KSÜ Tarım ve Doğa Derg 26 (1), 172-182, 2023
KSU J. Agric Nat 26 (1), 172-182, 2023
https://doi.org/10.18016/ksutarimdoga.vi.995995

Limon ve Portakal Kabuğu Ekstraktları Içeren Yenilebilir Film Kaplamaların Kalamar (*Loligo vulgaris*) Halkaları ve Gökkuşağı Alabalığı (*Oncorhynchus mykiss*) filetolarında Mikrobiyolojik Kalitesi ve Raf Ömrü Üzerine Etkisi

Berna KILINÇ [1], Göknur SÜRENGİL [2], Hüsniye TANSEL YALÇIN [3]

[1]Ege University, Faculty of Fisheries, Fish Processing Technology Department, 35100 Izmir, Türkiye.[2]Isparta University of Applied Sciences, Faculty of Eğirdir Fisheries, Fishing and Processing Technology Department, 32200 Isparta, Türkiye, [3]Ege University, Faculty of Science, Biology Department, Basic And Industrial Microbiology Section, 35100 Izmir, Türkiye.

[1]https://orcid.org/0000-0002-4663-5082, [2]https://orcid.org/0000-0002-4560-7856, [3]https://orcid.org/0000-0003-4870-6267

✉: goknursurengil@isparta.edu.tr

ÖZET

Bu çalışmanın amacı, meyve kabuklarının (portakal ve limon) ekstrakt olarak değerlendirerek antimikrobiyal özelliklere sahip yenilebilir filmler üretmek ve gökkuşağı alabalığı filetoları ile kalamar halkalarında raf ömrüne etkisinin belirlenmesidir. Bu amaçla ksantan, keçiboynuzu ve karagenan kullanılarak portakal ve limon kabuğu ekstraktlarından antimikrobiyal film üretimi gerçekleştirilmiştir. Gökkuşağı alabalığı filetoları (*Oncorhynchus mykiss* 1792) ve kalamar halkaları (*Loligo vulgaris* 1798), bu ürünlerin raf ömrünü uzatmak amacıyla meyve kabuklarından üretilen antimikrobiyal yenilebilir filmlerle kaplanmıştır. Sonuç olarak, kalamar halkalarının (CS) toplam mezofilik bakteri sayısı (TMC), 6. günde mikrobiyolojik tüketim sınırını aşarken, limon kabuğu+keçiboynuzu (LLS) ve limon kabuğu+karagenan (LKS) ile kaplı kalamar halkalarının TMC sayısının 8. günde bile bu sınırı aşmadığı belirlenmiştir. Bu çalışma, sadece balıkçılık ürünlerinden fonksiyonel ürünlerin üretilebilmesine değil, aynı zamanda meyve kabuklarının da bu amaçla değerlendirilebilmesine neden olmuştur. Bu çalışmanın sonuçları, su ürünleri ve meyve suyu işleme tesislerinin yanı sıra gıda üreticileri tarafından da değerlendirilebilir.

Su Ürünleri

Araştırma Makalesi

Makale Tarihçesi
Geliş Tarihi : 16.09.2021
Kabul Tarihi : 18.03.2022

Anahtar Kelimeler
Meyve kabukları,
Mikrobiyal flora,
Kalamar halkaları,
Gökkuşağı alabalığı filetoları,
Yenilebilir filmler

The Impact of Edible Film Coatings With Lemon and Orange Peel Extracts on Microbiological Quality and Shelf-Life of Squid (*Loligo vulgaris*) Rings and Rainbow Trout (*Oncorhynchus mykiss*) Fillets

ABSTRACT

The aim of this study is to produce edible films with antimicrobial properties by using the discarded fruit peels (orange and lemon) as extracts and to determine the effect on shelf life of rainbow trout fillets and squid rings. For this purpose, antimicrobial edible films were performed the orange and lemon peels extracts by using xanthan, locust bean and carrageenan gums. Rainbow trout fillets (*Oncorhynchus mykiss* 1792) and squid rings (*Loligo vulgaris* 1798) were covered with this antimicrobial edible films from discarded fruit peels to extend the shelf-life of these products. As a result, total mesophilic bacteria count (TMC) of squid rings (CS) exceeded the microbiological limit of the consumption on day 6, whereas TMC of squid rings covered with limon peel+locust bean (LLS) and limon peel+carrageenan (LKS) did not exceed this limit on day 8. This study gave rise to not only can be produced of functional products from the fishery products but also the fruit peels residues can also be evaluated for this purpose. The results of this study can be evaluated by seafood and fruit juice processing plants as well as food producers.

Fisheries

Research Article

Article History
Received : 16.09.2021
Accepted : 18.03.2022

Keywords
Fruit peels,
Microbial flora,
Squid rings,
Rainbow trout fillets,
Edible films

Atıf Şekli: Kılınç, B., Sürengil, G., & Yalçın, H. T., (2023) The impact of edible film coatings with lemon and orange peel extracts on microbiological quality and shelf-life of squid (*Loligo vulgaris*) rings and rainbow trout (*Oncorhynchus mykiss*) fillets. *KSÜ Tarım ve Doğa Derg 26* (1), 172-182. https://doi.org/10.18016/ ksutarimdoga.vi.995995

To Cite : Kılınç, B., Sürengil, G., & Yalçın, H. T., (2023). The impact of edible film coatings with lemon and orange peel extracts on microbiological quality and shelf-life of squid (*Loligo vulgaris*) rings and rainbow trout (*Oncorhynchus mykiss*) fillets. *KSU J. Agric Nat 26*(1), 172-182. https://doi.org/10.18016/ksutarimdoga.vi.995995

INTRODUCTION

Fish and fishery products are included in food products that have been deteriorated very quickly, as they are vulnerable to chemical enzymatic and microbiological degradation. (Ashie et al., 1996). For this reason, nowadays it is very important to use natural products instead of chemicals preservatives in order to extend the shelf life of seafood products, to ensure their quality and safety (Mohan et al., 2016; Viji et al., 2017; Kılınç et al., 2017; Mei et al., 2019). There have been found some natural inhibitors in herbal foods such as some spices and herbs have active ingredients with antimicrobial effect. Some examples can be given for these natural inhibitors: eugenol in cloves, allicin in garlic and onion, cinnamic aldehyde in cinnamon, isothiocionate in mustard, timol and isotimol in sage, anetol in anise, vanillin in vanilla etc (Ünlütürk & Turantaş, 2003). A large number of studies have recently investigated the effect of plant extracts on the pathogenic microorganisms (Fernandez-Lopez et al., 2005; Ertürk et al., 2010; Bhalodia & Shukla, 2011; Khan et al., 2013; Gonelimali et al., 2018). Some plants have been contained essential oils with antimicrobial effect (Akarca & Şevik, 2021). Essential oils in citrus fruits (citral etc.) are located in the fruit peels. Essential oils in lemon and orange have been stated to prevent the development of certain concentrations of bacteria (Ünlütürk & Turantaş, 2003). Many fruit juice production factories have been found in Türkiye. Fruit and vegetable peels have various positive effects on health in terms of bioactive components such as polyphenols, carotenoid etc. Peels have more biological activity than other fractions of fruit and vegetables therefore, it is very important to evaluate them (Kılınç et al., 2018). Furthermore, fruit peels are quite valuable because of the antimicrobial properties. For this purpose, the aim of this study was to evaluate fruit peels (oranges and lemons) which have been discarded and to create edible films with antimicrobial properties. This study gave rise to not only produce antimicrobial films (food coating materials) for producing of functional fishery products but also fruit peels were evaluated in this purpose. Another aim was to determine the impact of edible films with lemon and orange peels by using xanthan, locust bean and carrageenan on the microbial flora and the shelf-life of squid rings and rainbow trout fillets.

MATERIALS and METHODS

Preparation of lemon and orange peels extracts

In this study lemon (*Citrus limon*) and orange (*Citrus sinensis*) peels were supplied and in shade dried naturally. THE Dried lemon and orange peels were powdered at using an electric mill. The lemon and orange peels were pulverized separately and exracted with ethanol using in a mechanical mixer for 24 hours. The obtained resulting mixture was filtered and evaporated with a rotary evaporator according to method of Baytop, 1999. Prepared extracts were kept in the refrigerator until used.

Production of Edible Film Solutions From Fruit Peels

The edible film solutions were produced from orange and lemon peels because of which have the highest antimicrobial effect (Kılınç et al., 2018). Preparation of edible films was proceeded according to Sothornvit et al. (2011). Film solution was prepared by using at the ratio of 1% (w v^{-1}) xanthan, locust bean, carrageenan gums in distilled water at 90°C for 30 minutes. The mixture was homogenized with magnetic mixer. Glycerol was added into the mixture at the ratio 3 % as a plasticizer. 3.2% (g $100ml^{-1}$) natural antimicrobial in concentrations obtained as the result of Minimum Inhibition Concentration (MIC) of fruit peel extracts were added according to Kılınç et al. (2018). The solution was left to cool at room temperature.

