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DETERMINATION OF SHELF LIFE OF MARINADE AND BRINE INJECTED RAINBOW TROUT (*Oncorhynchus mykiss*, WALBAUM 1792) AT REFRIGERATOR CONDITIONS

Emre ÇAĞLAK, Barış KARSLI

Recep Tayyip Erdogan University, Faculty of Fisheries, Department of Seafood Processing Technology, Rize, Turkey

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Corresponding author:

Emre ÇAĞLAK, Recep Tayyip Erdogan University, Faculty of Fisheries, Department of Seafood Processing Technology, 53100 Rize, Turkey

E-mail: emre.caglak@erdogan.edu.tr

Abstract:

The aim of this study was to determine quality changes occurring in refrigerator (3 ±1ºC) of rainbow trout (*Oncorhynchus mykiss*) was injected marinade brine and salt brine. The trouts were stored into 3 groups as control, marinade (4% acetic acid-8% salt) injected and brine (20% salt) injected groups. Moisture, crude protein and crude fat of fresh trout were found 78.04%, 16.83% and 4.18%, respectively. Total volatile basic nitrogen (TVB-N) and thiobarbituric acid (TBA) values were determined below the limit values during the storage period. TVB-N and TBA values of control, marinade injected and brine injected groups were found as 20.42 mg/100g, 0.35 mg MA/kg; 21.70 mg/100g, 0.30 mg MA/kg; 17.60 mg/100g, 0.30 mg MA/kg at the end of the storage, respectively. Total mesophilic aerobic bacteria (TMAB), total psychrophilic aerobic bacteria (TPAB) and total coliform counts were determined as 4.54 cfu/g, 4.34 cfu/g and 3.07 cfu/g at the end of the storage, respectively. In terms of sensory, the trouts were evaluated as raw and cooked, and quality values were determined to below the limit values for the control group at 11 day, marinade and brine injected groups at 13 day.

Keywords: Rainbow trout, Cold storage, Chemical quality, Brine injected, Marinade injected

Introduction

The aquaculture of fisheries in industrial sense made an important progress in the last 25 years in Turkey and all around the world. Among the aquaculture species, Trouts have an important part in this progress. Considering the potential culture fishing of Turkey, trouts constitute the portion of 54.86% (128 059) of the total aquaculture amount (233 393 tons) (TUIK, 2013). Within the increasing amount of aquaculture, important developments were observed in consumption, production and process techniques of trouts. Trouts are generally consumed as fresh, but also frozen, filleted, smoked and marinated trout products started to hit the shelves.

Various techniques were developed with the aim of protecting the quality of seafood. By means of being refrigerated, the deterioration of fisheries can be delayed for a length of time. Refrigeration process is generally conducted by keeping the product contact with ice and preserving it at a low temperature (close to the 0ºC). In salting method, the sterilizer effect of "C1" ion and the reduction in water activity of product inhibit the bacterial growth. The passing of salt water into the fish meat can be carried out with the help of salt injection machines and used in industry. Similarly, there have been many studies about the effect of marinade solution injected into the red meat on the quality. As various process techniques can be appliedsingly, combinated process techniques are also used in seafood. The implementation of salting techniques in smoking and drying process can be given as an example of combinated process technique. Marination preserves fish through the simultaneous action of salt and organic acids. Marinasyon involves increasing the ionic strength and decreasing the pH. The aim is not only to prevent microorganism growth but also to allow a way of valorization other than salting for different fish products. Marination is also used to tenderize or to change taste, textural and structural properties of meat (Çaklı, 2007; Deniz, 2009; Gökoğlu et al., 1999; Varlık et al,. 2011; Gökoğlu, 2002; Kocatepe et al., 2010; Fuselli et al., 1994; Kijawski and Mast, 1993; Oreskovich et al., 1992; Seuss and Martin, 1993).

The aim of the study was compare the quality attributes (sensorial, chemical, microbiological and biochemical) of marinade and salt brine injected rainbow trout under refrigerator conditions.

Materials and Methods

A total of 90 trout (Oncorhynchus mykiss) was purchased from aquaculture farms in Rize, Turkey. The fish were then transported to the laboratory in 30 min. The avarage lenght of the trouts were measured as 23.13 ±0.83cm, their avarage width as 4.77 ±0.11 cm and their avarage weight as 213 ±17.1g. The measurement of their lenght and width was carried out with 0.1 mm sensetive digital caliper (Mahr 16ER) and measurement of their weight was carried out with 0.01 sensetive digital scales (And GR-200).

