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Original Article

Effect of Different Plant Extracts Added to Ice on Sensory Preference of Sliced Salmon

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ABSTRACT

Salmon is usually sold in slices on ice in retail markets. Since ice is in direct contact with fish, it affects the sensory characteristics as well as the physicochemical properties. Improving the properties of ice can make positive contributions to fish flavor and consumer preference. In this study, sliced salmons were treated with ice containing one of either basil (B), rosemary (R), laurel (L), oregano (O) or fennel (F) extracts. Iced salmon without any plant extract was the control (C) group. Displaying sliced fish for sale on ice and placing back to cold room at the end of the day is a common practice. Samples were covered with ice, stored at 18±1°C during daytime and taken to the cold room (2±1°C) at night to simulate marketing conditions. Adding plant extracts to ice resulted in a remarkable change in fish flavor, and R, F, and L were the most popular treatments among all groups. In particular, rosemary-added ice significantly ($P<0.05$) increased the preference of consumption. Panelists emphasized that F samples can be consumed as appetizers. Dominant and pleasant aroma was also stated for L samples. The mesophilic aerobic bacteria count remained below 5 log CFU/g in all samples during 4 days. The total volatile basic nitrogen (TVB-N), thiobarbituric acid reactive substances (TBARS) and pH values of all groups remained within the limits of acceptability. Using plant extract-added-ice provided a suitable quality sale of salmon for 4 days and offered an option to consumers by giving the product different flavors.

Keywords: Plant extract, Icing, Fish, Salmon, Sensory preference

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INTRODUCTION

Chilling of harvested fish is the first thing to do in order to maintain the postmortem quality of flesh. Temperature is the most important factor to extend shelf life by retaining the freshness of fish. Since fish is highly perishable, it is necessary to store it at the minimum temperature just above the freezing point of water. Icing delays microbial growth, slows down enzymatic activity and prevents dehydration. Therefore, it has been the most common handling practice during the transportation, storage and marketing of fish (Huss, 1995).

Atlantic salmon is one of the major species produced in world aquaculture (4.5%). In 2018, the total number of Atlantic salmon production was 2435.9 thousand tonnes, and it is expected to continue growing. Salmon is a high value species and widely marketable, and the importation of it is spread all over the world (FAO, 2020). In most countries, fresh salmon is marketed to consumers in slices on ice in the market. This facilitates the sale and helps the fish to maintain its freshness. The ice melts in time, washes the surface of the fish and prevents the loss of moisture. Based on being in direct contact with the fish, the properties of the ice are important, and it can be claimed that improving the properties of ice can make positive contributions to fish flavor and acceptance.

There are studies that have added plant extracts to ice in order to examine the chemical

quality of fish (Quitral et al., 2009; Yerlikaya, Ucak, Gumus & Gokoglu, 2015) or to create a biofilm (Bensid, Bendeddouche, Toy, Sigirci & Özogul, 2014a). However, it is also important to examine the effect of extract on the taste and appearance of fish in terms of consumer acceptance. Otherwise, it will not be possible to sell the product even if the treatment provides advantages in terms of fish quality and shelf life. Therefore, evaluating the sensory appreciation of treatment is of great importance. There are several methods to evaluate the sensory quality of fish such as QIM, EC or Torry Schemes (Barbosa, Bremner & Vaz-Pires, 2002). However, these methods are not adapted to measure the acceptance–preference when an additional treatment is applied on fish. The nine-point hedonic scale provides data about preference of consumers by evaluating the likes and dislikes of the product. The scale is simple to describe and easy to use for all types of foods (Stone & Sidel, 2004). On the other hand, when there are more than three types of food samples, there is a need for a rank-rating scale in order to determine the comparative perception and preference of consumers. The aim of the ranking method is to evaluate and compare the products with each other and place them in increasing order in terms of consumers' perceived intensities rather than mean scores along a predetermined scale (Cleaver, 2018).

Salmon is usually sold in slices on ice in retail markets. Since ice is in direct contact with the fish, it directly affects the quality and attributes of the fish. In this study, the potential of increasing consumer acceptance by adding various plant extracts to ice was investigated. Thus, the possibility of offering salmon, which has already been sold in slices on ice in retail markets, with extended variations of flavors was examined. It is known that when the stock rotation is not considered during the sale, the sliced fish can be placed back in the cold room at the end of the day and offered for sale on ice the next day. Therefore, while the effects of plant extracts added to ice on sensory properties of salmon were studied, and the changes in quality were also examined by simulating the sales conditions.

MATERIAL AND METHODS

Materials and preparation of ice

Whole gutted Atlantic salmon (*Salmo salar* Linnaeus, 1758) was purchased from Metro Gross market, İstanbul, Turkey. A total of 22.5 kg salmon were used for this study. Metro Gross market imported salmon from Norway in polystyrene boxes with ice within three days after the harvest, without breaking the cold chain. Salmons were wrapped with ice gel packs during purchasing and transferred to the laboratory within 30 minutes, then sliced in accordance with the sales conditions. The average size of a salmon slice was 126±6.55 grams.

