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**The Effect Of Glazing With Sumac (*Rhus Coriaria*, L.) Extract On The Quality Of Frozen Rainbow Trout (*Oncorhynchus Mykiss*) Fillets**

**ABSTRACT**

This study aims to investigate the effect of glazing with sumac (*Rhus Coriaria*, L.) extract on the quality of rainbow trout (*Oncorhynchus mykiss*) fillets during frozen storage. Fish fillets were glazed with 5% and 10% sumac extracts and were stored at -18°C for 6 months. Results showed that glazing with sumac treatment prevented lipid oxidation when compared to non-glazed and water-glazed treatments. Sumac extract decreased the free fatty acid production during 6 months of storage. PV, TVB-N and TBA values of S5 and S10 groups were lower than NG and G groups. Samples glazed with sumac extract showed the best results compared to non-glazed and water-glazed samples. Glazing with 10% sumac extract treatment significantly decreased the total aerobic mesophilic bacteria. Our results showed that sumac can be used as natural antioxidant, antibacterial agent and glazing material for delaying lipid oxidation and to inhibit the quality loss in frozen fish.

**Keywords:** Sumac, Glazing, Rainbow trout, Freezing, Quality

**1. INTRODUCTION**

Rainbow trout (*Oncorhynchus mykiss*) is one of the main farmed freshwater species, which accounts for 56% of the total fish production in Turkey. Consumption of this fish is increasing due to its positive effects on human health, its nutritional value and good taste. Fresh cooled trout have been usually exported to European Union countries [1]. Trout is highly perishable food due to its high water activity (aw), high amount of polyunsaturated fatty acids and its large quantities of free amino acids so it has a short shelf life. Biological reactions like lipid oxidation, fish enzymes activities and metabolic activities of microorganisms may cause quality deterioration of fish [2 and 3]. Longer shelf life and better quality can be achieved with freezing, low temperature storage, suitable packaging, using antioxidants and glazing [4, 5, and 6]. Although freezing is the most common method used for long-term preservation of seafood, some deteriorations such as lipid oxidation, weight loss by surface dehydration and protein denaturation occur during frozen storage [7 and 8]. Glazing has been used to retard the freezer burn and to prevent the deterioration of fish meat during frozen storage. Glazing is a method of surrounding the product with a thin layer of ice by spraying or immersion of the product into water. It excludes air from the surface of the fish, decreases the oxidation rate and protects the product from oxygen and dehydration. This method prevents the moisture loss by sublimation [4, 7, and 9]. Antioxidants are most commonly used additives in glazing solutions for delaying lipid oxidation [4]. Today consumers prefer minimally processed food that

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contain natural preservative because of the harmful effects of synthetic antioxidants. In this sense, glazing with natural antioxidant compounds are suitable for increasing the shelf life of seafood [10].

Sumac (*Rhus coriaria* L.) has been reported to possess natural antioxidant [11], antibacterial [12, 13 and 14] and antifungal [15] effects so it can be used as a food preservative. Sumac (*Rhus coriaria*, L.) is a member of the Anacardiaceae family and it has many applications in different countries [12]. It grows in Mediterranean and Southeastern Anatolian Region of Turkey. Fruits and leaves of sumac contain flavones, phenolic acids, hydrolysable tannins, anthocyanins and organic acids [11 and 16]. The antioxidant effects of sumac come from its phenolic components, especially gallic acid and its derivatives [17]. The purpose of this research was to investigate the effect of sumac extract as a glazing material on the oxidative changes of lipids, proteins and microbial properties of rainbow trout fillets (*Oncorhynchus mykiss*) under six months of frozen storage. According to our knowledge, this study will be the first one on treatment of glazing with sumac.

## 2. RESEARCH SIGNIFICANCE

According to our knowledge, this study will be the first one on treatment of glazing with sumac.