This study was planned as 3 groups and it used to 30 trouts in each groups. 2-cm pinpoints were used in injection process applied to the trouts and they were changed in each practice. The injection was carried out in 8 different points from back to the spinal cord and from head to the back (Figure 1). In each injection, 2.5 mL marinade brine and salt brine were injected into each fish with the purpose of being 20 mL in total. 4% marinade brine (4% acetic acid, 8% salt mixture) was injected into 1st group and 20% salt brine was injected into 2nd group and the 3rd group trouts were protected as pure (control). The trouts were put in styropor boxes and icing process was carried out to cover the fishes. During the study, the melted ice was removed from styropor boxes and new ice was added in every two days. Trouts were preserved under refrigerator conditions (3 ±1°C).

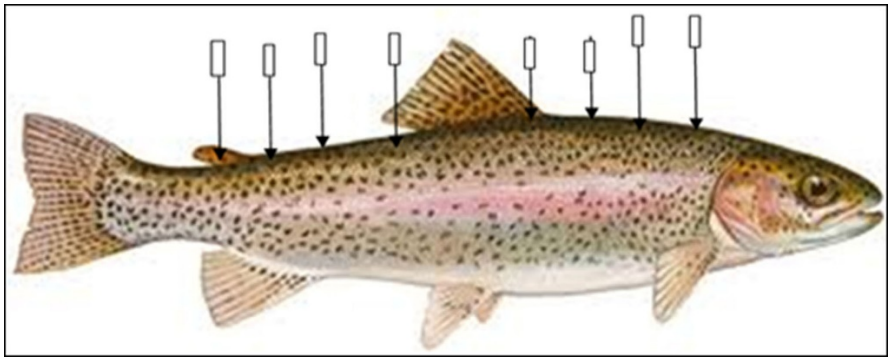

Figure 1. Injected sites on fish's back of marinade and brine solution

Nutritional, microbiological, chemical and sensory analyses were performed during the study. These analyses were carried out beginning on (0th day), 1st, 3rd, 5th, 7th, 9th, 11th and 13th days. In microbiological analysis; the analyses of total bacteria (psychrophilic, mesophilic), total coliform, yeast and mold were carried out according to Halkman (2005). In chemical and physical analyses; the determination of total volatile basic nitrogen (TVB-N) to Lücke and Geidel method (İnal, 1992), determination of thiobarbituric acid (TBA) to Tarladgis et al. (1960), pH-measurement was made according to Curran et al. (1980). The moisture was determined according to Norwitz (1970) method in which the obtained 5 g sample reaches the constant weighing in a 105°C drying oven. The crude fat content was determined according to soxhlet method by using petroleum ether (Velp SER 148/6, Milano, Italy). Crude protein determination to Norwitz (1970) by using kjehdahl method, inorganic matter (crude ash) to Norwitz (1970) and salt determination was made according to Karl (1994). In sensorial analysis; the raw and cooked products were evaluated separately according to modified method of Altuğ and Elmacı (2005) (1 point for the worst and 10 points for the best according to the taste, odour, appearance and texture criterias). The coooking process was carried out in sunflower seed oil for 5-8 minutes at the temperature of 120-130°C.

In statistical analysis; average ± standard deviation (n: 2-3) of the parallels of datas obtained from the study was determined. Depending on the progress of storage, with the aim of determining the differences in a group and between groups 'One Way Anova' and 'Turkey' were used to test the groups that had homogeneous variances, and the significance level was acknowledged as $P<0.05$. The groups which had abnormal distribution were tested by using 'Kruskal Wallis' and 'Mann Whitney U' tests and statistical analyses were performed by using SPSS 15.0 package (Sümbüloğlu and Sümbüloğlu, 2000). Analyses were carried out in Recep Tayyip Erdoğan University, Faculty of Fisheries, Seafood Processing Technology Laboratory.

Results and Discussion

The quality criterias of fisheries were explained by determining the nutritional, chemical, microbiological and sensory contents. Trouts are one of the most important species in terms of their aquaculture potential, dietary contents and consumer preferences.

The value of crude protein was found as 16.83 % and the value of crude fat as 4.18 % in fresh material. At the end of the storage, crude protein values of control (C), marinade (M) and brine injected (B) groups were determined as 16.05%, 17.40 % and 18.06 %, respectively. The crude fat value was estimated as 3.97 % in control group, 5.87% in marine brine injected group and 4.52 % in salt brine injected group (Figure 2). The statistical analysis of the crude protein and crude fat was made at the end of the storage and it showed that there were important differences between groups ($P<0.05$).

The values of dry matter were determined during the storage and given in Table 1. The dry matter value of fresh material was determined as 21.96%. The dry matter value of control group didn't change so much and reached the value of 19.12% on the 13th day of the storage period. By reason of the fact that raw material was injected with brine, it was observed that there was no spesific increase in dry matter values of marinade and salt brine injected groups. At the end of the storage period, the dry matter value was obtained as 22.46% in marinade brine injected group and 23.68% in salt brine injected group. The evaluation made on the 13th day of the storage showed that marinade and salt injected groups were different from control group in terms of statistical analysis ($P<0.05$).