Coating Fishery Products with Edible Film Solutions

In order to improve the sensory quality and extend the shelf-life of trout fillets and squid rings, edible film coatings containing lemon and orange peels by using xanthan, locust bean and carrageenan gums were used. Edible film solutions were applied on fishery products. Frozen-thawed rainbow trout fillets (*Oncorhynchus mykiss* Walbaum, 1792) and squid rings (*Loligo vulgaris* Lamarck, 1798) were obtained from fish markets. They were brought to the Laboratory of Fish Processing Technology of Ege University Fisheries Faculty in cold chain by using cooler box containing ice in approximately 30 minutes. The samples were put into the refrigerator at 4±1°C for thawing process for 15 hours. After thawing process, the samples were aseptically soaked into the edible film solution at room temperature (18°C) for two minutes. The samples were coated with orange and lemon peels by using xanthan, locust bean and carrageenan gum containing edible films, separately (Fig. 1). The coated fishery products without extract were identified as control.

After coating the samples with edible films, approximately 150-200 g of two trout fillets and 10 piece of squid rings were placed in strafor plates separately. The samples were incubated at 4±1°C for

10 days. Analysis was carried out on the 1st, 3rd, 6th and 8th day of storage. Total mesophilic, psychrotrophic, Enterobactericeae and lactic acid bacteria counts of samples were made in triplicate. Three strofor plates were used on each analysis day for microbiological analyses. The results were given as the mean value of three analyses.

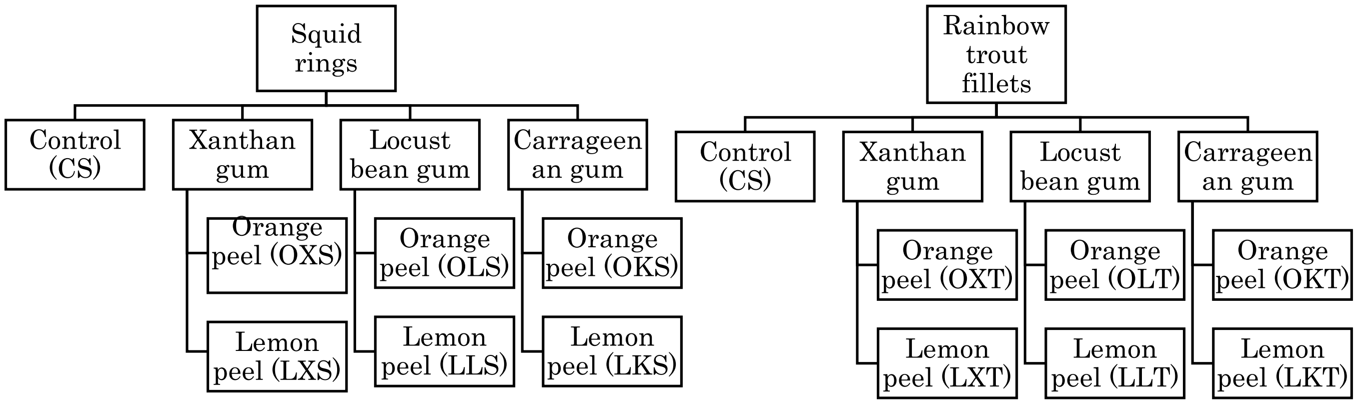

Figure 1. It is a group of coated (control) and uncoated aquaculture products with different extracts and edible films.

Şekil 1. Farklı ekstrakt ve yenilebilir filmler ile kaplanmış ve kaplanmamış (kontrol) su ürünleri grupları.

Analytical Methods

Microbiological analysis and bacteria identifications

Samples (10 g) were added aseptically to 90 ml of sterile Buffered Peptone Water solution (1 g ml-1 bacteriological peptone, Merck 1.07228.0500, Germany) and mixed in a Stomacher (IUL, Barcelona, Spain) at high speed for 1 min. Plate Count Agar (PCA, Merck 1.05463.0500, Germany) was used to evaluate total mesophilic bacterial counts (TMC) and total psychrotrophic bacterial counts (TPC). Violet red bile dekstrose Agar (VRBD-A, Merck 1.10275.0500, Germany) and De Man Rogosa Sharpe Agar (MRS, Merck 1.10660.0500, Germany) were used to asses Enterobacteriaceae (ENT), total coliform bacteria and lactic acid bacteria (LAB) respectively. On the other hand, Yeast Extract Glucose Chloramphenicol Agar (YGC, Merck 1.16000.0500, Germany) were used to grow molds and yeasts (MY). Plates were incubated 30°C at 24 h for TMC, 7 °C at 10 d for TPC. LAB were proceeded after incubation at 30 °C at 72 h under anaerobic conditions. Yeasts and fungi were incubated at 25 °C for 72 h (Harrigan & Mc Cance, 1976). After incubation periods, the means of counts with standard deviations, were reported as logarithms of the number of colony forming units (log CFU g-1). Furthermore, the isolated microorganisms were identified with API test kits with 20 NE (30 °C for 24 h), 20 E (36 °C for 24 h), 50 CH and 50 CHL (30 °C for 24 h) (Biomérieux, France) from bacterial flora. These kits were used according to the instructions of the manufacturer and the database provided by bioMerieux.

Sensory analysis

The sensory evaluation of the edible films coated rainbow trout fillets and squid rings were evaluated by 5 experienced panelists at the Ege University Fisheries Faculty Department of Fish Processing Technology. Prepared edible film coated and uncoated fishery products were presented to panelists in random order. On each analysis day, each sample was coded differently and then served to the panelits for evaluating the sensory characteristics of samples. The sensory evaluation of the samples was proceeded according to Paulus et al. (1979). In sensory evaluation, the panelists evaluated the following characteritics (color, odour, texture) and general acceptability defining criteria 9 to 1 of the samples. A hedonic scale ranging from 9 (very good completely fresh fish) to 1 (very bad, completely degraded fish) was employed in the evaluation.

pH analysis

The pH value was measured by using a Hanna 211 model pH meter (Cluj-Napoca, Romania), with the glass electrode applied directly to the homogenate (5 g of fish/5 mL of distilled water). The experiment was proceeded in triplicate.

Statistical analysis

The data were analysed by one-way ANOVA. Tukey's multiple range test was applied for determining group differences at 95% significance level. Analysis was performed using SPSS 15.0 for Windows (SPSS Inc., Chicago, IL, USA).

RESULTS

The total mesophilic bacterial counts (TMC) of the coated and uncoated rainbow trout fillets and squid rings are given in Table 1. Edible films with orange and lemon peels by using xanthan, locust bean and carrageenan on the rainbow trout fillets and squid rings delayed the growth of bacteria, when compared with uncoated samples. TMC of groups (OXS, LXS, CS) exceeded the microbiological limit of consumption on day 6, whereas TMC of groups (OXT, LXT, CT, OLS, OLT, LLT, OKS, OKT, LKT) exceeded this limit (7 log CFU g-1) according to the ICMSF (1986) on day 8. However, TMC of squid rings covered with limon peel+locust bean (LLS) and limon peel+carrageenan (LKS) did not exceed the limit of consumption on day 8. In another words, the lowest TMC was determined on squid rings covered with lemon peel+ locust bean (LLS) and lemon peel+ carrageenan (LKS) films, when compared with other groups.

Table 1 Total mesophilic bacterial counts (log CFU g-1) of coated and uncoated rainbow trout fillets and squid rings during storage

Çizelge 1. Kaplamalı ve kaplamasız gökkuşağı alabalığı filetolarının ve kalamar halkalarının depolama sırasındaki toplam mezofilik bakteri sayıları (log CFU g-1)

