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*Full Length Research Paper*

# Effects of processing methods on the sensory, mineral matter and proximate composition of rainbow trout (*Oncorhyncus mykiss*) fillets

**[*1]Pınar Oğuzhan and [2]Simay Angiş**

[*1]Department of Food Engineering, Faculty of Engineering, Ardahan, Ardahan University, Turkey
[2]Department of Fisheries , Faculty of Agriculture, Ataturk University, Erzurum, Turkey

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**In this research, the effects of processing methods of (hot smoking, cold smoking, grilling, frying) on the sensory, mineral matter and proximate composition of rainbow trout (*Oncorhynchus mykiss*) fillets were investigated. Proximate composition of raw trout fillets was determined as 70.3% moisture, 20.1% crude protein, 2.6% crude fat and 1.2% crude ash. According to the results of protein, fat and moisture contents of rainbow trout were found to be very significant (P<0.01) but ash content was found to be not significant (P>0.05) for all processing methods. Na, K, Ca, Mg, P, Fe, Zn and Mn contents of rainbow trout were found to be very significant (P<0.01) but Cu content was found to be significant (P<0.05) for all cooking methods. Mineral elements detected were Na>K>P>Mg>Zn>Fe>Mn>Cu. According to sensory evoluation results were observed hot smoked rainbow trout was had better taste parameters than the other processing methods.**

**Keywords**: Rainbow trout, processing methods, proximate composition, mineral matter.

## INTRODUCTİON

In recent years, increasing world population, is important in human nutrition deficiency causes protein sources of animal origin, this protein, the best degree of vulnerability and take advantage of resources at the beginning of a cheap way to resolve fishery is gaining importance day by day (Angis, 2004).

Fish is more nutritious than staple foods, providing animal protein, essential fatty acids and micronutrients. Fish is also a dietary source of other important nutrients, small fish which are eaten with bones are avaluable source of highly bioavailability Calcium. Minerals are essential nutrients, they are components of many enzymes and metabolism, and contribute also to the growth of the fish. The human body usually contains small amount of these minerals and the deficiency in these principal productivity and causes diseases. Fish muscle also contains mineral, vitamins and other nutritional compounds which are necessary in a diet (Mills, 1980; Larsen et al., 2000; Glover and Hogstrand, 2002; Rora et al., 2003; Devi and Sarojnalini, 2012)

Rainbow trout (*Oncorhynchus mykiss*) is the widespread cultured fish species all over the world (Emre and Kürüm, 1998) and also in Turkey, the total production in Turkey in 2006 is 57.659 tons (Tuik, 2006; İzci et al., 2009). The industry of aquatic products is a complex with fishing, breeding, processing and marketing. Fresh or non-processed-cooled aquatic products are basic foodstuff. The industrial products of aquaculture according to EU definitions are; slaughtered, salted, dried, smoked, cooked, frozen and canned products. Although the fish are commonly consumed as pan-fried by Turkish people, preferences of the consumers for cooking methods are increasingly changing. The Turkish consumer, however, has minimal knowledge about nutritive values of raw and cooked fish (Gökoğlu et al., 2004). Rich aquatic sourced Turkey, marketing much more processed aquatic foods day by day, by using the technological developments. In recent years high cost investments had been done in process sector so consumption of aquatic products are increased (Anonymous, 2001a). In Europe, particularly in Germany, Poland and the UK, there is a high market demand for