The crude ash value of fresh material was determined as 0.65%. The crude ash value of control group showed differences between the values of 0.65% and 0.97%. Crude ash values increased with the effect of inorganic matter in brine of marinade and salt injected groups during the storage. These values were determinated as 1.37% in marinade brine injected group and 2.28% in salt brine injected at the end of the storage. The differences ($P<0.05$) seen in the statistical analysis of marine and salt brine injected groups was given in Table 1.

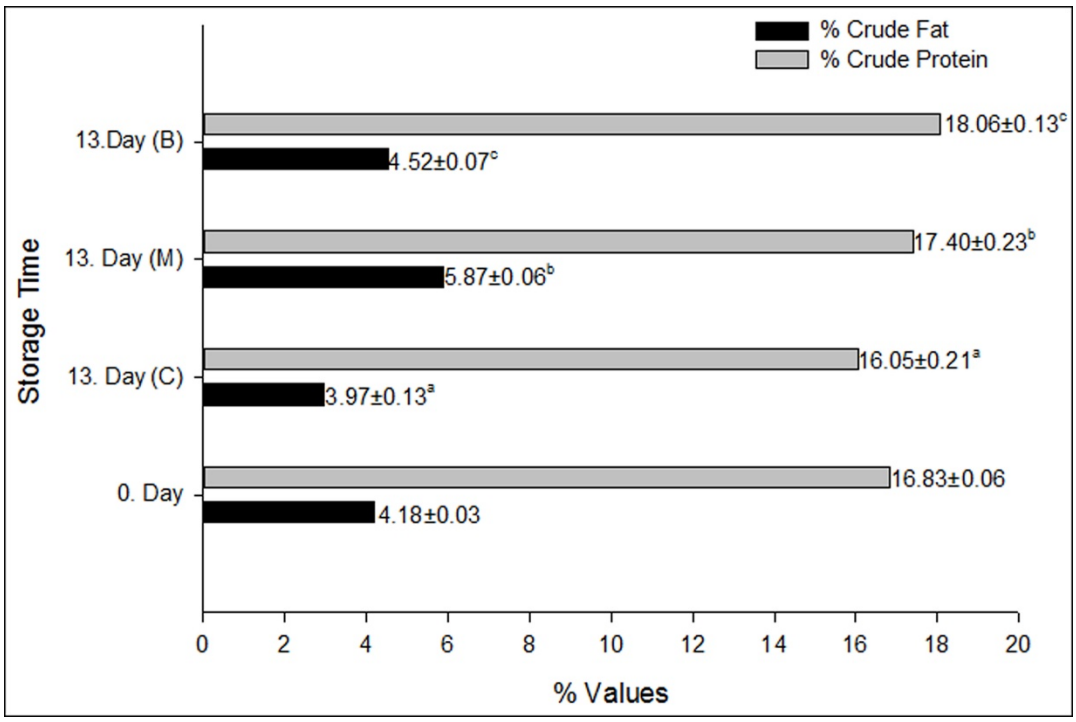

Figure 2. Crude fat and protein (%) values (P<0.05)

Duran (2006) stated that the amounts of dry matter, crude protein, crude fat and crude ash of trout (*Oncorhyncus mykiss* W.) were determined as 27.45%, 19.56%, 5.37% and 1.47%, respectively. Erdem (2006) studied on determining the meat quality of trout (*Salmo trutta, Forma fario*) and indicated that crude protein, crude fat, dry matter and crude ash values were between 14.70-18.69 %, 1.85-4.69 %, 19.09-24.14 %, 1.07-1.39 %. Bilgin et al. (2007a) examined the alterations in chemical structure of Salmo trutta macrostigma (Dumeril, 1858) and stated that the water amount of dry salted (from 78.9 to 53.06 %) and brined products (from 78.9 to 55.04) decreased during the storage and the amount of inorganic matter increased (from 1.33%, to 21.4-19.79 %). He stated that fluctuation results (min: 1.039 %, max: 3.74 %) were observed in the evaluation of fat values. It was observed that the values obtained from our study showed similarities with the protein, fat, ash and dry matter values of other researches.

The value of salt was found as 0.20% in fresh trout. An increase depending on salt concentration of solution was observed in salt and marinade brine injected groups (Table 1). The min-max values of salt in the marinade brine injected group were determined as 0.45% and 0.60%, respectively. On the 1st day of the storage, the salt value was detected as 1.0% in salt brine injected group. This salt value was found as 0.90% on the 13th day of the storage and no significant difference was determined (P>0.05).