Storage Time	Total Mesophilic Bacteria Counts (log CFU g^{-1})					
	OXS	LXS	CS	OXT	LXT	CT
Day 1	4.22 ± 0.03^{b1}	3.82 ± 0.24^{c1}	4.55 ± 0.21^{a1}	3.43 ± 0.55^{ab1}	3.05 ± 0.19^{b1}	3.55 ± 0.16^{a1}
Day 3	5.81 ± 0.19^{b2}	5.15 ± 0.02^{c2}	6.02 ± 0.14^{a2}	4.89 ± 0.05^{b2}	4.26 ± 0.07^{a2}	4.69 ± 0.06^{b2}
Day 6	7.15 ± 0.01^{b3}	7.02 ± 0.02^{c3}	7.90 ± 0.40^{a3}	6.50 ± 0.07^{ab3}	6.31 ± 0.44^{b3}	6.78 ± 0.23^{a3}
Day 8	8.38 ± 0.08^{b4}	8.11 ± 0.14^{c4}	8.93 ± 0.06^{a4}	7.40 ± 0.18^{ab4}	7.06 ± 0.06^{b4}	7.93 ± 0.04^{a4}
	OLS	LLS	CS	OLT	LLT	CT
Day 1	3.58 ± 0.47^{c1}	3.86 ± 0.05^{b1}	4.06 ± 0.61^{a1}	3.88 ± 0.10^{a1}	3.45 ± 0.51^{b1}	3.79 ± 0.51^{ab1}
Day 3	3.86 ± 0.40^{c1}	4.43 ± 0.07^{b2}	5.42 ± 0.31^{a2}	5.04 ± 0.22^{a2}	4.10 ± 0.05^{b2}	5.86 ± 0.05^{ab2}
Day 6	5.74 ± 0.23^{b2}	5.49 ± 0.14^{c3}	6.89 ± 0.12^{a3}	6.47 ± 0.26^{a3}	5.65 ± 0.28^{b3}	6.93 ± 0.28^{ab3}
Day 8	7.12 ± 0.11^{b3}	6.97 ± 0.83^{c4}	7.47 ± 0.08^{a4}	7.42 ± 0.64^{b4}	7.00 ± 0.15^{a4}	7.67 ± 0.15^{b4}
	OKS	LKS	CS	OKT	LKT	CT
Day 1	4.20 ± 0.42^{a1}	3.65 ± 0.21^{b1}	3.80 ± 0.14^{c1}	3.35 ± 0.21^{a1}	3.70 ± 0.14^{b1}	3.75 ± 0.35^{b1}
Day 3	5.22 ± 0.89^{b2}	4.55 ± 0.26^{c2}	6.84 ± 0.05^{a2}	4.95 ± 0.07^{b2}	5.11 ± 0.33^{b2}	6.37 ± 0.39^{a2}
Day 6	6.65 ± 0.64^{b3}	5.80 ± 0.42^{c3}	7.25 ± 0.21^{a3}	6.00 ± 0.14^{b4}	6.25 ± 0.07^{b3}	7.65 ± 0.21^{a3}
Day 8	7.40 ± 0.55^{b4}	6.73 ± 0.24^{c4}	8.42 ± 0.29^{a4}	7.46 ± 0.15^{b4}	7.09 ± 0.06^{b4}	8.27 ± 0.02^{a4}

n=3; Mean value ± standart deviation $^{a-c}$: a-c: different letters in the same row show statistically significant difference between the groups ($p<0.05$). $^{1-4}$: 1-4: different numbers in the same column show statistically significant difference for each group according to storage ($p<0.05$).

There was a reduction of approximately up to 1.5 log cycles between control and coated samples (LLS and LKS) after 8 days of storage. The edible films that were produced using locust bean with lemon peel extract and carrageenan with lemon peel extract caused a statistically significant ($p<0.05$) decrease in the TMC of coated samples compared to other groups. The inhibition of the microbial growth in coated samples was observed in the study and this result was thought to be related with the antimicrobial activiy of the lemon and orange peels. It was also determined that the differences between the groups of the TMC were significant ($p<0.05$) according to the coating types and the storage period ($p<0.05$). Total psychrotrophic bacterial counts (TPC) of the coated and uncoated rainbow trout fillets and squid rings are shown in Table 2. The highest TPC of groups were determined in the uncoated samples during the storage period, when compared with coated groups. The initial TPC (log CFU g^{-1}) of coated and uncoated samples increased signicantly during the storage period ($p<0.05$). *Enterobactericeae* bacteria counts (EBC) of coated and uncoated rainbow trout fillets and squid rings are given in Table 3.

Gradual increase in the number of EBC have been observed throughout the storage in all groups except for the groups (OXT, LXT, CT), in which EBC counts of samples were determined below the detectable value (<1 log CFU g^{-1}) during storage period.

Lactic acid bacteria (LAB) counts (log CFU g^{-1}) obtained from coated and uncoated rainbow trout fillets and squid rings during storage are shown in Table 4. While there was no statistically significant difference ($p>0.05$) in the lemon and orange coated groups during storage, the difference between the control group and the other groups was found to be significant ($p<0.05$). The lactic acid bacteria counts were determined statistically ($p<0.05$) higher in edible film coated groups, in which they thought to be stopped the other microbial growth due to the antimicrobial effect of lactic acid bacteria.

Table 2. Total psychrotrophic bacteria counts (log CFU g^{-1}) of coated and uncoated rainbow trout fillets and squid rings during storage

Çizelge 2. Kaplamalı ve kaplamasız gökkuşağı alabalığı filetolarının ve kalamar halkalarının depolama sırasındaki toplam psikrotrofik bakteri sayısı (log CFU g^{-1})

Storage Time	Total Psychrotrophic Bactria Counts (log CFU g^{-1})					
	OXS	LXS	CS	OXT	LXT	CT
Day 1	4.21±0.22^{b1}	3.62±0.29^{a1}	4.41±0.25^{b1}	3.43±0.36^{a1}	3.29±0.38^{a1}	3.51±0.03^{a1}
Day 3	5.01±0.22^{b2}	5.61±0.46^{b2}	6.21±0.17^{a2}	5.59±0.30^{a2}	5.51±0.49^{a2}	5.80±0.08^{a2}
Day 6	7.55±0.13^{b3}	7.46±0.06^{b3}	7.75±0.47^{a3}	7.30±0.11^{a3}	7.65±0.25^{a3}	7.34±0.07^{a3}
Day 8	8.20±0.09^{b4}	8.06±0.08^{b4}	8.72±0,29^{a4}	8.20±0.14^{a4}	7.10±0.14^{a4}	8.53±0.11^{a4}
	OLS	LLS	CS	OLT	LLT	CT
Day 1	4.53±0.12^{a1}	4.16±0.51^{b1}	4.53±0.21^{a1}	3.64±0.25^{b1}	3.49±0.09^{b1}	4.11±0.43^{a1}
Day 3	5.40±0.03^{a2}	4.76±0.97^{b2}	5.96±0.77^{a2}	4.71±0.22^{b2}	5.00±0.48^{b2}	6.48±0.54^{a2}
Day 6	6.75±0.30^{a3}	6.72±0.14^{a3}	6.99±0.60^{b3}	6.46±0.07^{b3}	6.86±0.05^{b3}	7.10±0.15^{a3}
Day 8	7.48±0.20^{a4}	7.12±0.16^{b4}	7.75±0.25^{a4}	7.27±0.23^{b4}	7.07±0.08^{b4}	7.79±0.23^{a4}
	OKS	LKS	CS	OKT	LKT	CT
Day 1	4.77±0.04^{a1}	3.55±0.08^{a1}	4.45±0.54^{a1}	3.60±0.26^{b1}	3.08±0.06^{b1}	4.16±0.20^{a1}
Day 3	5.44±0,02^{a2}	4.70±0.44^{a2}	5.15±0.59^{a2}	4.05±0.08^{b2}	3.99±0.06^{b2}	5.26±0.14^{a2}
Day 6	6.76±0.29^{a3}	6.84±0.72^{a3}	6.05±0.23^{a3}	5.87±0.07^{b3}	5.47±0.07^{b3}	7.32±0.20^{a3}
Day 8	8.30±0.08^{a4}	7.06±0.52^{a4}	8.70±0.14^{a4}	8.03±0.13^{b4}	7.78±0.06^{b4}	8.47±0.72^{a4}

n=3; Mean value ± standart deviation $^{a-c}$: a-c: different letters in the same row show statistically significant difference between the groups ($p<0.05$). $^{1-4}$: 1-4: different numbers in the same column show statistically significant difference for each group according to storage ($p<0.05$).