## 3. EXPERIMENTAL METHOD-PROCESS

### 3.1. Chemicals, Sumac Extract and Fish

All chemicals and solvents used in this study were purchased from Merck Chemical Company. Sumac (*Rhus coriaria*, L.) berry extract was purchased from a commercial company (Xi'an SR Bio-Engineering Co., Ltd, China). Two glazing solutions were prepared by dissolving sumac berry (*Rhus coriaria*, L.) extract (5% and 10%, w/v) in potable water, blended thoroughly by a magnetic stirrer for 1 h at room temperature and boiled for 5 min on a plate heater equipped with magnetic stirrer (Are2, VELPR, Italy). Then cooled and filtrated through Whatman No 4 filter paper. The liquid solutions of sumac extracts were kept at 0°C before using them for glazing of rainbow trout. A total of 80 rainbow trout (*Oncorhynchus mykiss*), 250 ±10 g weight, were purchased from a commercial aquaculture farm near İzmir. Fishes were transferred to the laboratory within 1.5 hours in sealed styrofoam boxes containing ice.

### 3.2. Glazing and Packaging Process

After transferring of fishes to the laboratory, they were eviscerated and washed with water and then rainbow trout fillets were divided into four groups and frozen at -25°C for 24 hours. The first group (NG) was placed on styrofoam plates without any treatment (non-glazing), the second group (G) was glazed with only water (water glazing), the third group (S5) was glazed with 5% sumac extract added water and the fourth group (S10) was glazed with 10% sumac extract added water (Table 1).

Table 1. Treatment groups and concentration of sumac

| Treatments | Glazing | Sumac Water |
|------------|---------|-------------|
| NG         | -       | -           |
| G          | Water   | -           |
| 5S         | -       | 5%          |
| 10S        | -       | 10%         |

NG: Non glazed, G: Glazed with water

5S: Glazed with 5% sumac extract

10S: Glazed with 10% sumac extract



Frozen fish fillets were dipped into 5% and 10% sumac extract added solutions 4°C for 1 min. Glazed trout fillets were put into a foam plates, wrapped with stretch film and stored at -18°C for 6 months. Chemical (thiobarbituric acid (TBA), peroxide value (PV), fatty acids (FFA)) and microbiological (total aerobic mesophilic bacteria (TAMB)) analyzes were performed at 1-month intervals. Analyzes were carried out after frozen fish samples were thawed in a refrigerator (+4°C) for one night.

### **3.3. Lipid Oxidation Analyses**

Thiobarbituric acid value (TBA) was determined as described by Tarladgis et al. [18] and was expressed as the equivalents mg of MDA/kg of fish. Peroxide value (PV) was determined according to Mattissek et al. [19]. Results were expressed as units of meq/kg of sample. Free fatty acids (FFA) content was determined according to Yetim, [20] and calculated as oleic acid %. Total volatile basic nitrogen (TVB-N) was determined according to Varlik et al. [21]. The amount of TVB-N of samples were calculated as mg N /100 g fish sausage.

### **3.4. Microbiological Analysis**

25 g of sample was taken from fish fillet aseptically and mixed with 225 mL of sterilized peptone water (BPW, Oxoid Ltd., Basingstoke, Hampshire, UK) in a stomacher bag then homogenized for 2 min in a stomacher. 0.1 mL of samples of serial dilutions of fish fillet homogenates (1:10) were inoculated onto plate count agar (Merck, 105463) for determination of total aerobic mesophilic bacteria (TAMB) and then incubated at 30°C for 3 days. Microbial counts were presented as colony forming units (CFU)/g fish sample [22].

### **3.5. Statistical Analysis**

All measurements were replicated two times for each group. Statistical analysis was carried out using SPSS statistical package program (IBM, version 21.0, USA). All data was given as mean values with their standard deviations (mean± SD). The statistical significances (p<0.05) were evaluated by Variance analysis (ANOVA). Storage data were analyzed using two-way ANOVA with treatment and storage time as main effects. Duncan's multiple range test was used to evaluate the comparison of means.