According to the analyses on salting process of seafood, the salt rate changed depending on salting method and duration (Bilgin et al., 2007a). Bilgin et al. (2007b) stated that the salt amount was 0.83% in *Salmo trutta macrostigma*'s meat and the salt amount of salted samples increased and reach the value of 1.92% before being smoked. Tömek and Yapar (1990) researched the alterations depending on storage in salted trouts (*Salmo gairdneri*) and didn't make an observation in the salt amount (%) of fresh material. It was stated that the salt amount increased in trouts during the 150-day storage. In our study, the salt amount was found as 0.2% in fresh material. Depending on the injection of marinade and salt, the salt amount (%) showed increase. The salt brine injected group's value was higher than the other groups depending on its salt concentration (%). Being compared with other researches, our study showed similarity based on salt concentration. It was thought that the differences in salt amount (%) in fresh material result from species differences.

The pH value was measured as 6.72% in fresh material. Unlike the other groups, the pH value of marinade brine injected group showed a decrease with the effect of acetic acid and decreased to value of 6.28% on the 9th day of the storage. It was observed that the pH values of salt brine injected group were higher than the values of control

group until the 7th day of the storage. However, the increasing pH value of control group exceeded the pH value of salt brine injected group on the 7th, 9th and 13th day of the storage. The pH values of all groups showed abnormal distribution during the storage. It was observed in the evaluation between the groups that the pH value of marinade brine injected group was lowest on the 9th day of the storage and important differences were seen among groups in these days of the storage ($P<0.05$).

Baygar et al. (2002) determined the pH value of cooled storage stuffed trouts as between 6.25-6.39. Hultman and Rustad (2002) determined that the pH value of salmon and cod fishes after being cool storaged as 6.27-6.39 and 6.7-6.9, respectively. Fuentes et al. (2010) reported that pH values of two brands of marinated salmon are 6.17 and 6.41. Morkore et al. (2008) stated that the pH alterations of Atlantic salmon were between values of 6.45-7.0. It was determined that the results of our study showed similarities with the literature datas.

TVB-N and TBA results are chemical parameters and give us information about the quality of fisheries. The TVB-N values showed a regular increase in all groups during the storage period and these values were given in Table 1. The lowest value of TVB-N was determined in salt brine injected groups as 17.60 mg/100g at the end of the storage. The value was determined as 20.42 mg/100g in control group and 21.70 mg/100g in marinade brine injected group. The TVB-N value of marinade brine injected group was generally higher than the values of control group and salt brine injected group during the storage.

The TBA analysis was carried out to determine the fat oxidation. According to the results of the analysis, fat oxidation showed a linear increase in control group and salt brine injected group but showed a non-linear increase in marinade brine injected group during the storage (Table 1). The result of TBA was determined as 0.06 mg MA/kg in fresh sample. The values TBA of marinade brine injected group, salt brine injected group and control group were found as 0.30, 0.30 and 0.35 mg MA/kg on the 13th day of the storage, respectively. The conducted evaluation showed that the TBA value of marinade brine injected group was detected lower than the other groups during the storage period. However, the difference between the groups were not considered as significant except the 5th, 7th and 9th day of the storage ($P>0.05$).

Baygar et al. (2002) stated that the cool storaged stuffed trouts exceeded the limit value of TVB-N (41.67 mg/100g) in the 7th day of storage. Chytiri et al. (2004) stated that TVB-N and TBA values were determined on the 18th day as 20.16 mg N/100g and 16.21 µg MA/g in whole products, 26.06 mg N/100g and 19.41 µg MA/g in fillets at 2 ºC, respectively. Rezaei et al. (2008) researched the quality changes of rainbow trouts which were preserved with ice after being catched and different periods. They determined that the TVB-N levels showed fluctuations during storage and TBA values didn't exceed the limit values during the 20-day storage. Larazzabal et al. (2010) stated that marinade trouts (*Salmo salar*) didn't exceed the limit values of 30 mg/100g (TVB-N) and 0.8 mg/kg (TBARS) during the 29-days storage period at 5 ºC. Oğuzhan and Angiş (2012) stated that the TVB-N value of refrigerated fillet trouts was 12.42 mg/100g in the beginning and TVB-N values of groups exceeded the limit value on the 10th (vacum packaged-dry salted group) and on the15th (other groups) days. They stated that the TBA values were estimated as 1.95 µmol MA/kg in the beginning and then they exceeded the limit values on the 15th, 20th and 25th days depending on the differences in groups during the storage. The datas of our study showed that TVB-N (30-35 mg/100g) and TBA (7-8 mg MA/kg) values were not exceeded limit values during the 13-day experiment. Being compared with other studies, our study showed differences and similarities with them in terms of TVB-N and TBA values. It was thought that the differences in results source due to processing steps and different fish species.

During the storage period, it was determined that the TMAB and TPAB count increased prominently (Table 2). TMAB count was determined as <1.47 log cfu/g in fresh sample and in all groups on the 1st day of the storage. At the end of the storage, the TMAB count was found as 4.67 log cfu/g in control group, 4.48 log cfu/g in marinade brine injected group and 4.54 log cfu/g in salt brine injected group. The TPAB count was determined as <1.47 log cfu/g in fresh sample. During the storage, TPAB count showed an increase and reached to value of 4.24 log cfu/g in control group, 4.26 log cfu/g in marinade brine injected group and 4.34 log cfu/g in salt brine injected group on the 13th day.