Basil (*Ocimum basilicum*), rosemary (*Salvia rosmarinus*), laurel (*Laurus nobilis*), oregano (*Origanum vulgare*) or fennel (*Foeniculum vulgare*) liquid extracts were purchased from Alfasol (Kimbiotek) Chemical Materials Ind. & Trade. Co. Ltd., Turkey. These extracts were added to tap water during ice making, separately. Extracts were dissolved in water at the ratio of 1:100 (v/v). Water with each extract was divided into 1 kg batches and frozen. Each ice block was crushed before use. Salmon slices were divided into 6 groups, each group was layered into a styrofoam box and covered with one of the prepared ice varieties. Salmon treated with basil (B), rosemary (R), laurel (L), oregano (O) or fennel (F) extracts added to ice were grouped by the name of the extracts. Control (C) group was determined as the salmon exposed to ice without any extracts. Fish to ice ratio were always maintained as 1:2 (w/w) and the ice was replenished during storage in case of need.

Experimental conditions and sampling

During day time, salmon slices were laid on the counter and surrounded by ice to simulate the retail sales conditions in a fish market. The ambient temperature was 18±1°C and humidity was 42.9±0.2%. Iced salmon was displayed for approximately eight hours on the counter. In the evening, salmon slices were placed in separate styrofoam boxes and covered with related ice varieties to imitate the conditions in the market. The boxes that allow draining were stored in an isothermal cold room at 2±1°C. Humidity of the cold room was 83±0.2%. The boxes were stored in the cold room for approximately sixteen hours until the morning. In the morning, fish were displayed on ice at 18°C again under retail sales conditions. This cycle continued, and the sampling was carried out every day for five days (including the day zero) at the noon time.

Sensory Tests

Two different tests were carried out for four days. Each day, panelists were asked to evaluate every group of iced salmon according to the hedonic preference test and then to rank for the rank-rating test. The hedonic preference test was performed by 12 experienced panelists using 9 to 1 scale, ranging from extreme dislike (score 1), neither like nor dislike (score 5) to extreme liking (score 9) (Stone & Sidel, 2004) (Figure 1a). The samples taking the sensory score of ≤4 were considered as spoiled. Both raw and cooked salmon were served for the evaluation. Samples were coded with three digit numbers to avoid any prejudgment. All descriptions were also given below the form. For cooked fish assessment, salmon was put in a glass jar which was placed into a water filled pot and heated up in a bain-marie. Thus, the possibility of irrelevant smell contamination that may occur during cooking was eliminated. After 20 minutes of simmering in the bain-marie, salmon was done, and the internal temperature was ~80-85°C. The cooked samples were served to the panelists immediately.

The panelists were also asked to rank the fish samples in ascending order of preference from the most liked (#1) to the disliked (#6) for the ranking preference test (Figure 1b) (Cleaver, 2018). Twelve panelists performed the ranking test. Thus, the panelists have determined the most favorite treatments.

Microbial analysis

Total aerobic bacterial counts were analyzed in triplicate in agar plates with duplicate measurements as described in the Bacteriological Analytical Manual (Maturin & Peeler, 2001). Ten grams of each fish sample were put into a sterile filter bag and stomached in 90 mL peptone water (0.1%). After homogenization, serial dilutions were prepared. For the estimation of aerobic bacteria, 1 mL aliquots from the appropriate dilutions were inoculated onto Plate Count Agar (PCA) (Merck No. 1.05463) plates. Pour plate technique was used. The plates were incubated at 37°C for 48 h. The results were reported as Colony Forming Unit per gram (CFU/g) of sample.

Name: Date:

HEDONIC PREFERENCE TEST

RAW SALMON	Sample Code 720	337	548	219	405	681
Appearance						
Odor						
Texture						

COOKED SALMON	Sample Code 720	337	548	219	405	681
Appearance						
Odor						
Taste						
Texture						

Comments:

Score	Hedonic Scale
9	Like extremely
8	Like very much
7	Like moderately
6	Like slightly
5	Neither like nor dislike
4	Dislike slightly
3	Dislike moderately
2	Dislike very much
1	Dislike extremely

(a)

RANKING PREFERENCE TEST

Please rank the samples from the most liked (#1) to the least liked (#6).

	1	2	3	4	5	6
Sample Code						

(b)

Figure 1. Sensory analysis forms of iced salmon for **(a)** Hedonic preference test and **(b)** Ranking preference test in which the codes present the samples as follows: 720-Basil; 337-Rosemary; 548-Laurel; 219-Control; 405-Oregano and 681-Fennel.