*Corresponding Author E-mail: pinaroguzhan@ardahan.edu.tr

smoked fish, such as eel, halibut, herring, mackerel, salmon and sprats. According to the FAO, the total world productions of smoked herring and salmon are about 38.000 and 86.000 tons, respectively. The consumer preference for these products resulted not only from their traditionally desirable smoky flavor, but also from their high contents of PUFA of the n-3 family in fish lipids. These FA decrease the contents of triacylglycerols, cholesterol, and low density lipoproteins in the human serum, and inhibit the aggregation of blood platelets and the damage to blood vessels (Stolyhwo et al., 2006). Having some difficulties in fresh fish consumption coerces aquaculture industry to make researches for extending shelf life. Processing technology has gain importance because of the structure and being suitable for microbial augmentation of aquatic products (Babadoğan, 1998). One of the processing of aquatic products is smoked. With developing the fisheries industry fresh fish consumption is decreased significantly in Turkey. According to 2001 year's data total capacity of institutions which certificated by EU is 111.887 ton/year. 69.810 ton/year of this amount is processed products; the other part is (42.077 ton/year) non-processed aquatic products and 2.675 ton/year of processed products is smoked products (Anonymous, 2001b).

Smoking is one of the oldest methods of food preservation and is still widely used in fish processing. In Europe about 15% of the total quantity of fish for human consumption is offered on the market in the form of either cold or hot-smoked products (Stolyhwo and Sikorski, 2005). At present, the effects of brining and smoking on color and sensory perception are at least as important as the preservative effect due to the use of modern refrigerating systems. There are three different stages of the total smoking process; brining, heating and smoking (Yanar et al., 2006). The smoking process was basically used in the past for preservative purposes, although the changes in color, odor, flavor and texture which were provoked in foods by this process were also judged as desirable. Nowadays, due to the great advance of preservative techniques, smoking is used fundamentally for the development of sensory properties in food (Guillén et al., 2006). There are three methods used to smoke fish: the traditional method by combustion, at either low temperature (cold smoking ≤30ºC) or high temperature (hot smoking ≥60ºC); use of a high voltage electrostatic field which accelerates smoke deposition; and use of liquid smoke which lowers the content of polynuclear aromatic hydrocarbons (potently carcinogenic compounds) in liquid smoked fish (Goulas and Kontominas, 2005). Higher losses of fat during processing, high frequency of gaping, low and uneven coloring distribution have increased concomitantly with the increased filled fat content. Therefore, it is important to gain more knowledge about interactions between the fresh fat content and other chemical changes during the processing step. The electrostatically smoked fillets loss more lipids and were less oxidized than the traditional cold-smoked salmon (Espe et al., 2002).

Determination of some proximate profiles such as protein content, lipid, ash and other nutrients is often necessary to ensure that they are within the range of dietary requirement and commercial specifications. The study of micro- nutrients present in living organisms is of biological importance because many of such micro-nutrients take part in some metabolic processes and are known to be indispensable to all living things. Fishes contain small amount of these micro-nutrients some of which are essential nutrients, being components of many enzymes system and metabolic mechanisms that contribute to the growth of the fish. The most important micro-nutrients in form of mineral salts include Ca, K, P, Fe, Cl, while many others are required in trace amount. The deficiency in these principal nutritional mineral elements induces a lot of malfunctioning as it reduces productivity andcauses diseases such as inability of blood to clot, osteoporosis, anemia etc. (Shul'man, 1974, Mills, 1980; Watchman 2000; Effiong and Fakunle, 2011).

The aim of this research was to determine the effects of processing methods (hot smoking, cold smoking, grilling, frying) on the sensory, mineral matter and proximate composition rainbow trout (*Oncorhynchus mykiss*) fillets.

## MATERİALS AND METHODS

### Preparing samples and cooking

Fish material, rainbow trout (*Oncorhynchus mykiss*) (250±25 g) were obtained from Ataturk University Agricultural College Fisheries Department's rainbow trout breeding and research center. Fish were carried to laboratory and washed with tap water. The fish were eviscerated, stored until rigor had resolved and then filleted (Robb et al., 2002). Fillets were washed again for removing blood and mucous remains. Five groups were constituted: group A- hot smoking; group B- cold smoking; group C- frying; group D- grilling and group E- raw. Primarily, Group A and B were brined in 28 g salt mixed with 100 ml water for per fish and brine were prepared as 80º salinometers (Kolsarıcı and Özkaya, 1998). The preservative effect of salting is mainly due to the decrease in water activity ($a_w$) and thus prevention of growth of many spoilage microorganisms along with the formation of a more membranous surface which further inhibits the growth of microorganisms (Goulas and Kontominas, 2005). After holding 1 hours in the brine, fish fillets were hanged in smoking cabinet for removing the water approximately for 30 minutes in room temperature. Group A was done hot smoking between 80-90ºC temperature for 3 hours and group B cold smoking under 30ºC temperature for 8 hours in a smoking cabinet (oven). Group C was fried in sunflower oil at 180ºC.

