Comparison of Physicochemical Quality, Macronutrient and Energetic Values of Fresh and Canned Tuna After Storage Different Periods

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Abstract

We evaluated the nutritional value of fresh and canned tuna based on the date of production and expiration and measured the concentration of heavy metals in samples. The twenty cans of tuna and 5 kg of fresh tuna were prepared. After 6, 9 and 11 months storage of canned fish, percentage of proximate, pH and concentration of heavy metals measured. The results showed that the proximate composition of canned samples changed comparing to the fresh samples during different periods. The percentage of fat and protein increased and decreased significantly respectively. The energy values of canned fish decreased over time, but on 11th month storage after production, it was higher than fresh fish. The concentration of heavy metals significantly increased over time, but obtained contents were lower than the limits allowed by international standards which will not pose a problem for human consumption.

Introduction

One of the indicators for evaluating the nutritional value of aquatic animals is determining the percentage of moisture, fat, protein and ash. The proteins in fish tissue have better nutritional value than the red meat proteins due to their essential amino acids. Due to the difference in proteins in terms of nutritional value, measuring this index in foods containing high protein is very necessary and valuable (Alipour, Shabanpour, Sadeghi, & Shabany, 2011). The amount of fat and moisture in canned fish depends on various factors such as the season and place of fishing, the rate of sexual maturation and reproductive cycle, fish species and size, processing method and fish storage time (Aberoumand, 2011).

Tuna fish is found in tropical waters and is scattered around the world. Tuna fish and related species belong to six genera of the family Scombridae. Tuna fish is one of the most important food sources for human consumption, but it can to store large amounts of heavy metals, which is sometimes used to measure environmental pollution (Ikem & Egiebor, 2005).

One of the benefits of canned food is its preservation and safety. The main steps in the canning process include cooking, cooling, packaging after adding oil or tomato sauce to cans and sterilizing (Selmi, Monser, & Sadok, 2008). To prevent the growth of thermophilic bacterial spores, it should not stored at temperatures above 35 °C. Changes in food quality during storage are due to changes in physicochemical and microbiological properties that reduce their nutritional value, taste and safety. Because of easy to use of canned fish, today the distribution and consumption of these products has been widely spread, so that in 2012, 569 million cans of canned tuna were produced by 134 production factories in the country (Fisheries Research Institute of Iran). Because of the high consumption of this product due to the use of metal cans for packaging, this product may be contaminated (Bonyadian, Moshtaghi, Nematellahi, & Naghavi, 2012). On the other hand, due to the increasing pollution of aquatic ecosystems, there is a possibility of quality problems and pollution in this valuable food source (Cheung, & Chan, 1999).

Velayatzadeh & Askari (2014) investigated on the accumulation of heavy metals such as mercury, cadmium, tin, nickel, zinc and iron in canned samples of tuna in Iran. The results showed that the levels of the heavy metals of nickel, mercury, zinc and tin in canned Hoover fish were lower than those allowed by the WHO and FDA, but cadmium levels were high. In another study conducted by Velayatzadeh, Askari Sari, Beheshti, Hosseini, &, Mahjoub, (2010), the accumulation of heavy metals in canned tuna in the cities of Shushtar, Isfahan and Hamedan in Iran was compared. He showed that the concentrations of metals such as mercury, cadmium, tin and nickel were below the permissible levels and international standards. Rahimi, Fadaei Fard, Karimi, Shakarian, & Garshasbi, (2014). investigated the determination of arsenic concentration in canned tuna in Isfahan and Shahrekord in Iran. In his study, the concentration of arsenic in 60 canned tuna was measured. Arsenic concentrations in canned tuna samples were lower than the EU standard. Ghazi Khansari & Afshar (1996) studied the concentration of heavy metals in tuna fish. Their results showed that the amount of accumulation of metals such as cadmium, arsenic, lead, mercury and tin was lower than global standards. Lashkari Moghadam, Rabbani, & Ahmadi Panahi, (2010). conducted a study on the accumulation of heavy metals in canned tuna fillets and oil and found that the amount of nickel in tuna muscle was low but its amount was high in canned fish oil. The amount of cadmium in the product was more than the standard.

Emami Khansari, Ghazi Khansari, & Abdollahi, (2002) evaluated the amount of heavy metals in canned tuna. Their results showed that the amount of metal toxins in canned tuna in Iran was less than the permitted level by FAO (2003), and will not pose a danger to consumers. The study results of Qomi Behbahani & Javaheri Baboli (2014) showed that the percentage of protein and fat in the canned fish increased compared to fresh fish (control) and the percentage of moisture decreased significantly. Naseri, Rezaei, Moieni, Hosseini, & Eskandari, (2011) studied the changes in fat and chemical composition under different conditions of sterilization in canned silver carp. Their results showed that the amount of fat, protein, moisture and ash in fresh silver carp was significantly different from the canned fish. In this experiment, the percentage of moisture and fat decreased during the sterilization process and the percentage of protein and ash increased.