Table 1. Biochemical and chemical analysis results

Time		Dry matter (%)	Crude ash (%)	Salt (%)	pH	TVB-N mg/100 g	TBA mg MA/kg
Fresh	C	$21.96\pm0.01_{A}$	$0.65\pm0.01_{AF}$	$0.20\pm0.00^{a}_{A}$	$6.72\pm0.03^{a}_{A}$	$14.08\pm0.00^{a}_{A}$	$0.06\pm0.01^{a}_{A}$
1.day	C	$21.98\pm0.01^{a}_{A}$	$0.67\pm0.17^{a}_{ACF}$	$0.30\pm0.00^{a}_{B}$	$6.40\pm0.01^{a}_{BD}$	$14.08\pm1.00^{a}_{A}$	$0.07\pm0.01^{a}_{A}$
	M	$21.96\pm0.66^{a}_{A}$	$1.13\pm0.04^{b}_{BD}$	$0.60\pm0.00^{b}_{B}$	$6.46\pm0.01^{b}_{BD}$	$14.08\pm1.99^{a}_{A}$	$0.11\pm0.01^{a}_{A}$
	B	$22.42\pm1.50^{a}_{AB}$	$1.67\pm0.09^{c}_{B}$	$1.00\pm0.00^{c}_{B}$	$6.42\pm0.00^{a}_{BCD}$	$14.08\pm0.00^{a}_{A}$	$0.10\pm0.01^{a}_{B}$
3.day	C	$21.84\pm0.92^{a}_{A}$	$0.97\pm0.16^{a}_{BC}$	$0.30\pm0.00^{a}_{B}$	$6.38\pm0.01^{ab}_{BD}$	$15.49\pm0.00^{a}_{AB}$	$0.10\pm0.02^{a}_{AB}$
	M	$21.94\pm0.33^{a}_{A}$	$1.15\pm0.09^{a}_{BD}$	$0.60\pm0.00^{b}_{B}$	$6.33\pm0.01^{a}_{BC}$	$15.49\pm1.99^{a}_{A}$	$0.08\pm0.02^{a}_{A}$
	B	$22.63\pm0.38^{a}_{AB}$	$1.76\pm0.03^{b}_{B}$	$0.95\pm0.07^{c}_{B}$	$6.47\pm0.05^{b}_{B}$	$14.78\pm1.00^{a}_{ABC}$	$0.11\pm0.01^{a}_{B}$
5.day	C	$19.72\pm0.46^{a}_{B}$	$0.86\pm0.00^{a}_{CF}$	$0.30\pm0.00^{a}_{B}$	$6.44\pm0.05^{a}_{BC}$	$16.19\pm1.00^{a}_{AB}$	$0.14\pm0.01^{a}_{B}$
	M	$22.06\pm0.58^{b}_{A}$	$1.34\pm0.02^{a}_{CDE}$	$0.55\pm0.07^{b}_{B}$	$6.31\pm0.01^{b}_{BC}$	$16.19\pm1.00^{a}_{AB}$	$0.08\pm0.02^{b}_{A}$
	B	$22.58\pm0.21^{b}_{AB}$	$1.61\pm0.04^{a}_{B}$	$0.95\pm0.07^{c}_{B}$	$6.48\pm0.02^{a}_{B}$	$15.49\pm0.00^{a}_{ABCD}$	$0.11\pm0.01^{ab}_{B}$
7.day	C	$21.49\pm0.83^{a}_{A}$	$0.68\pm0.04^{a}_{F}$	$0.30\pm0.00^{a}_{B}$	$6.52\pm0.06^{a}_{C}$	$16.19\pm1.00^{a}_{AB}$	$0.19\pm0.01^{a}_{C}$
	M	$22.49\pm0.56^{a}_{A}$	$1.14\pm0.19^{a}_{BD}$	$0.60\pm0.00^{b}_{B}$	$6.30\pm0.11^{a}_{C}$	$16.90\pm1.99^{a}_{ABC}$	$0.11\pm0.01^{b}_{A}$
	B	$22.79\pm0.67^{a}_{AB}$	$1.52\pm0.51^{a}_{B}$	$0.95\pm0.07^{c}_{B}$	$6.45\pm0.02^{a}_{BC}$	$16.19\pm1.00^{a}_{ABD}$	$0.12\pm0.00^{b}_{B}$
9.day	C	$22.08\pm0.66^{a}_{A}$	$0.74\pm0.00^{a}_{F}$	$0.35\pm0.07^{a}_{B}$	$6.51\pm0.02^{a}_{C}$	$16.90\pm1.99^{a}_{BC}$	$0.22\pm0.01^{a}_{C}$
	M	$22.29\pm0.10^{a}_{A}$	$1.06\pm0.00^{b}_{B}$	$0.45\pm0.07^{b}_{B}$	$6.28\pm0.03^{b}_{C}$	$19.71\pm1.99^{a}_{BCD}$	$0.13\pm0.02^{b}_{A}$
	B	$23.00\pm0.36^{a}_{AB}$	$1.75\pm0.11^{c}_{B}$	$0.75\pm0.07^{c}_{C}$	$6.39\pm0.02^{c}_{CD}$	$16.90\pm1.99^{a}_{BCD}$	$0.23\pm0.00^{a}_{C}$
11.day	C	$21.27\pm1.09^{a}_{A}$	$0.77\pm0.02^{a}_{F}$	$0.35\pm0.07^{a}_{B}$	$6.34\pm0.02^{a}_{D}$	$19.01\pm1.00^{ab}_{CD}$	$0.30\pm0.01^{a}_{D}$
	M	$22.25\pm0.29^{ab}_{A}$	$1.3\pm0.04^{b}_{DE}$	$0.45\pm0.07^{b}_{B}$	$6.43\pm0.04^{b}_{BCD}$	$20.42\pm1.00^{a}_{CD}$	$0.23\pm0.08^{a}_{B}$
	B	$23.38\pm0.11^{b}_{AB}$	$1.88\pm0.10^{c}_{BC}$	$0.90\pm0.00^{c}_{B}$	$6.36\pm0.01^{ab}_{D}$	$16.90\pm0.00^{b}_{CD}$	$0.29\pm0.03^{a}_{D}$
13.day	C	$19.12\pm0.44^{a}_{B}$	$0.75\pm0.05^{a}_{F}$	$0.35\pm0.07^{a}_{B}$	$6.51\pm0.04^{a}_{C}$	$20.42\pm1.00^{ab}_{D}$	$0.35\pm0.04^{a}_{E}$
	M	$22.46\pm1.31^{b}_{A}$	$1.37\pm0.03^{b}_{E}$	$0.50\pm0.00^{b}_{B}$	$6.55\pm0.14^{a}_{D}$	$21.70\pm0.99^{a}_{D}$	$0.30\pm0.01^{a}_{B}$
	B	$23.68\pm0.89^{b}_{B}$	$2.28\pm0.14^{c}_{C}$	$0.90\pm0.00^{c}_{B}$	$6.4\pm0.04^{a}_{CD}$	$17.60\pm1.00^{b}_{D}$	$0.30\pm0.01^{a}_{D}$