**Table 1.** Chemical composition (n=6) and sensory quality (n=100) of fish processed by different methods

| | Hot Smoked | Cold Smoked | Fried | Grilled | Raw |
|---|---|---|---|---|---|
| **Chemical Composition (%)** | | | | | |
| Protein** | 28.0±1.25e | 22.6±1.56b | 26.1±0.15d | 23.9±0.64c | 20.1±1.25a |
| Fat** | 7.5±0.38d | 4.7±0.36b | 12.9 ±0.05e | 5.7±0.36c | 2.6±0.49a |
| Moisture** | 59.2±2.55a | 64.9±0.93c | 62.1±0.22b | 65.0±0.26c | 70.3±1.65d |
| Ash* | 2.0±0.30a | 1.8±1.19a | 1.6±0.04a | 1.7±0.05a | 1.2±0.03a |
| **Sensory Quality** | | | | | |
| Flavour** | 4.0±0.73c | 2.8±0.73c | 3.9±0.71b | 2.8±0.73a | - |
| Appearance** | 4.1±0.65c | 3.7±0.73b | 2.9±0.74a | 3.0±0.98a | - |
| Odour** | 3.6±0.80b | 3.7±0.73b | 3.0±0.74a | 3.2±0.93a | - |
| Masticatory Function** | 3.8±0.65b | 4.0±0.76b | 3.1±0.63a | 3.3±0.65a | - |
| General Appreciation ** | 3.9±0.70b | 3.8±0.77b | 3.0±0.71a | 2.8±1.00a | - |

**: P<0,01 Very Important, *: P>0.05 Not Important. Different letters mean statistically different from each other.

Group D was grill in an electrically oven at 180ºC for 30 min. All fish in each lot were homogenized using a kitchen blender and analyzed to determine proximate composition and mineral contents. All assays were conducted on duplicate samples of the homogenates.

### Analyses

### Proximate composition

The moisture content of trout was determined by drying the fish meat in an oven at 105ºC. Crude protein content was calculated by converting the nitrogen content determined by Kjeldahl's method (6.25xN). Fat content was determined with using the soxhelet system. Ash value was obtained by dry-ashing in a furnace at 525ºC for 18 hours (Gökalp et al., 1999).

### Mineral matter content

Except P value (with UV spectrophotometer, Pharmicia LKB-Biochrom, ULTROSPEC-III), Ca, Mg, Na, K, Fe, Cu, Mn and Zn elements are determined with atomic absorption spectrophotometer. Approximately 2 g sample were burned at 525ºC for obtaining element quantities. The ash samples were dissolved with dripping 1-2 drops diluted acid (37% $H_2SO_4$) on it. After this stage, dissolved ash put with filtering to 100 ml glass balloon. The analyses were done from these clear dregs (Gökalp et al., 1999).

### Sensory evaluation

Sensory evaluation was carried out according to method of Hernández et al. (2001). Ten trained panelists for flovour, odour, appearance, masticatory function and general appreciation examined samples. A value of 1 corresponded to the lowest and a value of 5 to the highest point for each parameter.

### Statistical analysis

The results which obtained from this research were analyzed by variance followed by Duncan test. With using SPSS 18.0 (SPSS, 1999).

