 log cfu/g, respectively (P>0.05). On day 14 of cold storage, the total *Pseudomonas* bacteria count of the control, 1% and 2% laurel oil-involving samples was determined as 9.04, 8.98 and 7.56 log cfu/g, respectively. A statistically significant difference was determined between the control and the 2% laurel oil group (P<0.05). The initial (day 0) LAB count in the control, 1% and 2% laurel oil groups were determined as 3.35, 3.13 and 2.70 log cfu/g, respectively (P>0.05). On day 14 of cold storage, this number was 6.42 log cfu/g in the control group whereas in the 2% laurel oil group, it was determined as 4.80 log cfu/g. The initial (day 0) *Enterobacteriaceae* count in the control, 1% and 2% laurel oil groups were determined as 1.43, 1.10 and 0.77 log cfu/g, respectively (P>0.05). On day 14 of cold storage, this number was 7.60 log cfu/g in the control group whereas in the 2% laurel oil group, it was determined as 6.37 log cfu/g. It was determined that there was no significant difference between the control and 1% laurel oil groups (P>0.05), however there was a significant difference with the 2% laurel oil group (P<0.05). The initial (day 0) coliform count in the control, 1% and 2% laurel oil groups were determined as 2.50, 1.89 and 0.76 log cfu/g, respectively (P>0.05). On day 14 of cold storage, this number was 7.35

Table 2. *Main components of laurel EO analyzed by GC-MS*

Retention Time	Compounds	%
10.13	α-Pinene	2.84
11.83	Sabinene	8.44
12.02	β-Pinene	2.25
14.64	1,8-Cineole	62.36
17.84	Linalool	3.73
21.54	Terpinen-4-ol	2.82
29.10	α-Terpinyl acetate	10.54
	Others	7.02

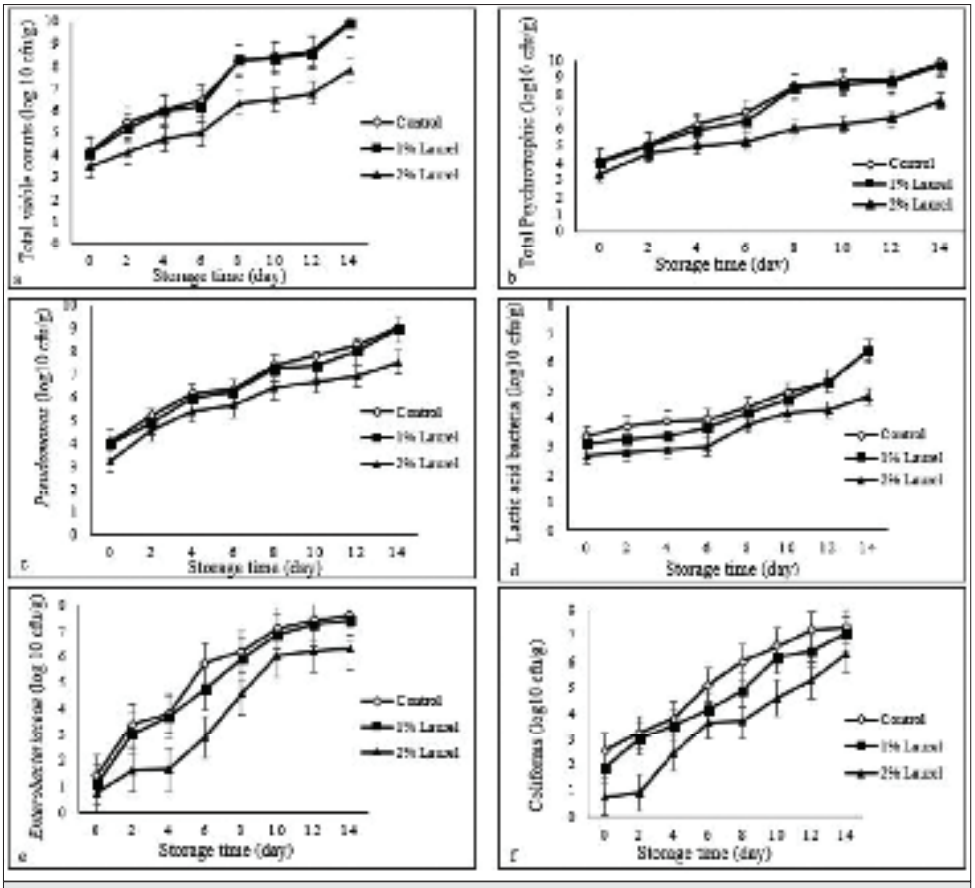

Fig 1. Total viable (a), Total psychrotrophic bacteria (b), *Pseudomonas* (c), Lactic acid bacteria (d), *Enterobacteriaceae* (e), Coliform bacteria (f) counts of rainbow trout fillets treated with various concentrations of laurel EO during cold storage