The different letters (A, B, C, D, E, F) in the same column shows statistical differences were detected within the same group in the different storage day ($P<0.05$). The different letters (a, b, c) in the same column shows statistical differences were detected among groups in the same storage day ($P<0.05$).
C: Control, M: Marinade injected, B: Brine injected

Total coliform count was found as <1.47 log cfu/g in marinade and salt brine injected groups till the 13th day and in control group till the 11th day. At the end of the storage, it was detected as 3.30 log cfu/g in control group, 3.19 log cfu/g in marinade brine injected group and 3.07 log cfu/g in salt brine injected group. The yeast-mould count was determined <100 cfu/g in all groups during the storage (Table 2).

It was stated that the limit value of mesophilic aerobic bacteria in fresh fish was 6-7 log cfu/g and this value must be lower than 5 log cfu/g in a qualified product (Huss, 1988; Aguilera et al., 1992; Chytiri et al., 2004; Köse and Erdem, 2004; Bilgin et al., 2006; Cakli et al., 2006a; Bao et al., 2007; Duyar et al., 2012). Also it was stated that the limit value of psychrophile bacteria must be 5 log cfu/g (Erkan and Özden, 2008). Limit values of total coliform bacteria which indicates fecal contamination were determined as 2.3 log cfu/g, 2.39 log cfu/g and 2.6 log cfu/g in different literatures (Patır and İnanlı, 2005; Kaba and Erkoyuncu, 2011). Chytiri et al. (2004) stated that the limit value of total coliform bacteria amount of iced rainbow trouts (7 log cfu/g) was exceeded by whole fishes on the 18th day and by fillets on the 10th day. Fernandez et al. (2008) stated that Atlantic salmon fillets were stored with different package methods at the temperature of 2ºC. During this storage, total mesophilic bacteria count exceeded the limit value (6 log cfu/g) in the 11th day and the total psychrophile bacteria count came approached value of 5 log cfu/g in 20 days.

