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PROXIMATE AND MINERAL ANALYSIS OF ATLANTIC SALMON *(SALMO SALAR)* CULTIVATED IN BULGARIA

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Abstract

Problem statement: *Only limited information exists on nutrients in salmonoids meat in Bulgaria, which may to be different and vary to a greater extent than the nutrient composition of other fish items. The present paper is aimed to determine the proximate composition, macro and trace elements of Atlantic salmon`s meat. These data could be helpful in judging the value of nutrient composition data as a base for dietary recommendations.*
Organisms: *12 species of Atlantic salmon (Salmo salar).*
Approach: *The aim of this study was to determine the proximate composition and levels of iron, potassium, sodium, calcium, phosphorus, magnesium, copper, selenium and zinc in Atlantic salmon cultivated for the first time in Bulgaria. The content of protein, fat and ash and concentrations of iron, potassium, sodium, calcium, phosphorus, magnesium, copper, selenium and zinc were determined by automatic systems and electro thermal atomic absorption spectrometry (ETAAS) after microwave digestion. Mean values and their respective coefficients of variation were calculated from the measured concentrations.*
Conclusion: *In order to provide an accurate overview and to be able to calculate reliable dietary intakes, it is important to know the fish composition data.*

Key words: *Atlantic salmon, Proximate composition, Macro elements, Trace elements.*

INTRODUCTION

The first evidence connecting humans to salmon was found in southwestern France and northern Spain in caves that were occupied during the Upper Paleolithic period. Salmon fish traps from around 6000 B.C. have been found in Sweden and salmon fish nets from around 6250 B.C. have been found in Danish bogs. Atlantic salmon, once abundant throughout the North Atlantic, were prized food by Gauls, Romans, and Native Americans alike (Clay, 2004).

Today more than 50% of the global salmon supply was farmed (Johnson, 2001). According to the United Nations Food and Agriculture Organization (2005), salmon is farmed in 24 countries, as the major producers of salmon are Norway and Chile (Bostick et al., 2005).

Among seafood species consumed in the world, salmon is an important contributor of many nutrients. She is preferred fish species for consumption because of its rapid growth and rich and diverse composition of the meat (Exler, 2007; Stancheva et al., 2010). In other side fish tissue is an excellent source of macro and essential trace elements such as iron (Fe), zinc (Zn) and selenium (Se) (Briggs and Schweigert, 1990). The accurate determination of these elements is therefore important in nutrition studies, particularly because meat, as a biological material, exhibits natural variations in the amounts of nutrients contained (Greenfield and Southgate, 2003). Therefore, it is essential that nutrient data, including trace element contents, are regularly updated to reflect the current data situation and to monitor possible changes (Gerber et al., 2008). These data could be helpful in judging the value of nutrient composition data as a base for dietary recommendations (Leonhardt and Wenk, 1997).

Overall, the most widely used trace elements determination techniques in salmon are Uv-Vis spectrophotometry (Bland et al., 1999), ETAAS (Angelova et al.,2006; Gosslim et al., 2007; Dospatliev et al., 2008), X-ray fluorescence, ICP-OES (Farias et al., 2002;

Dospatliev et al., 2010; Dospatliev et al., 2011) and ICP-MS (*Forrer et al., 2001; Matsuura et al., 2001*).

The aim of this study was to examine the proximate composition and the concentration of essential elements like iron (Fe), potassium (K), sodium (Na), calcium (Ca), phosphorus (P), selenium (Se), magnesium (Mg), copper (Cu), and zinc (Zn).

MATERIALS AND METHODS

Fish

The farmed Atlantic salmon (Salmo salar L.) were grown in aquaculture base of Eurocorrect Ltd., Vacha Dam Lake, Bulgaria comprising duplicate 8m×8m×6m net cages. The fish were fed a commercial ration of the Soprofish® series (Subotica Ltd., Subotica, Serbia). The diets consisted of 13/45 (fat/protein levels) for the 3 mm, pellet sizes.

Sample Preparation

Immediately after catching, they were anaesthetized (el stunning) and stored on ice in an insulated box and transported to the Central laboratory of Trakia University on the next day. The mean weight and length of the salmon were 89.32±1.42 g and 15±0.85cm. There fish was beheaded. Spinal meat samples (35 grams) without skin from all fish specimens were taken and examined. They were prepared for the experiment in standard ways dried at 105^{o} C in a fan oven and stored in dark plastic bottles.