Fathi Achachloui & Abroumand (2015) investigated on some of the physicochemical properties of two types of fish (*Euthynnus affinis*) and (*Katsuwonus pelamis*) fresh and canned at different storage times. Their results showed that the amount of fat, protein, ash and energy value in canned *Katsuwonus pelamis* changed significantly during the three months storage. In *Euthynnus affinis* also, the protein percentage also changed significantly. In this experiment, there was no significant difference in pH during both canned fish species during storage.

Ezzatpanah, Ganjavi, Givianrad, & Shams, (2009) studied on the levels of lead and cadmium in canned yellow fin tuna. Lead and cadmium levels were lower than recorded levels by the Institute for Industrial Research and Standards and the European Union Committee. In his experiment, it was found that the lead and cadmium content was significantly reduced during the canning process, including defrosting, cooking and sterilization.

Although the consumption of some nutritious fish is high in the world, due to the bioaccumulation of lead (Pb), cadmium (Cd), mercury (Hg) and other heavy metals that enter the fish muscles from the environment, it can have adverse effects on Have human health. These three metals are considered as one of the most important pollutants in the aquatic environment of fish, which is due to toxicity and accumulation in marine organisms and due to high durability in the environment (Castro-González & Méndez-Armenta, 2008). Although heavy metals are natural pollutants in the aquatic environment, their levels have increased due to industrial activities (Sarmiento, DelValls, Nieto, Salamanca, & Caraballo, 2011). Mercury is one of the most abundant toxic metals and is a particularly important element because its mineral form is biologically converted in aquatic environments and even low concentrations of metals may threaten the health of aquatic organisms and humans (Olmedo, Pla, Hernández, Barbier, F. Ayouni, & Gil 2013). Honarvar (1999) stated the reason for the increase the percentage of protein during the canning process was heat treatment in the preliminary stage and sterilization, which caused the separation of moisture from the fish tissue and ultimately increased the percentage of dry matter and protein content.

Moini, Taheri, Koochehkian, & Astaki, (2008) showed the increase the percentage of fat in canned fish compared to the control sample was the thermal process performed on the fish tissue, because during this process a high percentage of moisture in the fish lost, which increased the percentage of dry matter and fat content. Another reason for the increase in the percentage of the fat in canned food was the addition of oil to the canned food during processing. Aberoumand (2011) showed, the percentage of protein in fresh and canned tuna during 4 months of storage was 22 and 23.9%, respectively. In this study, the moisture content in the range of 49.6-51%, protein in the range of 19.8-23.9%, fat in the range 18.4-21.4% and ash was in the range 2.4-3%. Baygar & Gokoglu (1999) investigated on fresh and canned Hoover fish for pH. Their results showed that the pH of fresh fish was 5.62 and canned fish was 5.83. The purpose of this study was to evaluate the nutritional value (fat, protein, ash and moisture) and measure the heavy metals in canned tuna during 6, 9 and 11 months storage from the time of production which we can determine the best time to consume canned fish.

Materials And Methods

2.1. Preparation of samples

This research has been done in the fisheries laboratory of Khatam Alanbia University of Technology in Behbahan. To prepare the samples, 15 canned tuna and 5 kg of fresh tuna fish were purchased from Behbahan city market. The tuna were placed in completely clean plastic bags. After transferring the samples to the fisheries laboratory, all samples were washed thoroughly with distilled water to remove viscous substances and heavy metals adsorbent particles from the fish's body surface. First, all laboratory dishes are washed with detergent and then the dishes are placed in nitric acid for 24 h which thoroughly cleaned. Finally, it was washed with distilled water and then dried. First, the head, tail and internal organs of the fish were removed with a knife, and then the muscle fillets was separated and transferred to pre-cleaned containers.

Fresh fish and canned fish after 6, 9 and 11 months from production were transferred to Maroon Green Soil laboratory located in Behbahan city, Iran for analysis of proximate compositions and measurement of heavy metals. The proximate compounds (fat, protein, moisture, ash contents, and energy values), pH, and heavy metals such as copper, zinc, iron, and mercury measured.