Table 3. Enterobacteriaceae bacteria counts (log CFU g^{-1}) of coated and uncoated rainbow trout fillets and squid rings during storage

Çizelge 3. Kaplamalı ve kaplamasız gökkuşağı alabalığı filetolarının ve kalamar halkalarının depolama sırasındaki Enterobactericeae bakteri sayıları (log CFU g^{-1})

Storage Time	*Enterobactericea* Bacteria Counts (log CFU g^{-1})					
	OXS	LXS	CS	OXT	LXT	CT
Day 1	2.35±0.38^{a1}	2.44±0.20^{a1}	2.21±0.13^{a1}	<1 ^{a1}	<1 ^{a1}	<1 ^{a1}
Day 3	3.00±0.09^{b2}	2.65±0.36^{a1}	3.20±0.03^{b2}	<1 ^{a1}	<1 ^{a1}	<1 ^{a1}
Day 6	3.60±0.17^{a3}	3.56±0.01^{a2}	3.48±0.19^{a2}	<1 ^{a1}	<1 ^{a1}	<1 ^{a1}
Day 8	4.38±0.04^{b4}	4.17±0.09^{a3}	4.64±0.05^{c3}	<1 ^{a1}	<1 ^{a1}	<1 ^{a1}
	OLS	LLS	CS	OLT	LLT	CT
Day 1	2.16±0,02^{a1}	2.15±0.15^{a1}	2.38±0.33^{a1}	2.62±0,04^{a1}	2.27±0.52^{a1}	2.57±0.70^{b1}
Day 3	2.65±0.11^{a2}	2.66±0.28^{a2}	2.60±0.05^{a2}	2.80±0.57^{b1}	2.55±0.35^{b2}	3.05±0.21^{a2}
Day 6	3.42±0.24^{a3}	3.29±0.05^{a3}	3.37±0.04^{a3}	3.20±0.85^{b2}	2.95±0.35^{b43}	3.80±0.09^{a3}
Day 8	3.91±0.16^{a4}	3.83±0.18^{a4}	4.19±0,01^{a4}	3.90±0.42^{b3}	3.37±0.52^{b4}	4.26±0.23^{a4}
	OKS	LKS	CS	OKT	LKT	CT
Day1	1.81±0.47^{c1}	2.23±0.12^{b1}	2.53±0.59^{a1}	2.23±0.12^{b1}	2.03±0.11^{c1}	2.41±0.10^{a1}
Day 3	2.41±0.10^{c2}	2.91±0.06^{b2}	3.14±0.14^{a2}	3.21±0.18^{a2}	2.57±0.15^{c2}	3.13±0.21^{b2}
Day 6	2.74±0.66^{c3}	3.45±0.18^{b3}	4.45±0.21^{a3}	3.66±0.30^{b3}	3.57±0.12^{c3}	3.82±0.11^{a3}
Day 8	3.76±0.08^{c4}	3.98±0.04^{b4}	4.80±0.14^{a4}	3.97±0.07^{b4}	3.98±0.07^{b4}	4.74±0.06^{a4}

n=3; Mean value ± standart deviation $^{a-c}$: a-c: different letters in the same row show statistically significant difference between the groups ($p<0.05$). $^{1-4}$: 1-4: different numbers in the same column show statistically significant difference for each group according to storage ($p<0.05$).

pH values of the coated and uncoated rainbow trout fillets and squid rings showed initial decrease followed by an increase as reported in Table 5. The sensory evaluation of the coated and uncoated rainbow trout fillets and squid rings are presented in (Table 6-8). The sensoy evaluation of groups was determined by the sensorial characteristics such as color, odour and texture, as well as general acceptability. Color, odour, texture and general accetability characteristics of all the groups (OXT, OXS, LXT, LXS, CS, CT, OLS, OLT, LLT, LLS, OKS, LKS, OKT, LKT) were statistically significant ($p<0.05$) decrease during the storage period.

Table 4. Lactic acid bacteria counts (log CFU g^{-1}) of coated and uncoated rainbow trout trout fillets and squid rings during storage

Tablo 4. Kaplamalı ve kaplamasız gökkuşağı alabalığı filetolarının ve kalamar halkalarının depolama sırasındaki laktik asit bakteri sayıları (log CFU g^{-1})

Storage Time	Lactic acid bacteria Counts (log CFU g^{-1})					
	OXS	LXS	CS	OXT	LXT	CT
Day 1	$<1^{a1}$	$<1^{a1}$	$<1^{a1}$	2.28 ± 0.02^{a1}	2.75 ± 0.06^{b1}	2.31 ± 0.33^{a1}
Day 3	2.89 ± 0.02^{a2}	2.60 ± 0.28^{a2}	2.09 ± 0.12^{b2}	3.18 ± 0.20^{a2}	2.40 ± 0.32^{b2}	2.41 ± 0.29^{b1}
Day 6	3.19 ± 0.27^{a3}	3.55 ± 0.10^{a3}	2.59 ± 0.16^{b3}	3.77 ± 0.04^{a3}	3.76 ± 0.05^{a3}	3.50 ± 0.16^{b2}
Day 8	3.75 ± 0.03^{a4}	3.97 ± 0.10^{a4}	3.50 ± 0.19^{b4}	4.29 ± 0.16^{a4}	4.44 ± 0.06^{a4}	3.87 ± 0.12^{b3}
	OLS	LLS	CS	OLT	LLT	CT
Day 1	2.30 ± 0.43^{c1}	2.61 ± 0.01^{b1}	2.33 ± 1.02^{a1}	3.09 ± 0.13^{a1}	3.07 ± 0.21^{a1}	3.45 ± 0.13^{b1}
Day 3	3.41 ± 0.04^{b2}	4.78 ± 0.20^{a2}	2.72 ± 0.90^{c2}	4.08 ± 0.20^{c2}	4.84 ± 0.04^{a2}	3.43 ± 0.25^{b1}
Day 6	4.40 ± 0.25^{b3}	5.30 ± 0.09^{a3}	3.80 ± 0.10^{c3}	5.80 ± 0.40^{a3}	5.30 ± 0.05^{b3}	4.30 ± 0.30^{c2}
Day 8	6.70 ± 0.32^{b4}	7.74 ± 0.25^{a4}	5.20 ± 0.27^{c4}	7.37 ± 0.36^{a4}	7.59 ± 0.20^{a4}	5.84 ± 0.52^{b3}
	OKS	LKS	CS	OKT	LKT	CT
Day 1	2.86 ± 0.37^{b1}	3.30 ± 0.28^{a1}	2.19 ± 0.83^{c1}	2.79 ± 0.23^{a1}	2.76 ± 0.81^{a1}	1.90 ± 0.84^{b1}
Day 3	3.82 ± 0.05^{b2}	4.09 ± 0.12^{a2}	2.72 ± 0.90^{c2}	3.60 ± 0.26^{a2}	$3.\ \pm0.02^{a2}$	3.16 ± 0.01^{b2}
Day 6	4.95 ± 0.32^{b3}	5.69 ± 0.03^{a3}	3.89 ± 0.78^{c3}	4.55 ± 0.60^{a3}	$4.80\pm0.14^{a3}81$	4.24 ± 0.19^{b3}
Day 8	6.55 ± 0.01^{b4}	6.56 ± 0.12^{a4}	5.04 ± 0.08^{c4}	5.92 ± 0.18^{a4}	6.47 ± 0.57^{a4}	4.84 ± 0.08^{b4}

n=3; Mean value ± standart deviation $^{a-c}$: a-c: different letters in the same row show statistically significant difference between the groups ($p<0.05$). $^{1-4}$: 1-4: different numbers in the same column show statistically significant difference for each group according to storage ($p<0.05$).

Table 5. pH values of coated and uncoated rainbow trout fillets and squid rings during storage

Çizelge 5. Kaplamalı ve kaplamasız gökkuşağı alabalığı filetoları ve kalamar halkalarının depolama sırasındaki pH değerleri

Storage Time	pH Values					
	OXS	LXS	CS	OXT	LXT	CT
Day 1	7.47 ± 0.12^{b1}	7.17 ± 0.15^{a1}	7.53 ± 0.21^{b1}	6.30 ± 0.10^{b1}	6.43 ± 0.15^{b1}	6.64 ± 0.15^{a1}
Day 3	7.44 ± 0.30^{b1}	7.25 ± 0.23^{b2}	8.07 ± 0.15^{a2}	6.55 ± 0.01^{b2}	6.57 ± 0.01^{b2}	6.61 ± 0.05^{a1}
Day 6	7.15 ± 0.03^{b2}	7.16 ± 0.02^{b1}	7.51 ± 0.03^{a1}	6.96 ± 0.12^{b3}	6.63 ± 0.04^{a3}	6.83 ± 0.01^{b2}
Day 8	7.26 ± 0.05^{b3}	7.26 ± 0.04^{b2}	7.59 ± 0.02^{a3}	6.68 ± 0.11^{b4}	6.82 ± 0.05^{b4}	6.99 ± 0.02^{a3}
	OLS	LLS	CS	OLT	LLT	CT
Day 1	6.67 ± 0.01^{b1}	5.90 ± 0.14^{c1}	7.05 ± 0.12^{a1}	6.20 ± 0.05^{b1}	6.29 ± 0.08^{c1}	6.33 ± 0.03^{a1}
Day 3	6.94 ± 0.09^{b2}	6.26 ± 0.06^{c2}	7.31 ± 0.05^{a2}	6.32 ± 0.06^{b2}	6.28 ± 0.04^{c1}	6.58 ± 0.07^{a2}
Day 6	7.11 ± 0.11^{b3}	6.68 ± 0.17^{c3}	7.42 ± 0.12^{a3}	6.86 ± 0.11^{b3}	6.41 ± 0.11^{c2}	7.21 ± 0.23^{a3}
Day 8	7.39 ± 0.13^{b4}	6.85 ± 0.06^{c4}	7.79 ± 0.18^{a4}	7.23 ± 0.22^{b4}	6.96 ± 0.17^{c3}	7.35 ± 0.17^{a4}
	OKS	LKS	CS	OKT	LKT	CT
Day1	7.03 ± 0.35^{c1}	7.17 ± 0.15^{b1}	7.77 ± 0.15^{a1}	6.20 ± 0.36^{b1}	6.45 ± 0.24^{ab1}	6.64 ± 0.15^{a1}
Day 3	7.03 ± 0.21^{b1}	6.96 ± 0.05^{c1}	7.67 ± 0.29^{a2}	6.40 ± 0.35^{b2}	6.49 ± 0.35^{ab1}	6.50 ± 0.14^{a2}
Day 6	6.72 ± 0.16^{b2}	6.11 ± 0.06^{c2}	7.17 ± 0.20^{a3}	6.30 ± 0.07^{b3}	6.22 ± 0.14^{ab2}	6.42 ± 0.03^{a3}
Day 8	7.57 ± 0.31^{b3}	7.26 ± 0.04^{c3}	7.63 ± 0.55^{a4}	6.69 ± 0.16^{b4}	6.89 ± 0.04^{ab3}	7.13 ± 0.14^{a4}

n=3; Mean value ± standart deviation $^{a-c}$: a-c: different letters in the same row show statistically significant difference between the groups ($p<0.05$). $^{1-4}$: 1-4: different numbers in the same column show statistically significant difference for each group according to storage ($p<0.05$).