Reagents

Reagents were qualified as pure (Merck® and Fluka®). The standard solutions for ETAAS determination of K, Na, Ca, Fe, Mg, Zn and Cu with concentration of 1000 mg/l were supplied by Merck (Darmstadt, Germany). Double-distilled water was used for all the procedures. The samples were analyzed with Perkin-Elmer A Analyst 800 atomic absorption spectrometer (Norwalk, CT).

Mineralization of samples

We weighed 3.0 g of air-dried salmon to the nearest 0.01 g in a round-bottomed 100 ml flask and added 22.5 ml of HCI and 7.5 ml of HNO_3 acid. We connected the flask to a reflux condenser and let it stand for no less than 16 hours at room temperature, then heated gently to boiling for 2 hours. After cooling and flushing the condenser with 25 ml of 12.5% nitric acid the sample was filtered and 100 ml of 12.5% nitric acid was added to the part of it in liquid phase.

Proximate Analysis

The samples were prepared AOAC (2006; method 983.18) and subjected to moisture analyses using air drying AOAC (1997; method 950.46). Crude protein content was calculated by converting the nitrogen content by multiplying by 6.25 due to the fact protein is 16 percent nitrogen (100/16=6.25), determined by Kjeldahl's method using an automatic Kjeldahl system (Kjeltec 8400, FOSS, Sweden). Lipid content was determined by the method of the Soxhlet using an automatic system (Soxtec 2050, FOSS, Sweden). Crude ash was determined by incineration in a muffle furnace (MLW, Germany) at 550^{o} C for 8 h. Crucibles were brought about the room temperature and weighted.

Statistical analysis

Statistical analyses were performed using STATISTICA 6. The accuracy of the measurements was assessed by standard deviation (SD) and relative standard deviation (RSD) for n = 12.

RESULTS AND DISCUSSIONS

Table 1. Proximate composition of the muscle of Atlantic salmon (Salmo salar).

Proximate composition				
Element	Technique	n	Mean	SD
Moisture	AOAC 950.46	12	73. 65	0.076
Crude protein	AOAC 988.05	12	18.81	0.056
Crude fat	AOAC 960.39	12	4.46	0.158
Crude ash	AOAC 942.05	12	0.96	0.013

The results of proximate analysis in the flesh of salmons are shown in Table 1. Moisture, protein and lipid and ash contents of the salmon meat averaged 73.65, 18.81, 4.46 and 0.96%, respectively. However, the present values are favorably comparable with the published reports in different salmon species (USDA 2005; Exler, 2007; Stancheva and Merdzhanova, 2011).

The concentration ranges and averages of macro elements in the salmon fishes analyzed are summarized Table 2.

Table 2. Mineral contents of Atlantic salmon (Salmo salar).

Macro elements (mg/100g)					
Element	Technique	n	Mean	SD	RSD
Ca	ETAAS	12	5.45	0.11	0.86
P	ETAAS	12	118.20	7.02	2.04
Na	ETAAS	12	195.05	6.29	2.18
K	ETAAS	12	244.7	5.6	1.18
Mg	ETAAS	12	32.69	0.70	1.53

Calcium is an essential macro element and it is present in the structure of bone. Calcium is present in a healthy human body at about 2% of body weight (Öksüz, 2012). The daily requirement of calcium of human, salmon can be seen as a poor source of calcium because raw tissue contained between 3.5 and 8.7 mg/100g.

Phosphorus is structural component of hard tissues such as bone and scales, as well as a constituent of various coenzymes, phospholipids and nucleic acids. Fish can obtain a substantial number of required minerals directly from their rearing water, but phosphorus is one essential mineral that must be supplied by the diet (Lall, 2002). Fish meat is a rich source of phosphorus and can be on the order of 140-200 mg per 100 g of product. This element occurs in almost all species of fish (Stanek and Janicki, 2011). In our study was determined 118.20 ± 7.02 per 100 g.

Sodium is a natural ingredient in raw animal products. Sodium content in fish varies a great deal, depending on the species and variety. Especially, Atlantic salmon contain fewer than 60 mg of sodium per 100 gr. In our study was determined 195.05 ± 6.29 per 100 g at the result significantly different from what was expected.