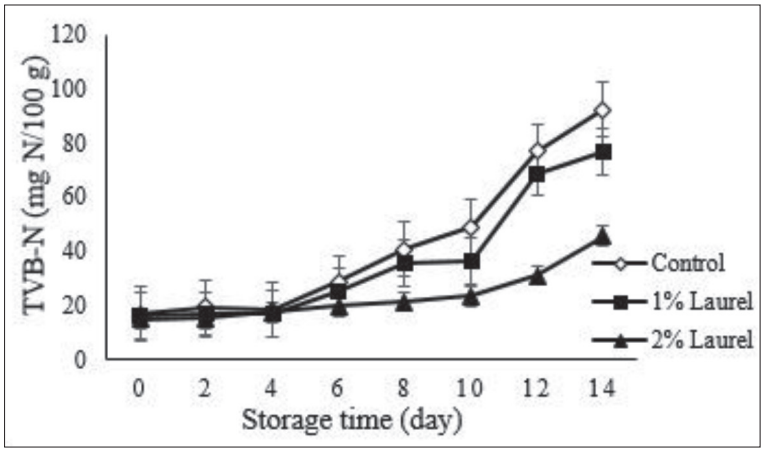

Fig 2. TVB-N values of rainbow trout fillets treated with various concentrations of laurel EO during cold storage

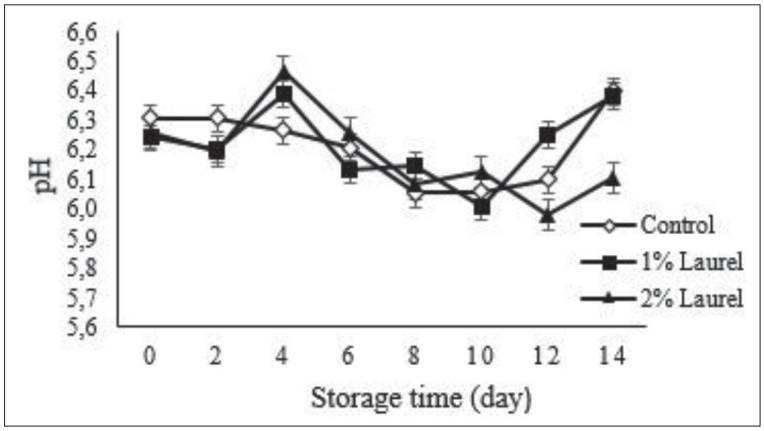

Fig 3. pH values of rainbow trout fillets treated with various concentrations of laurel EO during cold storage

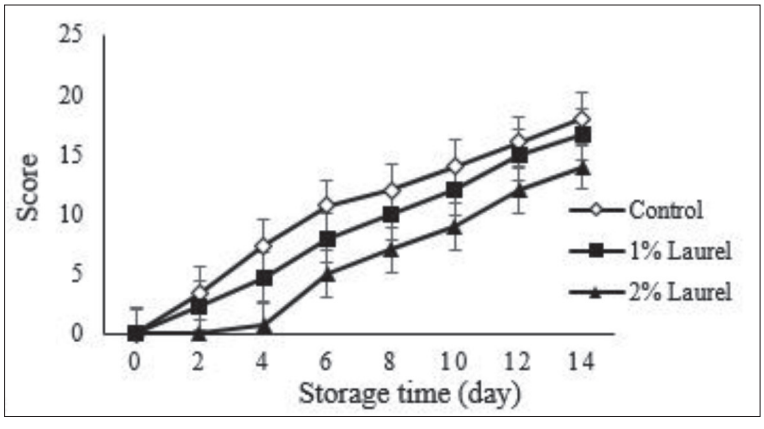

Fig 4. Change in sensory quality scores of rainbow trout fillets treated with various concentrations of laurel EO during cold storage

log cfu/g in the control group whereas in the 2% laurel oil group, it was determined as 6.30 log cfu/g. A statistically significant difference was determined among the groups (P<0.05). In none of the control, 1% or 2% laurel oil groups, fecal coliform group microorganisms were isolated.

It was observed that the TVB-N value increased in the control, 1% and 2% laurel oil groups throughout the period of storage. The initial (day 0) TVB-N value in control, 1% and 2% laurel oil groups were 16.6, 16.3, 14.9 mg/100 g, respectively, and there was no statistically significant difference among the groups (P>0.05). On day 14 of cold storage, this number was 92.1 mg/100 g in the control group whereas in the 2% laurel oil group, it was determined as 45.5 mg/100 g, and a statistically significant difference was detected between these values (P<0.05). *Fig. 2* shows the TVB-N values measured for the samples throughout cold storage.