Physicochemical analyzes

Total volatile basic nitrogen (TVB-N), thiobarbituric acid reactive substances (TBARS) and pH measurements were carried out. For TVB-N determination, 10 g fish sample was boiled with magnesium oxide, and 0.1 N hydrochloric acid (HCl) was used to hold the vapor components by the steam distillation. HCl was titrated with 0.1 N sodium hydroxide, and the amount of TVB-N was calculated as mg/100g (Schormüller, 1968). In order to determine the lipid oxidation, 5 g sample was homogenized with 100 µL of butylated hydroxytoluene and 50 mL of distilled water. After the addition of 2.5 mL of 4 N HCl and further 97.5 mL of distilled water, the sample was heated, and steam was distilled. The condensed liquid was mixed with 2-thiobarbituric acid reactive and placed into a hot water bath (80°C) for 30 mins. Optical density was measured at 532 nm followed by cooling. Results were expressed as mg malondialdehyde/kg (mg MA/kg) (Vyncke, 1970). The pH analysis was carried out with the homogenized and 1:10 diluted sample. The pH value was measured using a pH-meter (Jenco, 6173pH, China).

Statistical analyzes

Statistical analyzes were performed using SPSS 21 (IBM SPSS Version 21, IL, USA). The results were analyzed by means of analysis of variance (ANOVA). The significant difference level among batches was chosen as 0.05. Tukey tests were used, and standard errors were presented in the tables. Friedman two-way analysis of variance was used to evaluate the statistics of rank-rating sensory tests. Analyzes were carried out in triplicate, and this study was replicated twice.

RESULTS AND DISCUSSION

Sensory evaluation

The initial quality of salmon was defined as excellent (day 0) since the sensory scores were 8.64 and 8.33 for the raw and cooked samples, respectively. Sales conditions were imitated for 4 days, and panelists evaluated each group of iced salmon according to hedonic preference test and ranked for ranking preference test. After one day on ice, with or without plant extracts, the scores of all groups were similar ($P \geq 0.05$), and the overall acceptability was high. As a result of hedonic preference test, none of the samples were regarded as spoiled during 4-day storage. During this period, salmon slices were displayed on ice –with or without plant extracts– during daytime and taken to the cold store in iced boxes in the evening.

Sensory quality of control samples was found to be similar to the other groups in terms of freshness for 4 days (Table 1). However, the ranking preference test showed that control samples were not preferred by any panelists on the first day, yet they were liked by only 8% of the panelists on the 2nd and 3rd days of the study (Table 2). Likewise, basil-added ice (B) resulted in acceptable quality during sales conditions (Table 1), but it was not among the panelists' favorite options (Table 2). Display and storage on oregano-added ice (O) gained the appreciation of 25% of panelists on the 3rd day. However, none of the panelists preferred this treatment on days 1 and 2, and only 8% preferred it on day 4, according to the ranking preference test. Bensid, Ucar, Bendeddouche & Özogul (2014b) kept anchovies in a cold store with ice containing thyme (0.04% w/v) and oregano (0.03% w/v). These amounts were lower than that of our study, and the samples were highly preferred by the panelists due to their desirable odor. In another cold storage study, 1% thyme or laurel essential oil was added into homogenized bluefish fillets and put in plastic bags which were stored in ice. It was determined that the sensory scores of treated groups were higher than the untreated group (Erkan et al. 2011).

The addition of plant extracts to the ice led to an evident change in fish flavor which was defined as herbal or spicy by the panelists after being cooked. The flavors obtained by adding oregano or basil to the ice were not preferred compared to other treatments. However, the flavors released in other three groups (R, F, and L) were among the most popular ones in the ranking test (Table 2). In particular, addition of rosemary to ice (R) significantly improved the aroma and increased the preference. These samples (R) usually received the highest sensory scores in hedonic preference test, and the panelists expressed a pleasant flavor and aroma. According to the ranking preference test, rosemary

Table 1. Sensory scores of control and basil, rosemary, laurel, oregano or fennel extract added iced raw and cooked salmon samples.