## RESULTS AND DİSCUSSİON

The moisture, protein, ash and fat content of raw and cooked rainbow trout fillets are given on Table 1. Protein, fat and moisture contents of rainbow trout were found to be very significant (P<0.01) but ash content was found to be not significant (P>0.05) for all processing methods. Inversely proportional to the decrease in moisture content of the samples of protein, fat and ash contents showed significant increase. Low moisture content of the samples were hot-smoked and fried. These samples also showed the highest protein content. The highest ash content of the hot smoked samples was determined. The reason the high fat content in fried samples of fish oil absorbed during cooking is that it. Frying produced the highest water loss and fat gain, more than processing methods.

Smoking increased atlantic mackerel (*Scomber scombrus*)'s protein too, from 18.3±0.3% to 24.0±0.3% (Bhuiyan et al., 1986). But higher protein content mud eel fish (*Monopterus albus*)'s protein (66.7±0.61%) went down after smoked (27.1±0.67%) (Vishwanath et al., 1998).

Different cooking methods had increased the protein content of rainbow trout from 19.80±0.03% to 26.34±0.23% (fried); 20.66±0.67% (boiled); 23.26±0.00% (baked); 25.00±0.41% (grilled) and 29.04±0.48% (microwave-cooked) (Gökoğlu et al., 2004). Parallel

**Table 2.** The mineral compositions of raw and processed fish (n=4) (mg/kg)

| Group | Na** | K** | Ca** | Mg** | Fe** | Cu* | Mn** | Zn** | P** |
|---|---|---|---|---|---|---|---|---|---|
| A | 5205±21.4c | 3909±7.9e | 88±3.6b | 331±2.5d | 1.4±0.05a | 0.35±0.02b | 0.53±0,02b | 4.6±0.08b | 2666±7.55b |
| B | 7126±49.7d | 3675±16c | 68±3.3a | 292±3.6b | 1.9±0.05c | 0.28±0.03a | 0.60±0,02c | 6.1±0.07c | 2727±4.99c |
| C | 487±5.4b | 3200±2.9b | 151±2.7c | 258±5.3a | 1.8±0.04b | 0.37±0.04b | 0.50±0,03b | 3.4±0.02a | 2560±2.43a |
| D | 524±4.4b | 3795±8.4d | 669±3.8e | 319±2.5c | 1.7±0.05b | 0.35±0.03b | 0.37±0,01a | 3.4±0.02a | 3178±5.08d |
| E | 450±5.9a | 3008±7.9a | 641±2.9d | 414±3.6e | 2.0±0.03d | 0.34±0.04b | 0.68±0,03d | 9.1±0.06d | 3372±6.68e |

A: Hot Smoked, B: Cold Smoked, C: Fried, D: Grilled, E: Raw.

**:P<0,01 Very Important, *:P<0.05 Important. Different letters mean statistically different from each other

results had observed in another report. Four different cooking methods (baked, broiled, deep-fried and microwave) tried in four different fish species (grouper *Epinephelus morio*; red snapper *Lutjanus campechanus*; Florida pompano *Trachinotus carolinus* and Spanish mackerel *Scomberomorus maculates*) increased protein content of fish (Gall et al., 1983). Kocatepe et al. (2011) reported that protein content for anchovy (*Engraulis encrasicolus*, Linnaeus 1758) from 22.71±0.04% (raw), 22.44±0.16% (frying) and 25.55±0.16% (grilled). Similar findings have been reported for grilled and fried fish species (Musaiger and D'Souza, 2008), raw and cooked (frying and grilling) horse mackerel (Erkan et al., 2010a), raw and cooking (frying and grilling) snakehead fish (Marimuthu et al., 2012).