According to the sensory evaluation, the groups LKS, LLS and LXS were the most preferred group in terms of the odour, whereas the groups OXT, OLT and OKT were showed the best favorable sensorial characteristics in terms of color from the panelists at the beginning of the storage. At the end of the storage period (on day 8), general acceptability scores of the groups decreased to 1.80, 1.00, 1.60, 1.20, 1.40, 1.60 for the groups OXS, LXS, CS, OXT, LXT and CT, respectively, while general acceptability scores of the groups decreased to 1.60, 1.60, 1.80, 2.00, 2.40, 1.00 for the groups OLS, LLS, CS, OLT, LLT and CT. In addition to this, Sensory evaluation of the groups OKS, LKS, CS, OKT, LKT and CT decreased to 1.60, 2.60, 1.20, 1.80, 2.60, 1.20, respectively on the 8th day of storage. When compared with coated and uncoated samples, the lowest general acceptability scores were determined in uncoated samples.

Table 6. Sensory evaluation of coated by using orange and lemon peels with xanthan and uncoated rainbow trout fillets and squid rings during storage

Çizelge 6. Depolama sırasında ksantanlı portakal ve limon kabukları ile kaplanmış ve kaplanmamış gökkuşağı alabalığı filetoları ve kalamar halkalarının duyusal değerlendirmesi

Storage Time		Sensorial Quality					
		OXS	LXS	CS	OXT	LXT	CT
Day 1	color	7.20±1.30^{a1}	7.20±1.30^{a1}	8.60±0.89^{b1}	8.80±0.45^{c1}	7.20±0.84^{a1}	8.00±1.00^{b1}
	odor	7.80±1.30^{a1}	8.00±1.00^{a1}	8.40±0.55^{b1}	8.00±0.71^{b1}	7.60±0.89^{a1}	7.60±0.55^{a1}
	texture	8.40±0.89^{a1}	8.20±0.45^{a1}	8.80±0.45^{b1}	8.20±0.45^{a1}	8.40±0.55^{ab1}	8.60±0.55^{bc1}
	general	8.00±0.71^{b1}	7.60±1.14^{a1}	8.60±0.55^{c1}	8.00±0.71^{b1}	7.20±0.84^{a1}	8.60±0.55^{c1}
Day 3	color	5.20±0.84^{a2}	5.60±0.89^{b2}	6.80±1.10^{c2}	6.80±1.10^{b2}	5.80±0.45^{a2}	7.80±0.45^{c2}
	odor	6.40±0.55^{b2}	6.20±1.10^{b2}	5.80±0.84^{a2}	5.80±1.10^{a2}	6.20±0.45^{b2}	5.80±0.45^{a2}
	texture	7.20±0.84^{b2}	7.00±0.71^{b2}	6.60±0.89^{a2}	5.80±1.30^{b2}	7.00±1.00^{c2}	5.40±0.89^{a2}
	general	5.40±0.89^{a2}	5.60±1.14^{a2}	7.40±0.55^{b2}	7.20±0.84^{b2}	6.40±0.55^{a2}	7.40±0.55^{b2}
Day 6	color	3.60±0.89^{b3}	2.80±0.84^{a3}	4.80±1.30^{c3}	5.00±0.71^{b3}	4.20±1.30^{a3}	4.00±1.58^{a3}
	odor	5.20±0.84^{b3}	7.00±1.00^{c3}	4.20±0.84^{a3}	4.00±0.71^{b3}	5.00±0.71^{c3}	3.40±1.52^{a3}
	texture	5.40±0.89^{b3}	5.20±0.84^{c3}	4.40±1.14^{a3}	4.40±1.14^{a3}	4.80±0.45^{b3}	5.40±1.14^{c3}
	general	5.60±0.89^{c3}	4.80±0.45^{b3}	3.60±1.34^{a3}	5.40±0.89^{c3}	4.80±0.84^{b3}	4.20±1.30^{a3}
Day 8	color	1.40±0.55^{a4}	1.40±0.55^{a4}	2.40±0,89^{b4}	2.00±1.00^{ab4}	1.80±0.84^{a4}	2.20±0.84^{b4}
	odor	3.20±1.10^{c4}	2.80±0.84^{b4}	1.20±0.45^{a4}	2.00±0.71^{a4}	1.80±0.84^{a4}	1.80±0.84^{a4}
	texture	2.40±0.55^{c4}	2.00±0.71^{b4}	1.40±0.55^{a4}	2.40±0.55^{b4}	2.20±0,84^{ab4}	1.80±0.84^{a4}
	general	1.80±0.84^{ab4}	1.00±0.71^{b4}	1.60±0.89^{a4}	1.20±0.84^{b4}	1.40±0.55^{b4}	1.60±0.89^{a4}

n=3; Mean value ± standart deviation $^{a-c}$: a-c: different letters in the same row show statistically significant difference between the groups (p<0.05). $^{1-4}$: 1-4: different numbers in the same column show statistically significant difference according to storage (p<0.05).

Table 7. Sensory evaluation of coated by using orange and lemon peels with locust bean gum and uncoated rainbow trout fillets and squid rings during storage

Çizelge 7. keçiboynuzu gam ile portakal ve limon kabuklarıyla kaplanmış ve kaplanmamış gökkuşağı alabalığı filetoları ve kalamar halkalarının depolama sırasında duyusal değerlendirilmesi

Storage Time		Sensorial Quality					
		OLS	LLS	CS	OLT	LLT	CT
Day1	color	8.00±1.22^{b1}	7.20±0.84^{a1}	8.20±0.84^{b1}	8.60±0.55^{a1}	7.60±0.55^{b1}	8.60±0.55^{a1}
	odor	8.00±0.71^{b1}	8.60±0.55^{a1}	8.00±0.71^{b1}	7.60±0.55^{a1}	8.20±0.84^{b1}	8.50±0.58^{c1}
	texture	8.20±0.84^{a1}	8.20±0.84^{a1}	8.40±0.55^{b1}	8.00±0.71^{a1}	8.00±0.71^{a1}	8.60±0.55^{b1}
	general	7.80±0.84^{a1}	8.20±0.84^{b1}	8.60±0.55^{c1}	8.20±0.84^{a1}	8.20±0.84^{a1}	8.60±0.55^{b1}
Day 3	color	5.60±1.14^{a2}	6.20±0.84^{b2}	6.20±1.10^{b2}	5.80±1.30^{a2}	6.40±0.55^{b2}	6.20±1.30^{b2}
	odor	6.40±0.55^{b2}	6.20±1.10^{b2}	5.80±0,84^{a2}	5.80±1.10^{a2}	6.20±0.45^{b2}	5.80±0.45^{a2}
	texture	6.20±1.48^{a2}	6.20±1.30^{a2}	6.80±1.10^{b2}	5.80±1.79^{a2}	6.20±1.48^{b2}	5.60±1.14^{a2}
	general	6.20±0.84^{a2}	6.00±1.00^{a2}	6.80±0.45^{b2}	6.00±1.22^{a2}	6.20±0,84^{a2}	6.80±0.45^{b2}
Day 6	color	3.80±1.48^{b3}	3.00±1.00^{a3}	4.60±1.67^{c3}	4.00±0.71^{a3}	4.40±2.07^{b3}	3.80±1.79^{a3}
	odor	3.20±1.30^{a3}	3.60±1.82^{b3}	3.60±1.14^{b3}	3.20±1.30^{b3}	3.60±0.89^{c3}	2.80±0.84^{a3}
	texture	4.80±1.48^{a3}	5.00±1.22^{a3}	4.80±1.30^{a3}	4.80±1.30^{a3}	5.40±0.55^{b3}	4.80±1.64^{a3}
	general	5.00±0.71^{b3}	4.80±1.10^{b3}	3.80±1.10^{a3}	4.80±1.30^{b3}	4.60±1.34^{b3}	4.20±1.30^{a3}
Day 8	color	1.80±0.84^{a4}	1.60±0.55^{a4}	2.20±0.84^{b4}	2.40±0.55^{b4}	2.20±0.84^{a4}	2.40±1.14^{b4}
	odor	2.20±0.84^{b4}	2.80±0.45^{c4}	1.40±0.55^{a4}	2.40±0.55^{b4}	2.20±0.84^{b4}	1.40±0.55^{a4}
	texture	2.40±0.55^{c4}	2.00±0.71^{b4}	1.40±0.55^{a4}	2.40±0.55^{b4}	2.20±0.84^{b4}	1.80±0.84^{a4}
	general	1.60±0.55^{a4}	1.60±0.55^{a4}	1.80±0.84^{b4}	2.00±0.71^{a4}	2.40±0.55^{b4}	1.00±1.00^{a4}