Raw Salmon				
	Day 1	**Day 2**	**Day 3**	**Day 4**
Control	$7.64\pm0.78^{a, X}$	$6.86\pm0.61^{a, X}$	$5.78\pm0.83^{ac, Y}$	$5.78\pm0.80^{a, Y}$
Basil	$7.35\pm0.67^{a, X}$	$6.88\pm0.46^{a, X}$	$5.57\pm1.06^{a, Y}$	$5.69\pm0.78^{a, Y}$
Rosemary	$7.47\pm0.66^{a, X}$	$7.49\pm0.65^{a, X}$	$6.93\pm0.60^{b, X}$	$5.78\pm0.46^{a, Y}$
Laurel	$7.46\pm0.87^{a, X}$	$7.39\pm0.60^{a, X}$	$6.99\pm0.71^{b, X}$	$5.75\pm0.90^{a, Y}$
Oregano	$7.35\pm0.81^{a, X}$	$6.76\pm0.88^{a, X}$	$6.58\pm0.67^{bc, X}$	$5.19\pm0.63^{a, Y}$
Fennel	$7.63\pm0.66^{a, X}$	$7.38\pm0.77^{a, X}$	$6.50\pm0.71^{ab, Y}$	$5.57\pm0.87^{a, Z}$
Cooked Salmon				
	Day 1	**Day 2**	**Day 3**	**Day 4**
Control	$7.14\pm0.85^{a, X}$	$6.78\pm0.59^{a, X}$	$5.76\pm0.67^{a, Y}$	$5.67\pm0.51^{a, Y}$
Basil	$7.52\pm0.73^{a, X}$	$6.94\pm0.43^{ab, X}$	$5.65\pm0.98^{a, Y}$	$5.57\pm0.97^{a, Y}$
Rosemary	$7.99\pm0.67^{a, X}$	$7.63\pm0.75^{b, XY}$	$6.91\pm0.91^{b, Y}$	$5.82\pm0.88^{a, Z}$
Laurel	$7.55\pm0.82^{a, X}$	$7.41\pm0.84^{ab, X}$	$6.87\pm0.63^{b, X}$	$5.57\pm0.80^{a, Y}$
Oregano	$7.48\pm0.67^{a, X}$	$6.66\pm0.66^{a, Y}$	$6.48\pm0.81^{ab, Y}$	$5.25\pm0.81^{a, Z}$
Fennel	$7.89\pm0.80^{a, X}$	$7.40\pm0.80^{ab, XY}$	$6.73\pm0.70^{b, Y}$	$5.37\pm1.01^{a, Z}$

$^{a, b, c}$: Mean values followed by different low-case letters show statistical difference ($P<0.05$) between the groups; $^{X, Y, Z}$: Mean values followed by different capital letters indicate significant ($P<0.05$) differences among the days for the same group.

Table 2. Percentages of the scores of ranking tests for the salmon treated with rosemary, fennel, laurel, oregano, basil extracts-containing and traditional ice on days 1, 2, 3, and 4.

	Percentage of ranking scores (%)			
	Day 1	**Day 2**	**Day 3**	**Day 4**
Rosemary	41	34	25	25
Fennel	25	25	17	17
Laurel	17	33	8	25
Oregano	0	0	25	8
Basil	17	0	17	0
Control	0	8	8	25

treatment was chosen by 41% of the panelists as the most liked treatment on day 1. Similarly, R was the most preferred treatment by 34%, 25%, and 25% of panelists on the 2nd, 3rd and 4th days of storage, respectively. In general, this treatment was regarded as the favorite treatment by the panelists, and samples were acceptable during 4 days of storage simulating selling conditions. In another study, sardines were covered with rosemary extract-added ice and stored in a refrigerated room (Özyurt et al., 2012). Unlike our study, it was not aimed to imitate the sales conditions, and samples were kept in the cold storage continuously. No significant differences were reported between sensory qualities of sardines stored with ice containing 0.05% and 0.1% rosemary extract. Samples were regarded acceptable in terms of sensory quality during 15 days of storage. Ozogul et al. (2011) studied the effect of rosemary extract on the quality of frozen sardines. They treated sardines with 1% and 2% extract, stored at -18°C and reported no significant difference between the control and processed samples in terms of color, odor and tightness during 4 months of storage. In addition, they noted a bitter taste in the samples treated with 2% rosemary extract, considering sensory test results.

As for the samples exposed to fennel-added-ice (F), the panelists emphasized that these salmon slices could be consumed as appetizers because of their nice and distinct fennel taste. Although a significant change in aroma was reported due to the addition of fennel into the ice, this change was mostly regarded as pleasant. On the first two days of storage, F samples were regarded as the most liked treatment by 25% of panelists; while it was liked by 17% on the 3rd and 4th days.

A dominant and pleasant aroma was also stated for the samples treated with laurel-added ice (L), and this aroma was defined as herbal. According to the ranking test of group L, the preference percentages of the panelists were 17%, 33%, 8% and 25% on the 1st, 2nd, 3rd and 4th days of storage, respectively. The panelists stated that the herbal or spicy flavors developed in R, F, and L may be preferred especially by the consumer who does not like the taste and smell of fish. It was also asserted that it could be an advantage for the consumer who prefers products with different flavors.

Quality assessment

The quality of freshly sold salmon depends on its microbiological and physicochemical conditions which can be affected by environmental factors. Even though the sensory characteristics of the fish marketed to the consumer seem very pleasant, they may not be suitable for consumption if there are significant losses in these quality parameters. So, it is necessary to evaluate the microbiological and physicochemical parameters in the sales conditions of the fish treated with plant extract-added ice.