Moisture alterations were similar with Vishwanath et al. (1998) in mud eel fish (*Monopterus albus*)'s moisture (77.00±0.08%) went down after smoked (45.70±0.00%). Moisture content for raw rainbow trout, reported by Gökoğlu et al. (2004) (73.38±0.01%) was closed to our value. According to this report different cooking methods were decreased the moisture content. For example; fried rainbow trout, 62.69±0.02%; boiled, 69.16±0.03%; baked, 65.30±0.07%; grilled, 65.83±0.05% and microwave-cooked 63.52±0.08%. In different fish species' moisture content was decreased after cooking too (Gall et al., 1983). Similarly, moisture content have been reported for fried black pomfret (*Parastromateus niager*) (Moradi et al. 2009), grilled and fried fish species (Musaiger and D'Souza, 2008), raw and cooking (frying and grilling) snakehead fish (Marimuthu et al., 2012).

Lipid content has an effect on the eating quality of rainbow trout (Robb et al., 2002). So, fat increment in this try is a desired specification. This result was opposed to Vishwanath et al. (1998) who reported that smoked mud eel fish fat content (10.74%) is lower than raw fish (9.82%). Increasing fat content in smoked fish was similar in Bhuiyan et al. (1986). Similarly, lipid content have been reported for fried black pomfret (*Parastromateus niager*) (Moradi et al. 2009), raw and cooking (grilling and frying) African catfish (Ersoy and Ozden 2009). They delivered fat content for raw atlantic mackerel 1.8±0.2% and for smoked mackerel 2.3±0.2%. (Gall et al., 1983) observed different results according to different cooking methods in four fish species. Fat content of raw rainbow trout was reported as 3.44±0.01% (Gökoğlu et al., 2004). The origin of this may be from the feed variations. The composition of lipids in smoked products depends primarily on their contents and state in the fish used for smoking. The conditions and time of chilling and frozen storage of fish affect the rate of oxidation. Further factors influencing the state of lipids are the preparation of the raw material for smoking, the smoking itself, and storage of the products. Brining, drying, heating, and the reactivity of smoke components may have an impact on the rate of lipid changes by affecting the tissue enzymes involved in oxidation reactions, as well as by generating and changing the stability (Stolyhwo and Sikorski, 2005). This result was supported by the other researchers.

The ash percent for raw rainbow trout was as 1.35±0.01 and for cooked fish 1.53±0.07 (Gökoğlu et al., 2004). Atlantic mackerel's ash values were 1.9±0.2% for raw and for smoked 5.1±0.3% (Bhuiyan et al., 1986). All cooking methods increased ash percent of 4 fish species (Gall et al., 1983). However, in smoked mud eel's ash percent (7.00±0.57) was higher than raw fish (6.00±1.00) (Vishwanath et al., 1998). Kocatepe et al. (2011) reported that ash content for anchovy (*Engraulis encrasicolus*, Linnaeus 1758) from 1.48±0.01% (raw), 2.02±0.01% (frying) and 1.97±0.00% (grilled). Similar findings have been reported for grilled and fried fish species (Musaiger and D'Souza, 2008), raw and cooked (frying and grilling) horse mackerel (Erkan et al., 2010a), raw and cooked (grilled and fried) marine fish species (Erkan et al., 2010b).

The mineral compositions of fish (in raw and cooked fillets) are given on Table 2. Na, K, Ca, Mg, P, Fe, Zn and Mn contents of rainbow trout were found to be very significant (P<0.01) but Cu content was found to be significant (P<0.05) for all processing methods. Na content was highest in cold and hot smoked samples. The reason for this is that they are treated with brine

before smoking operations. Ca content significantly decreased after smoking operations. All of processing methods, Mg, Fe, Mn, Zn and P contents were also decreased significantly. All these results are similar with the other reports (Gall et al., 1983; Steiner et al., 1991; Gökoğlu et al., 2004; Ersoy and Özden, 2009; Effiong and Fakunle 2011; Devi and Sarojnalini 2012; Effiong and Fakunle 2012).

The sensory quality of fish (in raw and processed fillets) are given on Table 1. Flavour, appearance, odour, masticatory function and general appreciation of rainbow trout were found to be very significant ($P<0.01$) for all processing methods. According to the findings in terms of flavor and health concluded that the best processing method is smoking process.

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