Rezaei et al. (2008) stated that the limit value (10^6 microorganism/g) was exceeded in the 12th day by rainbow trouts which were kept in ice after being catched. Oğuzhan and Angiş (2012) stated salted and packaged rainbow trouts that the total mesophilic bacteria count was found as 10.24 log cfu/g in control group on the 10th day, 8.11 log cfu/g in dried salted group on the 20th day and 8.53 log cfu/g in brined group on the 15th day. And it was stated they exceeded the limit values. Moreover, the total mesophilic bacteria counts of the control group, dry salted group and brined group were reached 10.60 log cfu/g on the 10th day, 8.24 log cfu/g on the 20th day and 8.88 log cfu/g on the 15th day, respectively. Öksüztepe et al. (2011) determined the chemical and microbiological qualities of rainbow trouts consumed in Elazığ. According to their study, the min-max total mesophilic bacteria, total psychrophile bacteria and total coliform counts were found 1.60-6.07 log cfu/cm^2, <1.0-2.05 log cfu/cm^2 and 1.84-2.95 log cfu/cm^2, respectively.

In our study, all groups didn't exceed the limit value of total mesophilic/psychrophilic bacteria during the storage period. Only, the total coliform bacteria amount of control group was over the limit values on the 11th day and the total coliform bacteria amount of marinade and salt brine injected groups were over the limit values on the 13th day. It was determined that the datas of our study were substantially compatible with other researches in terms of total mesophilic bacteria, total psychrophile bacteria and total coliform bacteria count. Moreover, differences observed in studies changes depending on process steps, bacterial flora of water, different contaminations and inhibity effect (mucus layer etc.) (Öksüztepe et al., 2011).

Results of sensory evaluation (appearance, texture, odour. taste) of all groups are shown in Figure 3. With the evaluation of appearance, texture and odour analyses of raw product, the control group was determined under the consumable limit value (5 points) on the 11th day, and marinade and salt brine injected groups were determined under the limit on the 13th day of the storage. With the evaluation of appearance, texture, taste and odour analyses of cooked product, it was seen that the control group was under the consumable limit value (5 points) on the 13th day. It was stated that the cooked products of marinade and salt brine injected groups was not under the consumable limit value (5 points) during the storage. The sensory scores of raw and cooked products showed that there were important differences in the statistical evaluations in a group and between the groups.

Table 2. Microbiological analysis results

Time		TMAB log cfu/g	TPAB log cfu/g	Total Coliform log cfu/g	Yeasts-Molds cfu/g
Fresh	C	<1.47	<1.47	<1.47	*
1.day	C	<1.47	2.57	<1.47	*
	M	<1.47	3.70	<1.47	*
	B	<1.47	<1.47	<1.47	*
3.day	C	2.69	2.69	<1.47	*
	M	1.74	1.74	<1.47	*
	B	1.60	1.60	<1.47	*
5.day	C	3.55	3.23	<1.47	*
	M	<1.47	2.56	<1.47	*
	B	<1.47	2.23	<1.47	*
7.day	C	3.43	3.30	<1.47	*
	M	<1.47	4.69	<1.47	*
	B	2.53	3.61	<1.47	*
9.day	C	4.40	4.20	<1.47	*
	M	3.56	4.06	<1.47	*
	B	4.26	4.09	<1.47	*
11.day	C	4.58	4.15	3.10	*
	M	4.41	4.11	<1.47	*
	B	4.44	4.13	<1.47	*
13.day	C	4.67	4.24	3.30	*
	M	4.48	4.26	3.19	*
	B	4.54	4.34	3.07	*

«*» <100 cfu/g bacteria count, TMAB: Total mesophilic aerobic bacteria, TPAB: Total psychrophilic aerobic bacteria. C: Control, M: Marinade injected, B: Brine injected.