Total viable microbial load of the fresh salmon was 3.32±0.08 log CFU/g on day zero. The microbial counts slightly increased during storage. Significant differences (P>0.05) were not determined between the groups during storage. All groups were slightly above 4 log on the fourth day (Table 3). Likewise, Rey, Garcia-Soto, Fuertes-Gamundi, Aubourg & Barros-Velazquez (2012) determined that the total aerobic count of hake iced with/without 0.4% or 0.8% citric, lactic and ascorbic acid commercial mixtures, was between 3 and 4.5 log CFU/g during 5 days of chilled storage. In another study, the aerobic counts of chilled mackerel (iced containing 0.02% of citric, lactic or ascorbic acids) were lower than the traditionally iced group on the 3rd and 6th days. However, the microbial load of traditionally iced fish was 4.21 log CFU/g on the 6th day (Sanjuas-Rey, Gallardo, Barros-Velazquez & Aubourg, 2012). Similarly, the mesophilic load of group C was higher than that of groups B and R on the 3rd day, but all groups were about 4 log CFU/g at the 4th day of storage in our study. Bensid et al. (2014b) reported that iced anchovy with/without oregano extract on the 6th day had the mesophilic bacteria counts above 7 log CFU/g. Mesophilic bacteria load of sardine with rosemary extract-added ice was also reported above 7 log CFU/g after 15 days (Ozyurt et al., 2012). In our study, mesophilic aerobic bacteria count remained below 5 log CFU/g, and all samples were acceptable for 4 days, when the sales conditions were imitated.

The pH value of the fresh salmon was 6.28±0.02 on day zero. Similar pH values were presented by Duun & Rustad (2008) for super chilled salmon. The acceptance limit for pH value is generally 6.8, and the fish is considered to be spoiled when the value increases to 7.0 (Ludorff & Meyer, 1973; Belitz, Grosch & Schieberle, 2009). In this study, even though there were statistical differences between the groups (P≤0.05), pH values of all samples remained below 6.8 during storage (Table 4). Bensid et al. (2014b) stated that pH was not significantly affected by the presence of thyme, oregano or clove plant extracts in ice during the chilled storage of anchovy unlike our study. Post-mortem pH increases due to the microbial activity which results in the rise of alkaline compounds such as TVB-N and can be between 6.0 to 7.1 (Özden, Inugur & Erkan, 2007). In this study, the microbial activity increased by about 1 log during five days in all groups, and it clearly seemed to affect neither pH nor TVB-N and not exceeded the limit values.

The initial TVB-N value of samples was 13.51±2.04 mg/100 g. Generally 30 mg/100 g TVB-N is considered as the limit of acceptance for fish (Sikorski, Kolakowska & Burt, 1990; European Economic Commission, 1995). It is also stated that the TVB-N parameter is an indicator of the suitability of fish for human consumption (Ozogul & Ozogul, 2000). As it was presented in Figure 2, none of the samples reached 30 mg/100 g. In a previous study, rosemary and oregano extract-icing were used to store Chilean jack mackerel for a 23-day chilling period (Quitral et al., 2009). The TVB-N content of all samples remained 5 mg/100 g during the first 4 days of storage. Especially after 10 days of storage, the TVB-N content of traditionally iced samples increased significantly and was higher than extract-iced groups. However, none of the samples contained TVB-N values above 25 mg/100 g. Likewise, TVB-N content of all samples were well below the acceptability limit in our study. Bensid et al. (2014b) examined the effect of ice containing thyme and oregano extracts on anchovy quality. They reported a small difference between the TVB-N values of control and the plant extract added groups, during the first days of storage. Likewise, no significant difference was reported between the TVB-N values of sardines, chilled with traditional or rosemary extract added ice, during storage (Ozyurt et al., 2012).

In this study, TBARS value was 0.48±0.07 mg MA/kg on Day zero. Fish, having TBARS value above 5–8 mg MA/kg (Nunes et al., 1992) or 8 mg MA/kg (Schormüller, 1968) is defined to be unacceptable. The salmon samples were in good condition in terms of lipid oxidation and did not even get close to the limit (Figure 3). Mixing plant extracts to water during ice making and letting this ice contact with the salmon decelerated lipid oxidation in comparison to control on the 4th day. Sanjuas-Rey, Barros-Velazquez & Aubourg, (2011) also stated that horse mackerel iced with 0.02% of citric, lactic and ascorbic acids had lower TBARS value than the control group during cold storage on the 4th day, similarly. Quitral et al. (2009) exposed Chilean jack mackerel to oregano and rosemary extracts-added ice and compared their quality to traditional ice. The TBARS values of the samples stored with plain ice increased after the 5th day of storage and reached 3 mg MA/kg, but extract-added ice samples' TBARS values were between 0.5-1 mg MA/kg during 23 days storage. In our study, TBARS values remained below 2 mg MA/kg in all groups during 4 days of storage, well below the limit of accept-

Table 3. Total viable aerobic plate counts of control and basil, rosemary, laurel, oregano or fennel extract added iced groups.