n=3; Mean value ± standart deviation $^{a-c}$: a-c: different letters in the same row show statistically significant difference between the groups (p<0.05). $^{1-4}$: 1-4: different numbers in the same column show statistically significant difference according to storage (p<0.05).

Samples of colonies with different morphological characteristics were analyzed throughout the storage period. After the stage of purified and the colonies were identified with API 20 E bacterial identification test kits. According to the results taken from the computer Identification Program, isolated bacteria with identification rates were given as follows: In the groups of CS and CT, the isolation rates of *Moraxella* spp., *Ochrobacretrum anthropi* and *Enterobacter aerogenes* were equivalent to 85.7%, 85.9 and 96.2%, respectively. Bacteria identified in squid rings and rainbow trout fillets covered with extracts of orange and lemon peels and films made by using xanthan, locust bean and carrageenan were *Serratia* *liquefaciens* 98.0%, *Serratia marcescens* 98.0%, *Pasteurella aerogenes* 97.6%, *Photobacterium damselae* 84.7%, *Pantoe spp.* 95.8%, *Erwinia spp.* 95.8%. On the other hand, the bacterial strains identified in the samples, which were covered with orange extracts, lemon peels and edible films were equivalent to 98.0%, 98.0%, 97.6%, 84.7%, 95.8% and 95.8% for *Serratia liquefaciens, Serratia marcescens, Pasteurella aerogenes, Photobacterium damselae, Pantoe* spp*.*, *Erwinia* spp, respectively. Hence *Serratia liquefaciens* and *Serratia marcescens* were the most important species of the *Enterobacteriaceae* family.

Table 8. Sensory evaluation of coated by using orange and lemon peels with carrageenan gum and uncoated rainbow trout fillets and squid rings during storage
Çizelge 8. Karagenan gam ile Portakal ve limon kabuklarıyla kaplanmış ve kaplanmamış gökkuşağı alabalığı filetoları ve kalamar halkalarının depolama sırasında duyusal değerlendirilmesi

Storage Time		Sensorial Quality					
		OKS	LKS	CS	OKT	LKT	CT
Day 1	color	7.60±0.89^{b1}	7.80±0.84^{b1}	7.00±0.71^{a1}	8.50±0.71^{b1}	8.20±0.84^{b1}	7.40±0.55^{a1}
	odor	8.00±0.71^{a1}	8.40±0.55^{b1}	8.40±0.89^{b1}	7.80±0.84^{a1}	8.00±0.71^{a1}	8.60±0.55^{b1}
	texture	8.40±0.55^{b1}	8.20±0.45^{a1}	8.60±0.55^{b1}	8.20±0.45^{a1}	8.40±0.55^{ab1}	8.60±0.55^{b1}
	general	8.40±0.55^{b1}	7.80±0.84^{a1}	8.60±0.55^{b1}	8.40±0.55^{a1}	8.40±0.89^{a1}	8.80±0.45^{b1}
Day 3	color	5.60±0.55^{b2}	6.00±1.00^{c2}	5.00±1.22^{a2}	5.00±0.71^{a2}	7.20±0.84^{b2}	5.20±1.10^{a2}
	odor	6.80±0.84^{a2}	7.40±0.55^{b2}	6.60±0.55^{a2}	5.60±0.89^{a2}	7.40±0.55^{c2}	6.40±0.55^{b2}
	texture	6.80±0.45^{a2}	8.00±0.71^{b2}	7.60±0.55^{c2}	6.60±1.14^{a2}	7.40±0.55^{b2}	6.40±0.55^{a2}
	general	7.80±0.45^{a2}	7.80±0.45^{a2}	7.40±0.55^{b2}	7.60±0.55^{ab2}	7.80±0.84^{b2}	7.40±0.55^{a2}
Day 6	color	3.60±1.14^{a3}	4.40±1.52^{b3}	5.40±1.52^{c3}	3.60±0.89^{a3}	4.00±0.71^{b3}	4.80±1.30^{c3}
	odor	6.00±1.00^{a3}	5.60±1.52^{b3}	4.00±0.71^{c3}	5.00±1.22^{c3}	3.80±1.10^{b3}	3.20±1.30^{a3}
	texture	4.80±0.45^{b3}	4.60±0.55^{b3}	3.60±0.55^{a3}	4.00±0.71^{a3}	5.40±1.14^{b3}	4.00±1.22^{a3}
	general	5.20±1.30^{b3}	5.60±1.52^{c3}	4.00±1.22^{a3}	3.20±1.30^{a3}	5.40±1.82^{c3}	3.60±0.55^{b3}
Day 8	color	2.20±0.84^{b4}	1.80±0.84^{a4}	2.20±0.84^{b4}	2.00±0.71^{a4}	2.00±0.71^{a4}	2.00±1.00^{a4}
	odor	3.00±0.71^{b4}	3.00±0.71^{b4}	1.60±0.55^{a4}	2.20±0.84^{b4}	2.20±0.84^{b4}	1.40±0.55^{a4}
	texture	3.00±0.71^{b4}	2.40±1.14^{a4}	2.20±0.45^{a4}	2.20±0.84^{b4}	1.80±0.45^{a4}	1.80±0.84^{a4}
	general	1.60±0.55^{b4}	2.60±0.55^{b4}	1.20±0.45^{a4}	1.80±0.45^{b4}	2.60±0.55^{b4}	1.20±0.45^{a4}

n=3; Mean value ± standart deviation $^{a\text{-}c}$: a-c: different letters in the same row show statistically significant difference between the groups (p<0.05). $^{1\text{-}4}$: 1-4: different numbers in the same column show statistically significant difference according to storage (p<0.05).

According to the API 50 CH bacteria identification test kit, the identified lactic acid bacteria species as follows: *Lactobacillus acidophilus* 89.1%, *Lactobacillus salivarius* 99.9%, *Lactococcus lactis* %81.8 and *Lactobacillus brevis* 99.6% in rainbow trout fillets and squid rings after coating with orange and lemon peels extract and xanthan. Bacteria isolated in rainbow trout fillets and squid rings after coating with orange and lemon peels extract and locust bean were *Lactobacillus paracasei* 97.9%, *Lactococcus lactis* 96.5%, *Lactobacillus brevis* 98.0% and *Carnobacterium maltaromaticum* 99.9%. After coating with orange and lemon peel extracts and carragenaan, the identified bacteria in rainbow trout fillets and squid rings were *Lactobacillus pentosus* 86.0%, *Lactobacillus brevis* 95.6%, *Leuconostoc mesenteroides* 78.4%, *Lactobacillus paracasei* 95.0%, *Lactococcus lactis* 72.4%.