## **4. RESULTS AND DISCUSSION**

### **4.1. Thiobarbituric Acid (TBA) Values**

TBA is an indicator to evaluate the lipid oxidation of seafood. Figure 1 presents the TBA values of non-glazed and glazed rainbow trout fillets stored at -18°C for 6 months. The initial TBA values of sumac glazed groups (S5: 0.48, S10: 0.35mg MDA/kg) were significantly lower than water glazed (G) (1.08mg MDA/kg) and non-glazed (NG) (1.49mg MDA/kg) groups (p<0.05). It indicated that sumac glazing was more effective in decreasing lipid oxidation (Figure 1). Sumac glazing may have shown a resistance to oxygen diffusion and delayed lipid oxidation in sumac-glazed samples. While the TBA values of sumac glazed groups increased slightly with the storage time, water glazed and non-glazed group increased highly (p<0.05). The sharp increase was observed in NG group (p<0.05). Due to an important effect of glazing on oxidation [23], NG group had a higher TBA value than G, S5, S10 groups at the beginning of the period. TBA values of all groups showed an increase during 6 months of storage but they did not exceed the acceptable limit value of 8mg MDA/kg [24]. TBA values of S5 and S10 groups were significantly lower than NG and G groups (p<0.05). Sumac showed an antioxidant character due

to its high amount of anthocyanins and tannins content so it significantly reduced the lipid oxidation.

Lin and Lin, [4] reported similar results and they found that glazing with three different tea extracts significantly reduced the oxidation of lipids. Mesarcova et al. [25] investigated the effect of hawthorn and agrimony extracts added glazing on lipid oxidation of frozen Atlantic herrings during 8 months of storage at  $-14^{\circ}\text{C}$  and they found that hawthorn and agrimony extracts added glazing had a significant influence on lipid oxidation changes of frozen Atlantic herring fillets within 4 months' storage. Sathivel, et al., [23] showed that distilled water and chitosan glazed salmon fillets samples had higher effect on decreasing lipid oxidation compared to uncoated sample during 8 months of storage at  $-35^{\circ}\text{C}$ .

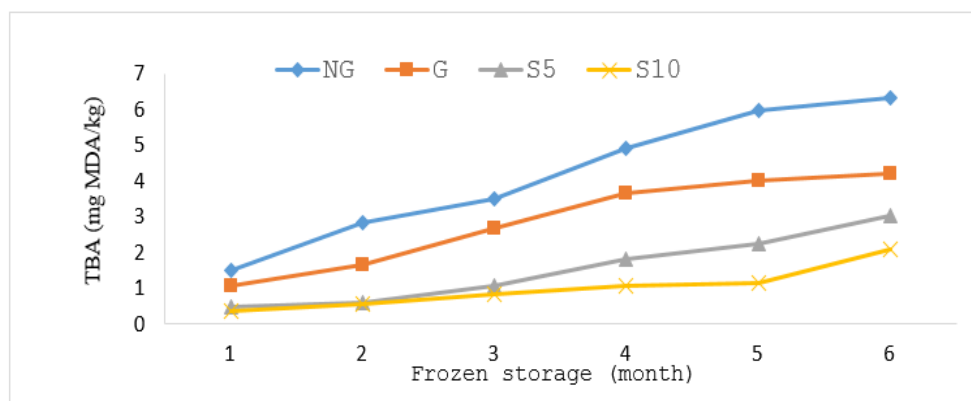


Figure 1. Effects of glazing with sumac extract on the TBA values of rainbow trout fillets during frozen storage at  $-18^{\circ}\text{C}$

#### 4.2. Peroxide Value (PV)

Hydroperoxide, is an initial oxidative product of polyunsaturated fatty acids, is measured as peroxide value and occurs as a result of lipid oxidation [4]. Peroxide value is initially unstable and break down quickly to secondary oxidation products such as aldehydes, ketones and alcohols [26]. The changes in peroxide value (PV) of frozen trout fillets is shown in Fig. 2. The initial PV were 1.96, 1.37, 0.88 and 0.68 meq  $\text{O}_2 \text{ kg}^{-1}$  for NG, G, S5 and S10 groups, respectively. NG group showed highest PV (11.35 meq  $\text{O}_2 \text{ kg}^{-1}$ ) at the end of the storage period. During frozen storage, peroxide value increased gradually for all groups ( $p < 0.05$ ). PV below 5 meq  $\text{O}_2/\text{kg}^{-1}$  indicates that fat is fresh or hydroperoxides have degraded into ketones. Rancidity starts when the PV between 5-10 meq  $\text{O}_2/\text{kg}^{-1}$  (7). In this study, control group exceeded the maximum limit value of 10 meq  $\text{O}_2/\text{kg}^{-1}$  at 5<sup>th</sup> months of storage. During six months of storage, S5 and S10 groups showed lower peroxide value compared to NG and G groups ( $p < 0.05$ ). S10 showed significantly lowest PV values than other groups ( $p < 0.05$ ). According to these results, glazing with sumac extract delayed lipid oxidation in frozen fish due to better antioxidant effect. The antioxidant characteristic of sumac comes from higher amount of phenolic compounds (12). Similar results were reported by [4, 27, 28, and 29].