Potassium is macro mineral, which is important for building muscle, metabolizing protein and carbohydrate, balances water and acid in the blood and body tissues. Salmonoids have the highest amounts of potassium, ranging between 375 to 628 mg. In farmed Atlantic salmon have only 384 mg, while wild Atlantic salmon have 628 mg, Sockeye has 375 mg, Chinook has 505 mg, farmed Coho has 460 mg, wild Coho has 434 mg and Pink salmon has 414 mg per 100 g. In this case, again observed numbers were so different from the expected (244.7 mg).

Magnesium is an essential element for organisms for oxidative phosphorylation and activates many enzymes (Öksüz, 2012). He is widely distributed among the foods, and it ranges from 25 to 76 mg in each raw edible 100 g of salmonoids (Silva and Chamul, 2000). Magnesium content of farmer salmon was determined as 32.6 mg/100g.

Table 3. Trace elements of Atlantic salmon (Salmo salar).

Trace elements (mg/100g)					
Element	Technique	n	Mean	SD	RSD
Fe	ETAAS	12	2.6	0.21	4.32
Zn	ETAAS	12	1.96	0.04	0.97
Cu	ETAAS	12	0.98	0.02	0.67
Se	ETAAS	12	0.34	0.01	0.26

The trace element contents of the salmon are given in Table 3. They were determined in the raw muscle. A lot of metals are necessary in low concentration for human, because they are essential elements, such as Fe, Cu and Zn.

The iron content of fish is very low compared to that of mammals (Watanabe et al., 1997). But according to the U.S. National Library of Medicine and the National Institutes of Health, salmon is a good source of iron, along with tuna for adults and children. The iron concentrations (mg/100g wet weight) in the samples analyzed ranged from 1.9 to 3.4 mg/100g with a mean of 2.6 ± 0.21.

Zinc is another important essential element and it is present active sites of many enzymes. It is also a natural component of many sea foods (Ikem and Egeibor, 2005). The zinc content of farmed salmon was about 1.96 mg/100 g., similar to cultured and wild coho salmon reported by Felton et al., (1994).

Copper and selenium are essential trace elements for fish metabolism and important micronutrients in the human diet (Ames, 1998). Copper is a cofactor in a wide range of enzymes including cytochrome oxidase, superoxide dismutase and lysyl oxidase (Watanabe et al., 1997). Copper is essential for good health but very high intake can cause adverse health problems such as liver and kidney damage (Ikem and Egeibor, 2005). Muscle copper concentrations in salmon were below the MAFF guideline value of 3.0 mg /100g (MAFF, 1995).

Selenium is important for a strong immune system and helps regulate the thyroid hormones. He is an integral component of glutathione peroxidase which protects cells from oxidative damage (Watanabe et al., 1997) and is an important nutrient for Atlantic salmon (Johnston et al., 2006). Most seafood is rich in the trace minerals selenium, and salmon is no exception, providing nearly 40 micrograms. Muscle selenium levels in the salmon were 0.34 within the range reported for healthy farmed salmon (Johnston et al., 2006).

CONCLUSIONS

The investigation focused on chemical composition of Salmon fish and provided in particular information on the both macro elements and trace elements in meat. Most of elements (Mg, Na, Fe and Cu) in the Bulgarian diet are derived from plant foods. From the other side, the macro elements Ca and P, and the trace elements Zn and Se, were derived mainly from meat and meat products. This well known fish meat is a very good source of minerals like phosphorus, potassium, sodium, magnesium, zinc and iron with the exception of calcium. Sodium was the highest in all macro elements, followed by P, K and Ca. The variation recorded in the concentration of minerals in salmon meat from another investigations and results, could have been be influenced by a number of factors such as seasonal and biological differences (size, age and sexual maturity), food source and environment (water chemistry, salinity, temperature and contaminants). However, we conclude that salmon cultivate from the Vacha Dam Lake is recommended for human consumption as a good source of macro elements and trace elements.

This investigation provides practical and useful information on the chemical composition of salmon, which is the first time cultivated in Bulgaria. It can be concluded that this study contributes to a description of the chemical and proximate composition of salmon meat which could be use to extend existing information. Furthermore, the mineral composition of salmon meat are presented, some of elements for the first time, in order to establish a database on the nutrient composition on salmon meat for further use in research on human consumption of this relative unknown type of meat in Bulgaria. These results will be important for the nutritionists and researchers for improving processing. It is also helpful for similar academic studies and to prepare tables of compositions of food.

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