DISCUSSION

Hassanzadeh et al. (2018) studied the effect of 2.00 % chitosan and 0.10% grape seed extract on the shelf-life of rainbow trout fillets. The authors reported in their study that the coatings had significant effect on reducing the total bacteria counts of samples. This result was very similar to our findings that the edible films with orange and lemon peels were also inhibited the growth of bacteria on rainbow trout fillets and squid rings. The results obtained in our study were well correlated with the previous studies (Chamanara et al., 2013; Korkmaz et al., 2019; Socaciu et al., 2018; Song et al., 2011) about observing slower increase in TMC of the coated fishery products, when compared with uncoated samples. The group of *Entebactericeae* was reported to be an indicator of the hygienic conditions of the fresh rainbow trout by Mexis et al., (2009). In addition to this, this group of microorganisms was also reported to be plant sourced bacteria (Ünlütürk & Turantaş, 2003). Uçak (2019) reported that the coating of rainbow trout fillets with gelatin-based film either alone or in combination with of garlic peel extract (GPE) inhibited the growth of *Enterobactericeae* during the storage. However, in this study the lowest bacterial count was found in gelatin coated samples incorporated with GPE. Volpe et al. (2015) and Chytiri et al. (2004) also reported in their study that slow growth of Enterobacteriaceae was observed during storage period. Our results were very similar to those of the above studies (Chytiri et al. 2004; Uçak 2019; Volpe et al. 2015), in which edible films inhibited the growth of *Enterobactericeae* on fishery products during the storage. In addition to this, the group of LAB generally was recognized as safe for human consumption, and they also could be found naturally dominate microflora of many foods (Ghanbari et al., 2013). Raeisi et al. (2015) studied the application of carboxymethyl cellulose (CMC) coatings incorporated with *Zataria multiflora Boiss*. essential oil (ZMEO) and grape seed extract (GSE) to extend the shelf life of rainbow trout fillets. Researchers reported in their study that high concentrations of ZMEO and GSE rapidly increased the LAB counts of the samples, thereby LAB counts showed a strong synergistic effects against spoilage microorganisms. Likewise, Joukar et al. (2017) reported in their study that LAB counts developed at refrigerator temperatures. The initial LAB counts of trout fillets was reported to be 1 log CFU g^{-1}, whereas this value reached to 6.28 log CFU g^{-1} at the end of storage period. Our results were very similar with the above study, which was reported by Joukar et al. (2017). Based on the period of storage there were various rates of decrease or increase in the pH values of rainbow trout were reported by Aksoy and Sezer 2019; Chamanara et al. 2013; Hosseini et al. 2016. The authors also reported that a slight increase in the pH value of all samples were observed at the end of the storage due to the growth of spoilage related bacteria, which caused the alkaline compounds to be increased. Yu et al., (2018) reported that edible coatings were represented an effective and environmentally friendly alternative that can be used to extend the shelf-life of all types of fishery products. Frangos et al., (2010) stated that salt and oregano oil (0.2%) that were used in cooked trout samples had sensorially acceptable pleasant odor and were also well accepted by the panellists. In one report; the shelf-life of eel was specified as 16 days for laurel and 20 days for myrtle whereas 12 days for the control group (Özoğul et al., 2014). In another report; Alparslan et al. (2019) reported that the results of sensorial and microbiological analysis revealed that the shelf-life of gelatin coated shrimp had 12 days, while gelatin film with orange peel essential oil coated shrimp was 15 days. Previous studies reported that it was advised the use of edible films enriched with plant extracts and essential oils to extend the shelf-life of fishery products (Korkmaz et al., 2019; Mei et al., 2019; Mohan et al., 2012; Uçak, 2019). Sallam (2007) reported that the major group of microorganisms, which was responsible for spoilage of stored fresh fish at chilled temperatures, was the gram-negative psychrotrophic bacteria. The results obtained in this study were in accordance with the other studies, in which the authors reported an increase in psychrotrophic bacterial growth on fishery products during cold storage (Bulat et al., 2020; Chamanara et al., 2013; Granda, 2015; Kılınç & Altaş, 2016; Kılınç et al., 2017). *Erwinia* and *Serratia* species reported to be the plant-based microorganisms and they also reported not to be indicated the fecal contamination (Surengil, 2014). In our study, the groups of identified bacteria species such as *Serratia liquefaciens* (98%), *Serratia marcescens* (98%) and *Erwinia* spp. (95.8%) were thought to be originated from the orange and lemon peels. Lacticacid bacteria can be found in vegetable-derived products and spices. Lactic acid bacteria was isolated from plants and spices, which were reported by (Fuselli et al., 2003). In this study, *Lactobacillus paracasei* was isolated from black pepper, *L. cellobiosus* was isolated from bay leaf and *L.acidophilus* was isolated from red pepper (Fuselli et al., 2003).

CONCLUSION

In our study the impact of edible films with orange and lemon peels on microbial flora and shelf-life of squid rings (*Loligo vulgaris*) and rainbow trout fillets (*Oncorhynchus mykiss*) were evaluated. When compared with the uncoated samples, edible film coated samples had determined longer shelf-life. In terms of microbiological and sensory evaluation; the results of microbiological count were lower and sensory attributes were determined much more favorable in edible film coated samples, when compared to control samples. Especially, the groups LKS, LLS and LXS were the most preferred group in terms of the odour, whereas the groups OXT, OLT and OKT were showed the best favorable sensorial characteristics in terms of color. TMC of squid rings (CS) exceeded the microbiological limit of the consumption on day 6, whereas TMC of squid rings LLS and LKS did not exceed this limit on day 8.

The differences of the TMC of the groups were determined statistically significant ($p<0.05$) according to the coating types and the storage period. The most important bacteria species of rainbow trout fillets and squid rings covered with edible films prepared by using lemon and orange peels were identified as: *Lactobacillus paracasei* 97.9%, *Lactococcus lactis* 96.5%, *Carnobacterium maltaromaticum* 99.9%, *Lactobacillus pentosus* 86.0%, *Leuconostoc mesenteroides* 78.4%, *Lactobacillus acidophilus* 89.1%, *Lactobacillus salivarius* 99.9%, *Lactobacillus brevis* 99.6%, *Serratia liquefaciens* 98.0%, *Serratia marcescens* 98.0%, *Erwinia spp.* 95.8%. Discarded fruit peels in fruit juice processing plants can be evaluated for producing functional fishery products, which would a good alternative for being produced edible films. The results of this study can be evaluated by seafood and fruit juice processing plants as well as food producers.

ACKNOWLEDGEMENT

This study was supported by Republic of Türkiye Ministry of Agriculture and Forestry (TAGEM). The Project number: TAGEM/13/AR-GE/9.

Statement of Conflict Of Interest

Authors have declared no conflict of interest.

Author's Contributions

The contribution of the authors is equal.

REFERENCES

Akarca, G. & Sevik, R. (2021). Biological Activities of *Citrus limon* L. and *Citrus sinensis* L. Peel essential oils. *Journal of Essential Oil Bearing Plants 24(6),* 1415-1427. https://doi.org/10.1080/0972060X.2021.2022000

Aksoy, A. & Sezer, Ç. (2019). Combined use of laurel essential oil and vacuum packing to extend the shelf-life of rainbow trout (*Oncorhynchus mykiss*) fillets. *Kafkas Üniversitesi Veteriner Fakültesi Dergisi 25(6)*, 197-212. DOI: 10.9775/kvfd.2019.21852

Alparslan, Y., Baygar, T., Metin, C., Yapici, H. H. & Baygar, T. (2019). The role of gelatin-based film coating combined with orange peel essential oil on the quality of refrigerated shrimp. *Acta Aquatica Turcica 15(2),* 197-212. https://doi.org/10.22392/actaquatr.485132

Ashie, I.N., Smith, J.P. & Simpson, B.K. (1996). Spoilage and shelf-life extention of fresh fish and shellfish. *Critcal Reviews Food Science and Nutrition 36(1-2),* 87-121. https://doi.org/10.1080/10408399609527720

Baytop, T. (1999). Türkiye'de bitkiler ile tedavi, geçmişte ve bugün. İstanbul: İstanbul Üniversitesi Yayın., Eczacılık Fakültesi.

Bhalodia, N.R. & Shukla, V.J. (2011). Antibacterial and antifungal activities from leaf extracts of Cassia fistula l.: An ethnomedicinal plant. *Journal of advanced pharmaceutical technology & research 2(2),* 104. doi: 10.4103/2231-4040.82956

Bulat, F.N., Kılınç, B. & Atalay, S.D. (2020). Microbial ecology of different sardine parts stored at different temperatures and development of prediction models. *Food Bioscience 38,* 100770. https://doi.org/10.1016/j.fbio.2020.100770

Chamanara, V., Shabanpour, B., Khomeiri, M. & Gorgin, S. (2013). Shelf-life extention of fish samples by using enriched chitosan coating with thyme essential oil. *Journal of Food Product Technology 22(1),* 3-10. https://doi.org/10.1080/10498850.2011.621583

Chytiri, S., Chouliara, I., Savvaidis, I.N. & Kontominas, M.G. (2004). Microbiological, chemical and sensory assessment of iced whole and filleted aquacultured rainbow trout. *Food Microbiology 21(2),* 157-165. https://doi.org/10.1016/S0740-0020(03)00059-5

Ertürk, R., Çelik, C., Kaygusuz, R., & Aydın, H. (2010). Ticari olarak satilan kekik ve nane uçucu yağlarinin antimikrobiyal aktiviteleri. *Cumhuriyet Tıp Dergisi 32,* 281-286.