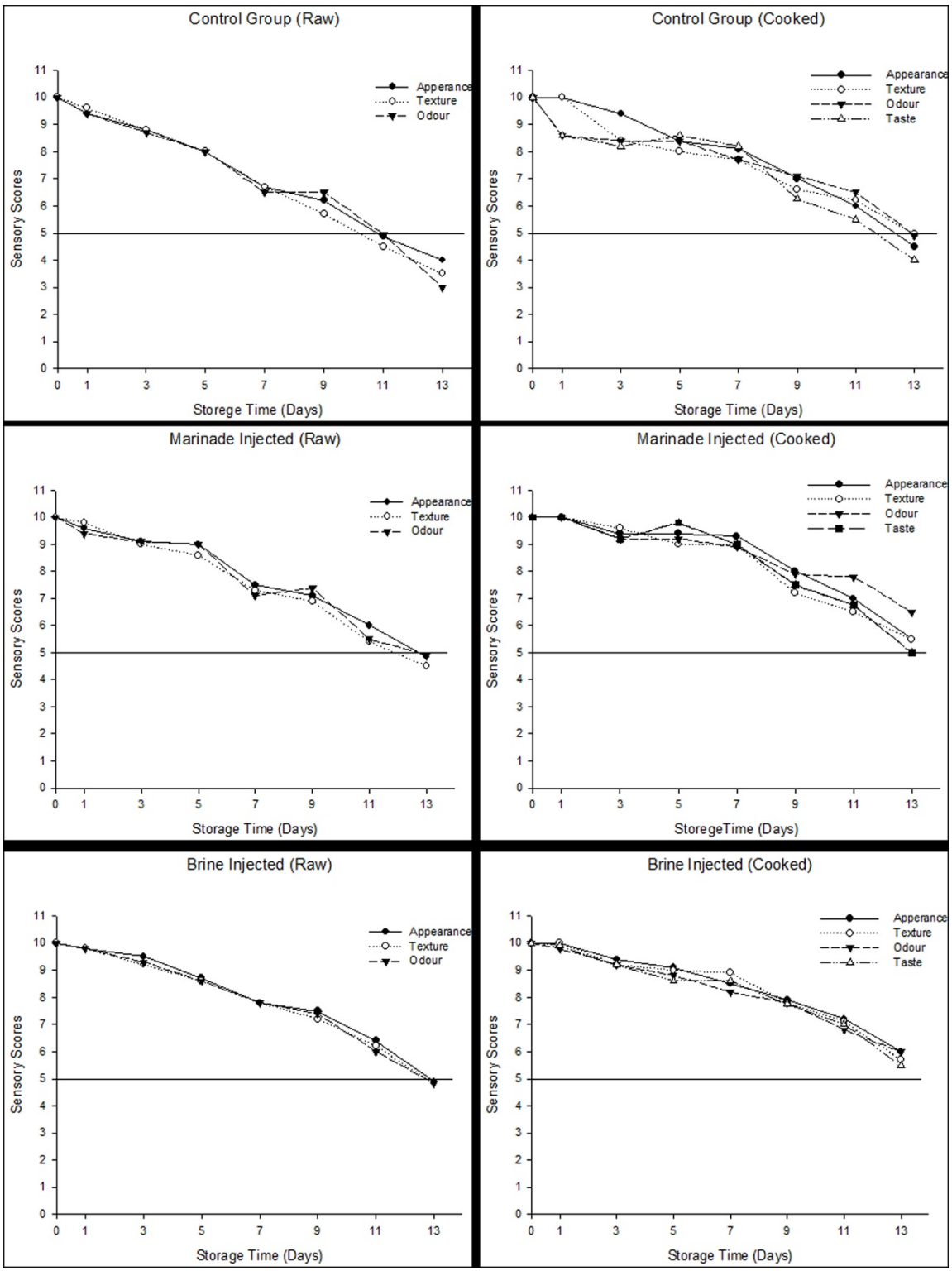

Figure 3. The sensory scores of raw and cooked trouts

It was stated that the most important criteria in determining the fisheries quality was the results of sensory analysis and an unproper product according to the sensory analysis could not be consumed. The results of other analyses must be evaluated with sensorial analysis (Baygar et al., 2002). It was stated in the study that cool stored and stuffed trouts lost their storable quality in the 6th day in terms of sensorial. Also, an other study stated that cool stored trouts preserved their consumable quality in terms of sensorial until the 9th day (Baygar et al., 2002; Metin and Varlık, 1997). Chytiri et al. (2004) kept the whole and filleted rainbow trouts in ice (2°C). According to the results of sensorial scoring, they determined that raw product stayed within the quality limits during 12-15 days and the cooked product stayed within the quality limits during 15-17days. Bao et al. (2007) determinated that the limit value of *Salvelinus alpinus* fillets under dry ice and super refrigerated conditions was 13 days in terms of sensorial. Rezaei et al. (2008) researched the quality evaluations of rainbow trouts in ice and they determined that consumable value of trouts in terms of sensorial was 12 days. The sensorial analyses of other researches confirmed the results of our study.

Also, the shelf-life studies on different fish species were examined. Lyhs et al. (2001) stated the shelf-lives of the vacuum-packaged 'gravad' rainbow trout slices based on microbiological and sensory analyses were 20 days and 18 days at 3 and 8°C, respectively. Cakli et al. (2006b) observed that shelf life of smoked trout was found at least 33 days in vacuum package, 47 days in 60% CO_2/40% N_2 gas mixture and 40 days in 50% CO_2/50% N_2 gas mixture according to results of microbiological analysis. Özden and Erkan (2006) were studied the effects of packing in oil and under vacuum on sensory, chemical and microbiological changes in marinated rainbow trout stored at chill temperatures (4 ±1°C). They determined that the shelf-life is 105 days for packaged in oil and 90 days for vacuum packaged samples.

Conclusion

According to our sensory, chemical, and microbiological analyses, control, marinade brine injected and salt brine injected groups preserved the consumable value until the 11th day, the 13th day and the 13th day, respectively.

While no important difference in terms of chemical was observed among groups, the microbiological results of marinade and salt brine injected groups were better than the control group. Especially, the sensorial likings of marinade and salt brine injected groups were determined quite high. It was thought that the developed application of marinade and salt brine injection would be beneficial in terms of both comsumption and quality differences.

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