It was determined that there was no statistically significant difference among the pH values of the control, 1% and 2% laurel oil groups at the initial (day 0), however on day 14 of cold storage, there was a statistically significant difference among the groups (P<0.05). *Fig. 3* shows the pH values of the samples as measured throughout cold storage.

It was determined that the sensory score of the rainbow trout fillets increased depending on the period of cold storage. On day 14 of storage, a statistically significant difference among the groups was determined (P<0.05). *Fig. 4* shows the scores of the change in the sensory quality of the rainbow trout fillets during cold storage.

DISCUSSION

In this study, the effect of various concentrations of laurel EO on the shelf-life of vacuum-packed rainbow trout fillets was investigated. The composition of the EO obtained from laurel leaves was determined by GC-MS. Many factors including the genotype of plant varieties, seasonality, geographical and weather conditions highly affect the composition of an EO [10]. In this study, the main components consisted of 1,8-cineole (62.36%), a-terpinyl acetate (10.54%) and sabinene (8.44%). These results are partially compatible with the results of previous studies [10,17-20].

In rainbow trout fillets, the initial total viable count was 4.14 log cfu/g in the control group whereas this number increased in all groups during storage. Many other researchers previously obtained similar results [10,21-24]. The maximum permissible level for freshwater fish is 7 log cfu/g [25]. In the control and 1% laurel group, this level was surpassed on day 8 of storage and the panelists also indicated that the samples had spoiled in terms of the sensory aspects. As for the 2% laurel group, it was

determined that the limit of 7 log cfu/g was surpassed on day 14. Zhang et al.[23] reported that in vacuum-packed (VP) carp fillets, the limit of 7 log cfu/g was surpassed on day 8. This study also revealed similar findings. The initial psychrotrophic bacteria count was determined as 4.10 log cfu/g in the control group. It was determined that the control and 1% laurel group surpassed the limit of 7 log cfu/g on day 8 of storage whereas in the 2% laurel group, the limit was surpassed on day 14. Özpolat et al.[26] reported that the initial psychrophile count was 3.08 log cfu/g, and there was an increase in the total psychrophile bacteria count based on the period of storage. In this study, the initial psychrotrophic bacteria count was 4.10 log cfu/g and similarly, an increase was determined in the number of bacteria during the period of storage. The initial *Pseudomonas* count was 4.09 log cfu/g in the control group which continuously increased throughout storage. As for the 2% laurel group, it was determined that throughout the period of storage, the *Pseudomonas* count had been significantly lower compared to the control group ($P<0.05$). Zhang et al.[27] reported that in vacuum-packed carp fish samples containing 0.1% cinnamon EO, the control group (vacuum-packed) showed a *Pseudomonas* initial count of 3.5 log cfu/g whereas in the samples containing 0.1% cinnamon EO, it was 2.8 log cfu/g. In this study, the control group had an initial *Pseudomonas* count of 4.09 log cfu/g whereas in the 2% laurel group, it was determined as 3.26 log cfu/g. In line with the aforementioned study, it was observed that the EO enabled a reduction in the initial *Pseudomonas* count. In their study which examined the effect of chitosan, thyme oil or their combinations on the shelf-life of smoked eel fillets stored under vacuum packaging (VP) at 4°C, El-Obeid et al.[8] reported that in the treated samples, the *Pseudomonas* count had been lower throughout the period of storage. This study also produced similar findings. When the control group and the 2% laurel group are compared in terms of the LAB count, it is observed that there had been a significant difference between the groups throughout storage ($P<0.05$). Zhang et al.[27] reported that during the period of storage, there was no significant difference in terms of LAB count between the VP samples and VC samples (0.1% cinnamon EO + vacuum packing). It is considered that this difference may result from factors such as the EO used, the concentration of the EO, initial microbial flora and manner of application. In this study, we have observed a very slow and gradual increase in the LAB count. Zhang et al.[23] reported that in vacuum-packed carp fillets, unlike *Pseudomonas,* the LAB count slowly increased reaching 7.74 log cfu/g after 12 days of storage. The results of this study are compatible with the aforementioned study. The *Enterobacteriaceae* count considered as the hygiene criteria in food, increased throughout the period of cold storage. The control group showed a gradual increase whereas in the 2% group, the *Enterobacteriaceae* count was found to be very low until day 8 of cold storage. Vilela et al.[28] reported that in vacuum-packed samples at 2°C, the *Enterobacteriaceae* count was generally lower in the samples of the group treated with laurel EO. Similarly, this study also determined that laurel EO was quite effective on both the initial and final *Enterobacteriaceae* count. Thus, our results are compatible with the aforementioned study. Özoğul et al.[9] in a study investigating the effect of nanoemulsions containing rosemary, laurel, thyme and sage EO on the quality characteristics of rainbow trout, reported that the initial *Enterobacteriaceae* count was 2.27 log cfu/g which increased depending on the period of storage in all groups and especially in the control group. In another study, Özoğul et al.[7] reported that the initial *Enterobacteriaceae* count was determined as 2.28 log cfu/g in the control group, which reached 5.92 log cfu/g in the group treated with laurel extract at the end of the storage, and that laurel and myrtle extracts reduced microbial development in fish. This study is also in conformity with both of the aforementioned studies. The number of microorganisms in the coliform group also revealed an increase in similarity with the *Enterobacteriaceae* count, based on the period of storage. da Silveira et al.[10] reported that in fresh sausage, the application of laurel leaves EO in concentrations of 0.05 and 0.1 g/100 g significantly reduced the total coliform population and extended the shelf-life of the product for 2 days. This study also determined that 1% and 2% laurel EO enabled a significant reduction in the initial count and that the coliform count had been lower than the control group until the last day of storage.