Fernandez-Lopez, J., Zhi, N., Aleson-Carbonell, L., Pérez-Alvarez, J.A. & Kuri, V. (2005). Antioxidant and antibacterial activities of natural extracts: application in beef meatballs. *Meat science 69(3),* 371-380. https://doi.org/10.1016/j.meatsci.2004.08.004

Frangos, L., Pyrgotou, N., Giatrakou, V., Ntzimani, A. & Savvaidis, I.N. (2010). Combined effects of salting, oregano oil and vacuum–packaging on the shelf-life of refrigerated trout fillets. *Food Microbiology 27(1),* 115-121. https://doi.org/10.1016/j.fm.2009.09.002

Fuselli, S.R., Casales, M.R., Fritz, R., & Yeannes, M.I., (2003). Typical microorganisms in cold marinated anhovies (*Engraulis anchoita)* filled with corn oil and spices. *Journal of Aquatic Food Product Technology 12(1),* 55-65. https://doi.org/10.1300/J030v12n01_04

Ghanbari, M., Jami, M., Domig, K.J. & Kneifel, W. (2013). Seafood biopreservation by lactic acid bacteria–a review. *LWT-Food Science and Technology 54(2),* 315-324. https://doi.org/10.1016/j.lwt.2013.05.039

Gonelimali, F.D., Lin, J., Miao, W., Xuan, J., Charles, F., Chen, M. & Hatab, S.R. (2018). Antimicrobial properties and mechanism of action of some plant extracts against food pathogens and spoilage microorganisms. *Frontiers in microbiology 9,* 1639. https://doi.org/10.3389/fmicb.2018.01639

Granda, X.C. (2015). Development of active edible coatings to ımprove the microbiological quality and safety of fish and seafood products. Departamento de Technologia de Alimentos Escuela Tecnica Superior de Ingenieros Agronomos Universidad Publica de Navarra. Memoria de Tesis Doctoral, 165 sy.

Harrigan, W., & McCance, M., (1976). Laboratory methods in food and dairy microbiolgy. Academic Press.

Hassanzadeh, P., Moradi, M., Vaezi, N., Moosavy, M.H. & Mahmoudi, R. (2018). Effects of chitosan edible coating containing grape seed extract on the shelf-life of refrigerated rainbow trout fillet. *Veterinary Research Forum: An International Quarterly Journal 9(1),* 73-79. PMID: 29719667

Hosseini, S.F., Rezaei, M., Zandi, M. & Ghavi, F.F. (2016). Effect of fish gelatin coating enriched with oregano essential oil on the quality of refrigerated rainbow trout fillet. *Journal of Aquatic Food Product Technology 25(6),* 835-842. https://doi.org/10.1080/10498850.2014.943917

ICMSF, (1986). Microorganisms in Foods: Vol 2: Sampling or Microbiological Analysis Principles and Specific Applications, 2nd ed. University of Toronto Press, Toronto, Ontario.

Joukar, F., Hosseini, S.M.H., Moosavi-Nasab, M., Mesbahi, G.R. & Behzadnia, A. (2017). Effect of farsi gum-based antimicrobial adhesive coatings on the refrigeration shelf life of rainbow trout fillets. *LWT Food Science and Technology 80,* 1-9. https://doi.org/10.1016/j.lwt.2017.01.074

Khan, U.A., Rahman, H., Niaz, Z., Qasim, M., Khan, J., Tayyaba. & Rehman, B. (2013). Antibacterial activity of some medicinal plants against selected human pathogenic bacteria. *European Journal of Microbiology and Immunology 3(4),* 272-274. https://doi.org/10.1556/eujmi.3.2013.4.6

Kılınç B, Altaş S, Sürengil, G. & Özdil, N. (2017). The development of new and alternative type of packaging for atlantic salmon (*Salmo salar*) fillets by producing nonwoven fabrics. *Journal of Food Processing and Preservation 41,* 1-8. https://doi.org/10.1111/jfpp.12850

Kılınç, B., Yalçın, H.T. & Sürengil, G. (2018). Meyve kabuklarının antimikrobiyal özellikleri ile yenilebilir film üretiminde kullanım potansiyelinin belirlenmesi. *The Black Sea Journal of Sciences, 8(1),* 144-157. https://doi.org/10.31466/kfbd.409052

Korkmaz, F., Kocaman, E. & Alak, G. (2019). Using of quinoa based film to extend the shelf life of rainbow trout fillets under cold storage. *Marine Science and Technology Bulletin 8(2),* 76-84. https://doi.org/10.33714/masteb.651262

Mei, J., Ma, X. & Xie, J. (2019). Review on natural preservatives for extending fish shelf life. Foods 8(10), 490. https://doi.org/10.3390/foods8100490

Mexis, S.F., Chouliara, E. & Kontominas, M.G. (2009). Combined effect of an oxygen absorber and oregano essential oil on shelf life extension of rainbow trout fillets stored at 4˚C. *Food Microbiology 26(6),* 598-605. https://doi.org/10.1016/j.fm.2009.04.002

Mohan, C.O., Ravishankar, C.N. & Gopal, T.K.S. (2016). Packaging interventions in low temperature preservation of fish –a review. *MOJ Food Process Technology 2(1),* 13-25. DOI: 10.15406/mojfpt.2016.02.00026

Mohan, C.O., Ravishankar, C.N., Lalitha, K.V. & Gopal, T.K.S. (2012). Effect of chitosan edible coating on the quality of double filleted Indian oil sardine (*Sardinella longiceps*) during chilled storage. *Food Hydrocoll 26(1),* 167-174. https://doi.org/10.1016/j.foodhyd.2011.05.005

Paulus, K., Zacharias, R., Robinson, L. & Geidel, H. (1979). Kritische betrachtungen zur bewertenden prufung mit skale als einem wesentlichen verfahren der sensorichen analyse. *LWT – Lebensmittel Wissenschaft und Technologie 12,* 52–61. http://pascal-francis.inist.fr/vibad/index.php?action=getRecordDetail&idt=PASCAL7910364204

Raeisi, M., Tajik, H., Aliakbarlu, J., Mirhosseini, S.H. & Hosseini, S.M.H. (2015). Effect of carboxymethyl cellulose-based coatings incorporated with Zataria multiflora Boiss. essential oil and grape seed extract on the shelf life of rainbow trout fillets. *LWT-Food Science and Technology 64(2),* 898-904. https://doi.org/10.1016/j.lwt.2015.06.010

Sallam, I.K. (2007). Antimicrobial and antioxidant effects of sodium acetate, sodium lactate, and sodium citrate in refrigerated sliced salmon. *Food Control 18(2),* 566–575. https://doi.org/10.1016/j.foodcont.2006.02.002

Socaciu, M.I., Semeniuc, C.A. & Vodnar, D.C. (2018). Edible films and coatings for fresh fish packaging: Focus on quality changes and shelf-life extension. *Coatings 8(10),* 366. https://doi.org/10.3390/coatings8100366

Song, Y., Liu, L., Shen, H., You, J. & Luo, Y. (2011). Effect of sodium alginate-based edible coating containing different anti-oxidants on quality and shelf life of refrigerated bream (*Megalobrama amblycephala*). *Food Control 22(3-4),* 608-615. https://doi.org/10.1016/j.foodcont.2010.10.012

Sothornvit, R. (2011). Edible coating and post-frying centrifuge step effect on quality of vacuum-fried banana chips. *Journal of Food Engineering 107(3–4),* 319–325. https://doi.org/10.1016/j.jfoodeng.2011.07.010

Sürengil, G., (2014). Su ürünlerinde farklı antimikrobiyal doğal ekstraktlar kullanılarak yenilebilir film uygulamaları, (Yüksek lisans Tezi), Ege Üniversitesi Fen Bilimleri Enstitüsü Su Ürünleri Anabilimdalı. Bornova, İzmir, Türkiye.

Uçak, I. (2019). Physicochemical and antimicrobial effects of gelatin based edible films ıncorporated with garlic peel extract on the rainbow trout fillets. *Progress in Nutrition 21(1),* 232-240. DOI: 10.23751/pn.v21i1.8222

Ünlütürk, A. & Turantaş, F. (2003). Gıda Mikrobiyolojisi. META Basım Matbaacılık Hizmetleri, ISBN: 975-483-383-4.

Viji, P., Venkateshwarlu, G., Ravishankar, C.N. & Srinivasa, G.T.K. (2017). Role of plant extracts as natural additives in fish and fish products a-review. *Fishery Technology 54,* 145-154.

Volpe, M.G., Siano, F., Paolucci, M., Sacco, A., Sorrentino, A., Malinconico, M. & Varricchio, E. (2015). Active edible coating effectiveness in shelf-life enhancement of trout (*Oncorhynchus mykiss)* fillets. *LWT-Food Science and Technology 60(1),* 615-622. https://doi.org/10.1016/j.lwt.2014.08.048

Yu, D., Regenstein, J.M. & Xia, W. (2018). Bio-based edible coatings for preservation of fishery products: A review. *Critical Reviews in Food Science and Nutrition 59(15),* 2481-2493. https://doi.org/10.1080/10408398.2018.1457623 .