	Total viable plate counts (log CFU/g)			
	Day 1	**Day 2**	**Day 3**	**Day 4**
Control	3.46±0.02$^{a, XY}$	3.45±0.10$^{a, X}$	3.54±0.07$^{a, XY}$	4.24±0.23$^{a, Y}$
Basil	3.31±0.06$^{a, X}$	3.18±0.09$^{a, X}$	3.26±0.04$^{b, X}$	4.37±0.13$^{a, Y}$
Rosemary	3.46±0.05$^{a, X}$	3.22±0.03$^{a, Y}$	3.27±0.05$^{b, Y}$	4.27±0.15$^{a, Z}$
Laurel	3.46±0.03$^{a, X}$	3.12±0.03$^{a, Y}$	3.18±0.16$^{ab, XY}$	4.45±0.05$^{a, Z}$
Oregano	3.44±0.20$^{a, X}$	3.34±0.13$^{a, X}$	3.39±0.07^{ab,}	4.39±0.02$^{a, Y}$
Fennel	3.45±0.07$^{a, XZ}$	3.16±0.03$^{a, YW}$	3.20±0.16$^{ab, XY}$	4.46±0.34$^{a, ZW}$

$^{a, b}$ Different letters in the same column indicate statistical difference (P<0.05) between the groups; $^{W, X, Y, Z}$ Different letters in the same raw show statistical difference (P<0.05) among the days for the same group.

Table 4. The pH values of control and basil, rosemary, laurel, oregano or fennel extract-added iced salmon groups.

	Day 1	Day 2	Day 3	Day 4
Control	6.28±0.06$^{abc, X}$	6.30±0.02$^{ac, X}$	6.32±0.03$^{ab, X}$	6.29±0.02$^{a, X}$
Basil	6.31±0.04$^{ac, X}$	6.31±0.01$^{a, X}$	6.30±0.04$^{ab, X}$	6.35±0.06$^{a, X}$
Rosemary	6.30±0.03$^{ac, X}$	6.25±0.01$^{b, Y}$	6.28±0.02$^{a, X}$	6.30±0.03$^{a, X}$
Laurel	6.26±0.02$^{c, X}$	6.33±0.01$^{c, Y}$	6.34±0.03$^{b, Y}$	6.35±0.05$^{a, Y}$
Oregano	6.32±0.01$^{a, X}$	6.29±0.07$^{abc, X}$	6.28±0.07$^{ab, X}$	6.29±0.02$^{a, X}$
Fennel	6.22±0.01$^{b, X}$	6.23±0.02$^{b, X}$	6.31±0.03$^{ab, Y}$	6.30±0.03$^{a, Y}$

$^{a, b, c}$ Mean values followed by lowercase letters show statistical difference (P<0.05) between the groups; $^{X, Y, Z}$ Mean values followed by capital letters indicate statistical difference (P<0.05) for the same group among the days.

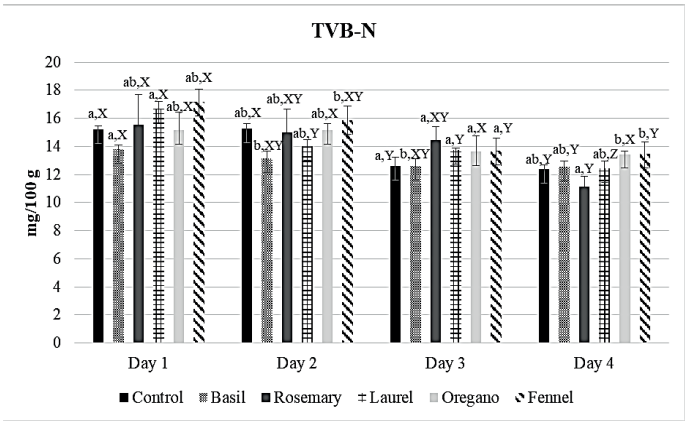

Figure 2. Total volatile basic nitrogen amounts of control and basil, rosemary, laurel, oregano or fennel extract-added iced groups.

$^{a, b, c}$Different lowercase letters indicate statistical difference (P<0.05) between the groups; $^{X, Y, Z}$ Different capital letters indicate statistical difference (P<0.05) among days.

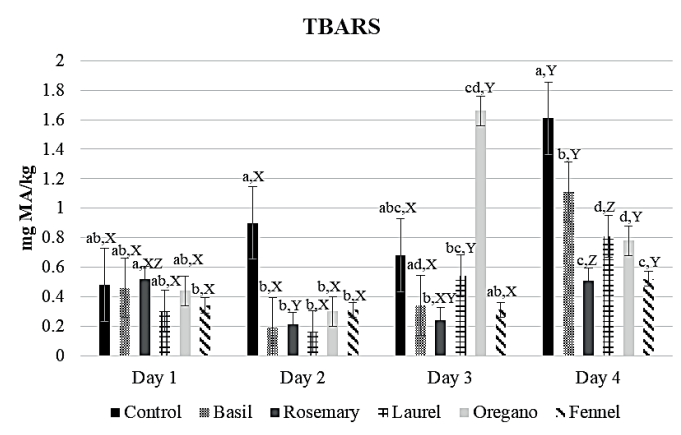

Figure 3. Thiobarbituric acid reactive substances analysis' results of control and basil, rosemary, laurel, oregano or fennel extract-added iced groups.