Cavonius and Undeland [27] investigated the effects of glazing with herring muscle press juice in frozen herring fillets during 52 weeks and they found that herring muscle press juice showed an antioxidant activity and decreased the PV values of fillets. Fadiloğlu and Coban [28] investigated the effects of chitosan edible coatings enriched with sumac on rainbow trout fillets during 12 days of cold storage and they found that treatment with chitosan and sumac reduced the PV value of fish fillets. On the other hand, Lin and Lin [4] glazed

the bonito fillets with three different tea extracts and they found that PV values of each treatment group increased during frozen storage but glazing with ice or tea did not make a significant difference in PV value during 16 weeks of frozen storage. Shi et al. [29] reported that a slower formation of PV was observed in rosemary-glazed shrimp samples during frozen storage.

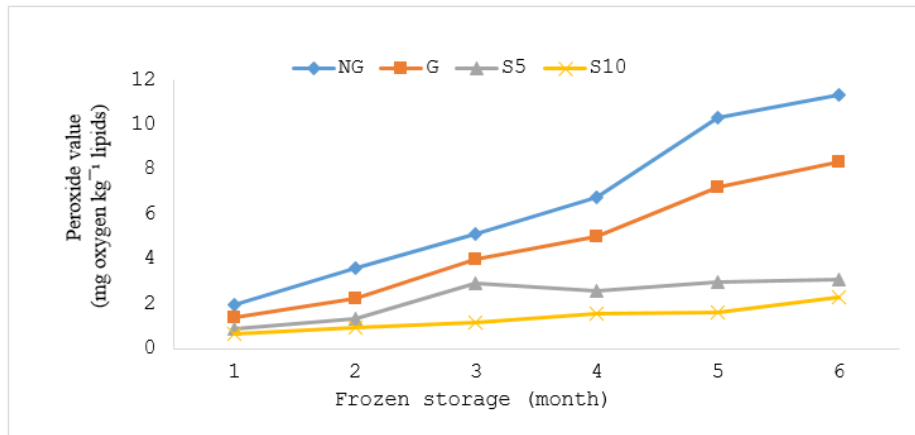


Figure 2. Effects of glazing with sumac extract on peroxide values (PV) of rainbow trout fillets during frozen storage -18°C

#### 4.3. Free Fatty Acids (FFA) Content

Free fatty acids (FFA) is accumulated in the frozen samples by hydrolysis of lipids [30]. FFA values of control and glazed rainbow trout fillets are shown in Fig. 3. The initial FFA values of NG, G, S5, S10 groups were 2.00, 1.75, 0.77 and 0.84 g oleic acid %, respectively. During three months of frozen storage, lipid hydrolysis occurred at a slow rate in S5 and S10 groups and NG had the highest FFA value. FFA values of all groups increased gradually during 6 months of storage ( $p < 0.05$ ). At the end of the storage period, lowest FFA level was found in S10 group (3.43g oleic acid %). FFA values of all groups did not exceed the acceptable limit value of 15 oleic acid % [31] throughout six-month storage period. Raising in FFA formation is due to the hydrolysis of phospholipids and triglycerides by the influence of lipases and phospholipases [32]. In this study, glazing with sumac treatment was able to control the lipid hydrolysis development in rainbow trout fillets and decreased the FFA production during six-month of storage. On the other hand, Shi et al. [29] found that glazing with water or rosemary did not make a significant difference in FFA content of shrimp during 20 weeks of frozen storage.