TVB-N is produced by the degradation of proteins and non-protein nitrogenous compounds as a result of microbial activity and used as a fish spoilage indicator [9,29,30]. The maximum permissible level of TVB-N in fish and fishing products is 35 mg N/100 g [8,31,32]. The initial (day 0) TVB-N value was 16.6 mg/100 g in the control group and it was determined that this value increased in all groups throughout the storage. The researchers also obtained similar results [9,21]. On day 14 of cold storage, the TVB-N value was determined as 45.5 mg/100 g in the 2% laurel group. Özoğul et al.[9] determined the TVB-N value as 44.91 mg/100 g in the laurel group on day 24 of storage, and reported that when the samples were rejected upon microbiological assessment, the TVB-N values had been lower than the limit in all samples. As for the present study, unlike the aforementioned study, it was determined that the TVB-N value had exceeded the limit when the samples surpassed the microbial limits and were rejected by the panelists in terms of sensory aspects.

In rainbow trout fillets, the initial (day 0) pH value was determined as 6.31 in the control group. There were various rates of decrease or increase in the pH values based on the period of storage, however on the final day of storage, all groups showed a slight increase in the pH value. Our findings have been compatible with those of Erkan et al.[30].

According to the results of the sensory analysis, the panelists reported that on day 8 of cold storage, the control

and 1% laurel groups were spoiled whereas the 2% laurel oil group was rejected on day 14 in sensory terms. The panelists informed that at the initial of storage (day 0) the smell of laurel oil was intense which eventually decreased during the storage period and the smell had become pleasant. The control group received the highest score through the period of cold storage whereas the 2% laurel oil group received the lowest score. It was determined that the findings of the microbial, chemical and sensory analyses were parallel. Özoğul et al.[9] reported an increase in the sensory scores of control and treatment groups throughout the period of storage and indicated that the shelf-life of rainbow trout reached 14 days for control and 17 days for treatment groups. In this study, the period was 8 days for the control and 1% laurel groups, whereas in the 2% laurel group, it was 14 days. Erkan et al.[30] reported that 1% thyme and laurel EO addition increased the shelf-life of fresh bluefish for about 3-4 days. Zhang et al.[27] reported that cinnamon EO extended the shelf-life of vacuum-packed carp fillets for approximately 2 days. Vilela et al.[28] reported that laurel EO had a significant effect on the preservation of color and shelf-life of fresh minced meat. In this study, it was determined that 1% laurel EO had a similar effect with that of the control group, hence did not extend shelf-life. On the other hand, 2% laurel EO was quite effective on microbial spoilage and extended shelf-life for approximately 4 days. The differences between these studies are considered to originate from the manner of application of EO.

The results reveal that the combination of vacuum packing and 2% laurel EO delays microbial spoilage in rainbow trout fillets and extends shelf-life for approximately 4 days. It has also been revealed that it enhances sensory quality characteristics, and particularly creates a pleasant smell and is preferable. It has been concluded that laurel EO may be used in extending the shelf-life of seafood due to its positive effects on microbial, chemical and sensory quality. Further, it may constitute an alternative to synthetic food additives for enabling the microbial safety of other meat and meat products as well as stability in sensory properties.

Conflict of Interest

The authors declare no conflict of interest.

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