$^{a, b, c, d}$ Different lowercase letters show statistical difference (P<0.05) between the groups; $^{X, Y, Z}$ Different capital letters show statistical difference (P<0.05) among the days.

ability. Özyurt et al. (2012) stored sardines with traditional ice and ice with 0.05% and 0.1% rosemary extract. After 15 days of cold storage, they reported that TBARS values were above 5 mg MA/kg for traditional and 0.05% extract-added samples, and above 4 mg MA/kg for 0.1% rosemary extract-added samples. However, in our study the sale conditions were imitated, and none of the samples reached TBARS value of 2 mg MA/kg. Ozogul et al. (2011) treated sardines with rosemary extract (1% and 2%) and reported that the antioxidant effect could be achieved at the extract level of 2%. However, they also expressed a bitter taste in the samples treated with this amount of extract. In another study, addition of citrus peel extracts into ice during cold storage of common carp suppressed secondary lipid oxidation products in comparison to the control (Yerlikaya et al., 2015). It was also reported that the rancidity development remained low in pink salmon stored in iced or chilled sea water. No difference (P>0.05) between TBARS values were observed among the samples for ten days of storage (Himelbloom, Crapo, Brown, Babbitt & Reppond, 1994).

CONCLUSION

The effects of plant extract-added-ice on the sensory properties of sliced salmon were studied and quality changes were examined under the imitated sales conditions. Addition of plant extracts to ice was determined to be beneficial both for retaining the quality of fish and creating new flavors. Plant extract-added ice treatment of fillets resulted in a remarkable change in fish flavor, and rosemary, fennel and laurel treatments were the most popular. In particular, rosemary added ice significantly increased sensory preference. All groups were acceptable after 4 days of study, imitating the retail conditions. The use of plant extract-added-ice provided a suitable quality sale of sliced salmon and offered a different option to the consumer by giving the fillets unique flavors for the perfect sensory experience. Good quality and alternative flavored seafood can create a positive perception for consumers and the market.

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REFERENCES

Barbosa, A., Bremner, H. A. & Vaz-Pires, P. (2002). The meaning of shelf-life. In H. A. Bremner (Ed.), *Safety and quality issues in fish processing* (pp. 173-190). Cambridge, United Kingdom: Woodhead Publishing. [CrossRef]

Belitz, H. D., Grosch, W. & Schieberle, P. (2009). *Food Chemistry.* Germany: Springer-Verlag Berlin Heidelberg.

Bensid, A., Bendeddouche, B., Toy, N., Sigirci, F. & Özogul, F. (2014a). Effects of ice containing three ethanolic plant extracts on formation and accumulation of biofilm communities on fish contact surfaces. *Indian Journal of Fisheries, 61*(3), 129-134.

Bensid, A., Ucar, Y., Bendeddouche, B. & Özogul, F. (2014b). Effect of the icing with thyme, oregano and clove extracts on quality parameters of gutted and beheaded anchovy (*Engraulis encrasicholus*) during chilled storage. *Food Chemistry, 145*, 681-686. [CrossRef]

Cleaver, G. (2018). Ranking and rank-rating. In S. E. Kemp, J. Hort & T. Hollowood (Eds.), *Descriptive analysis in sensory evaluation* (pp. 447-491). New Jersey: Wiley-Blackwell. [CrossRef]

Duun, A. S. & Rustad, T. (2008). Quality of superchilled vacuum packed Atlantic salmon (*Salmo salar*) fillets stored at -1.4 and -3.6°C. *Food Chemistry, 106*, 122-131. [CrossRef]

Erkan, N., Tosun, S. Y., Ulusoy, S. & Uretener, G. (2011). The use of thyme and laurel essential oil treatments to extend the shelf life of bluefish (*Pomatomus saltatrix*) during storage in ice. *Journal für Verbraucherschutz und Lebensmittelsicherheit, 6*(1), 39-48. [CrossRef]

European Economic Commission. (1995). Determinación de la concentración de bases nitrogenadas volátiles (NBVT) en pescados y productos de la pesca procedimiento de referencia. *Diario Oficial de las Comunidades Europeas N°L, 97*, 84-87.

FAO. (2020). The state of world fisheries and aquaculture 2020. Sustainability in action. Rome. Retrieved from http://www.fao.org/3/ca9229en/CA9229EN.pdf (accessed 19.01.21).