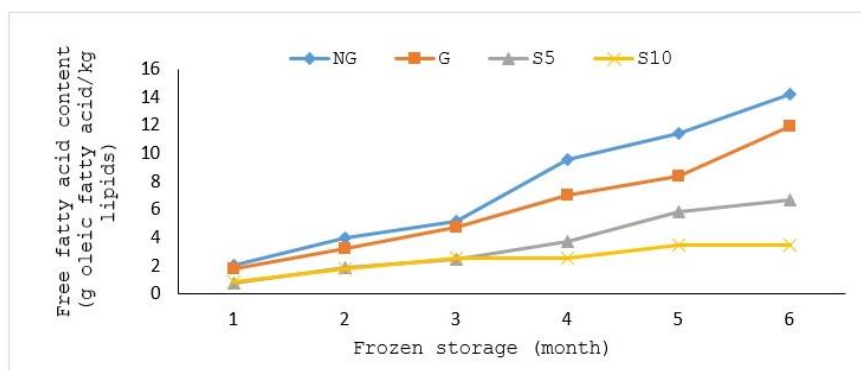


Figure 3. Effects of glazing with sumac extract on free fatty acid (FFA) of rainbow trout fillets during frozen storage at -18°C

#### 4.4. Total Volatile Basic Nitrogen (TVB-N) Value

TVB-N is generally used as fish spoilage indicator and increases by the spoilage bacteria and endogenous enzymes activity [33 and 34]. It includes measurement of ammonia, DMA, TMA and other nitrogenous compounds [35].

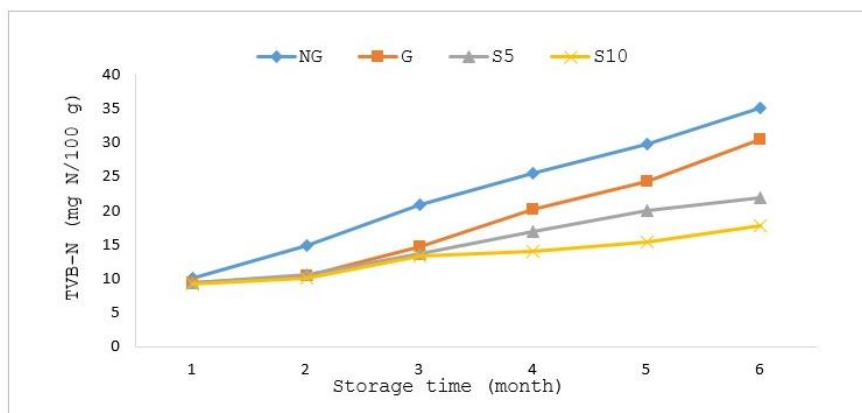


Figure 4. Effects of glazing with sumac extract on total volatile-based nitrogen (TVB-N) of rainbow trout fillets during frozen storage at  $-18^{\circ}\text{C}$

Figure 4 presents the TVB-N values of control and glazed rainbow trout fillets stored at  $-18^{\circ}\text{C}$ . The initial TVB-N values were 10.08, 9.29, 9.40 and 9.16 mgN/100g muscle for NG, G, S5 and S10 groups, respectively. TVB-N values raised during storage time ( $p < 0.05$ ). At the end of frozen storage, the TVB-N values increased to 35.04, 30.42, 21.82 and 17.82 mgN/100g trout for NG, G, S5 and S10 groups (Figure 4). Sumac extract inhibited the decomposition of macromolecular components reason by spoilage bacteria and endogenous enzymes. The differences among the samples were found statistically important ( $p < 0.05$ ). At 6<sup>th</sup> month, TVB-N value of NG group (35.04 mgN/100g) exceeded the spoilage limit value of 35.00 mg/100g [21] while the TVB-N values of other samples were below the limit value. Similar results were found by [4, 10, and 36]. Lin and Lin [4] glazed the bonito fillets with three tea extracts and stored at  $-20^{\circ}\text{C}$  for 16 weeks. They found that glazing with tea extracts decreased the TVB-N values of fillets. oban [36] found lower TVB-N values in glazed samples during 6 months of storage due to antioxidant effects of these essential oils. He and Xiao [10] used tangerine peel essential oils as a glazing layer on bream and stored  $-1^{\circ}\text{C}$  for 25 days. They found that TVB-N values of glazed samples were lower than control samples. Shi et al. [29] investigated the effect of glazing and rosemary (*Rosmarinus officinalis*) extract on preservation of mud shrimp (*Solenocera melantho*) during frozen storage and they found that the rosemary-glazed shrimp showed lowest TVB-N value during whole frozen storage.