Himelbloom, B. H., Crapo, C., Brown, E. K., Babbitt, J. & Reppond, K. (1994). Pink salmon (*Oncorhynchus gorbuscha*) quality during ice and chilled seawater storage. *Journal of Food Quality, 17*, 197-210. [CrossRef]

Huss, H. H. (1995). Quality changes and shelf life of chilled fish. In *Quality and quality changes in fresh fish. Food and agricultural organization of United Nations. Fisheries technical paper – 348.* Rome. Retrieved from http://www.fao.org/3/V7180E/V7180E07.htm (accessed 20.01.21).

Ludorff, W. & Meyer, V. (1973). *Fische und fischerzeugnisse*. Berlin, Germany: Paul Parey Verlag. Pp. 95-111, 176-269.

Maturin, L. & Peeler, J. T. (2001). Aerobic Plate Count, In *Bacteriological analytical manual*. Retrieved from https://www.fda.gov/food/laboratory-methods-food/bam-aerobic-plate-count (accessed 19.01.21).

Nunes, M. L., Cardinal, M., Mendes, R., Morao Campos, R., Bandarra, N. M., Lourenço, H. & Jerome, M. (1992). Effect of season and storage on proteins and lipids of sardine (*Sardina pilchardus*) minces and surimi. In H. H. Huss, M. Jakobsen & J. Liston, (Eds.), *Quality assurance in the fish industry* (pp. 73-81). Amsterdam: Elsevier.

Özden, Ö., Inugur, M. & Erkan, N. (2007). Preservation of iced refrigerated sea bream (*Sparus aurata*) by irradiation: Microbiological, chemical and sensory attributes. *European Food Research and Technology, 225*, 797-805. [CrossRef]

Ozogul, Y., Durmus, M., Balikci, E., Ozogul, F., Ayas, D. & Yazgan, H. (2011). The effects of the combination of freezing and the use of natural antioxidant technology on the quality of frozen sardine fillets (*Sardinella aurita*). *International Journal of Food Science and Technology, 46*, 236-242. [CrossRef]

Ozogul, F. & Ozogul, Y. (2000). Comparison of methods used for determination of total volatile basic nitrogen (TVB-N) in rainbow trout (*Oncorhynchus mykiss*). *Turkish Journal of Zoology, 24*, 113-120.

Özyurt, G., Kuley, E., Balikci, E., Kacar, C., Gökdogan, S., Etyemez, M. & Özogul, F. (2012). Effect of the icing with rosemary extract on the oxidative stability and biogenic amine formation in sardine (*Sardinella aurita*) during chilled storage. *Food and Bioprocess Technology, 5*(7), 2777-2786. [CrossRef]

Quitral, V., Donoso, M. L., Ortiz, J., Herrera, M. V., Araya, H. & Aubourg, S. P. (2009). Chemical changes during the chilled storage of Chilean jack mackerel (*Trachurus murphyi*): Effect of a plant-extract icing system. *LWT - Food Science and Technology, 42*, 1450-1454. [CrossRef]

Rey, M. S., Garcia-Soto, B., Fuertes-Gamundi, J. R., Aubourg, S. & Barros-Velazquez, J. (2012). Effect of a natural organic acid-icing system on the microbiological quality of commercially relevant chilled fish species. *LWT - Food Science and Technology, 46*, 217-223. [CrossRef]

Sanjuas-Rey, M., Barros-Velazquez, J. & Aubourg, S. (2011). Effect of different icing conditions on lipid damage development in chilled horse mackerel (*Trachurus trachurus*) muscle. *Grasas y Aceites, 62*(4), 436-442. [CrossRef]

Sanjuas-Rey, M., Gallardo, J. M., Barros-Velazquez, J. & Aubourg, S. (2012). Microbial activity inhibition in chilled mackerel (*Scomber scombrus*) by employment of an organic acid-icing system. *Journal of Food Science, 77*(5), 264-269. [CrossRef]

Schormüller, J. (1968). *Handbuch der lebensmittelchemie: band III/2 teil, tierische lebensmittel eier, fleisch, buttermilch.* Berlin-Heidelberg-New York: Springer-Verlag. 1341-1397, 1561, 1578, 1584p.

Sikorski, Z. E., Kolakowska, A. & Burt, J. R. (1990). Postharvest biochemical and microbial changes. In Z. E. Sikorski (Ed.), *Seafood: Resources, nutritional composition and preservation* (pp. 55-76). Florida, USA: CRC Press. [CrossRef]

Stone, H. & Sidel, J. (2004). *Sensory evaluation practices, 3rd Edition.* Amsterdam: Elsevier Academic Press. [CrossRef]

Yerlikaya, P., Ucak, I., Gumus, B. & Gokoglu, N. (2015). Citrus peel extract incorporated ice cubes to protect the quality of common pandora. *Journal of Food Science and Technology, 52*(12), 8350-8356. [CrossRef]

Vyncke, W. (1970). Direct determination of the thiobarbituric acid value in trichloracetic acid extracts of fish as a measure of oxidative rancidity. *Fette Seifen Anstrichmittel, 72*, 1084-1087. [CrossRef]