#### 4.5. Total Aerobic Mesophilic Bacteria (TAMB)

Total aerobic mesophilic bacteria (TAMB) of control and glazed trout fillet samples are shown in Figure 5. The initial TAMB were 2.79, 2.48, 2.19 and 2.08 log CFU/g for NG, G, S5 and S10 groups, respectively. These results confirmed that the fishes were in good quality (5-7 log CFU/g) [22]. After 6 months of storage TAMB of NG group (6.92 log CFU/g) reached the upper acceptable limit value of 7 log CFU/g. TAMB of all groups increased with time of storage ( $p < 0.05$ ). During the storage days, TAMB of non-glazed group were greater than glazed groups ( $p < 0.05$ ). Glazed



with sumac extract samples showed best results when compared to non-glazed and water-glazed samples. 10% sumac glazing significantly decreased the number of bacteria ( $p < 0.05$ ). Sumac showed antioxidant and antimicrobial effect due to its polyphenols, gallic acid, anthocyanins, hydrolysable tannins, tannic acid, ellagic acid, catechin, essential oils, gallotannins and malic acids content [28]. Soares et al. [37] and Fadiloglu and Coban [28] found similar results. Soares et al. [37] found that chitosan showed anti-microbiological protection when compared to water-glazed samples. Fadiloglu and Coban [28] reported that treatment with chitosan and sumac reduced the TAMB of fish fillets during 12 days of storage.

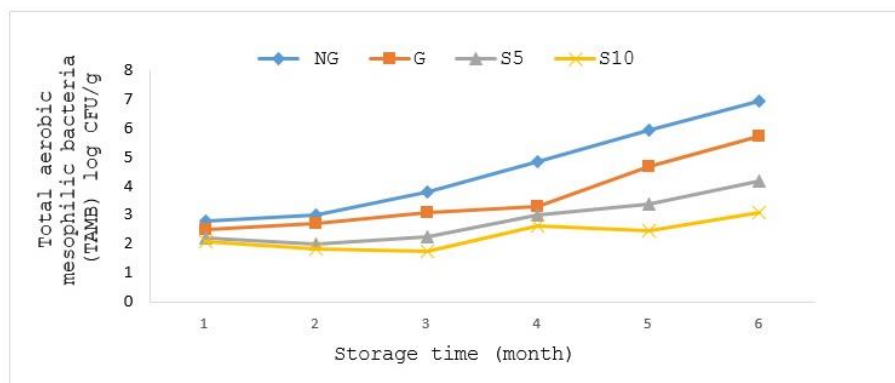


Figure 5. Effects of glazing with sumac extract on total aerobic mesophilic bacteria (TAMB) of rainbow trout fillets during frozen storage at  $-18^{\circ}\text{C}$

## 5. CONCLUSION AND RECOMMENDATIONS

Effect of glazing incorporated with sumac extract on frozen trout fillets was investigated in compliance with TBA, PV, TVB-N, FFA and TAMB. Glazing with sumac extract treatment was applied to protect the frozen trout fillets from undesirable quality changes during 6 months of frozen storage. Glazing with sumac extract showed resistance to oxygen diffusion and delayed lipid oxidation in glazed with sumac samples. Glazed with 5% and 10% sumac groups showed significantly lower TBA, PV, TVB-N, TAMB and FFA values than non-glazed and water-glazed groups ( $p < 0.05$ ). Our results showed that sumac can be used as natural antioxidant and antibacterial glazing material to inhibit the quality loss in frozen fish; especially glazed with 10% sumac extract retarded oxidative changes in frozen rainbow trout fillets during 6 months of storage.

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