2.2. Measurement of the moisture of the fish

To measure the percentage of moisture in tuna fillets and canned fish fillets, 10 g of the sample weighed, then, it was placed in a container. The prepared samples were placed in an oven at 103 ° C until reaching a constant weight. After leaving the oven, the container were placed in a desiccator for 30 min to cool and then weighed (AOAC, 2005).). Moisture percentage was determined using the following equation:

Percentage of dried matter = (weight of dried sample / initial weight of sample) × 100

Percentage of wet matter - Percentage of dried matter= Percentage of moisture

2.3. Measurement of protein percentage

The protein percentage of the samples was determined using the Kjeldahl method. The 1 g of each sample was placed into a digestion flask and then 150 ml of concentrated sulfuric acid was added to each flask along with the catalyst. The balloons in the desired device were placed to boil at low temperature for 30 min until the foam comes out. After that, the temperature was increased to digest the sample, which took time about 4 hr. After cooling the samples, distilled water was added to each balloon and placed in the titration section of the device. The samples were titrated with 1% normal sulfuric acid. The percentage of crude protein was obtained by determining the amount of total nitrogen using the formula 25.6 ×% N (AOAC, 2005). The number obtained indicated the amount of crude protein. The percentage of nitrogen was also determined using the following equation:

Percentage of nitrogen = amount of acid consumption 0.1 normal / sample weight × 100

2.4. Measurement of fat percentage

To measure the percentage of crude fat in the samples, the 5 g of fresh and canned fish samples were wrapped in filter paper and placed in the extractor of the Soxhlet apparatus. The 100 ml of ether was placed into a balloon and connected to the refrigerant. Extraction was performed by heater at a temperature of 60 ° C for 8 hr. Distillation of the solution continued until the solution was free of solvent (AOAC, 2005). The prepared samples were then dried under the hood. The fat percentage of the samples was calculated using the following formula:

Percentage of fat = weight of the final sample -initial weight of the sample / initial weight of the sample × 100

2.5. Measurement of ash percentage

An electric furnace was used to determine the percentage of ash in the samples. The 10 g of the samples already dried in the oven were placed in a container, then placed in an electric oven at 500 ° C for 12 hr. The container was placed in a desiccator for 30 min to cool the samples (AOAC, 2005). The amount of gray sample remaining in the container was the amount of sample ash, which is obtained based on the following equation:

Percentage of ash = (weight of ash/initial weight of sample) × 100

2.6. Measurement of energy values

The amount of fillet energy using the method of Schulze, Knaus, Wirth, & Rennert, (2005). (2005) was calculated. In this method, the total energy obtained from the protein and fat contents of the sample was determined based on the following relationship:

Energy level (kJ per 100 g of fillet) = (percentage of protein amount × 6.23 + percent of fat content × 8.39

2.7. Measurement of PH

The 5 g of fresh and canned fish samples were mixed with 45 cc distilled water. The homogenized sample was measured using a digital pH meter and its pH was determined (Masniyom, Benjakul, & Visessanguan, 2005).

2.8. Measurement of heavy metals

In order to chemically digest and measurement of concentration of heavy metals after transferring the samples to the laboratory, all samples were placed in an oven at 65 °C for 150 min until they reached a constant weight. Dry method was used to digest the samples. The 0.5 g of the weighed sample was placed into a 250 ml flask and 25 ml of concentrated sulfuric acid, 20 ml of 7 M nitric acid and 1 ml of 2% sodium molybdate solution were added. For uniform boiling of the solution, several welding stones were placed in a balloon. After cooling, 20 ml of a mixture of concentrated nitric acid and concentrated perchloric acid in a ratio of 1: 1 was added to the sample from the top of the refrigerant. The mixture heated until the white vapors of the acid have completely disappeared. Slowly 10 ml distilled water add to the cooled mixture while the balloon is rotating. A completely clear solution is obtained by heating. After cooling, this solution was transferred to a 100 ml balloon and until it reached volume (Kalay & Bevis, 2003; Eboh, Mepba, & Ekpo, 2006). Heavy metals were measured by atomic absorption using Perkin Elmer 4100. To measure heavy metals, first to 10 ml of the digested solution, 5 ml of 5% ammonium pyrrolidine carbamate solution was added and then the sample was shaken by a shaker for 20 min until the elements were complexed in metallic organic form in solution. Then 2 ml of methyl isobutyl ketone was added to the solution and mixed for 30 min. After 10 min, the samples were centrifuged at 2500 rpm and the elements were transferred to the organic phase. After adjusting the furnace and EDL system (source of cathode ray production) of the device and optimizing the atomic absorption device, the calibration curve of these elements was plotted by Win Lab 32 software with the help of their standards and the modifiers of palladium and then the concentration of heavy metals in ready solutions measured (Olowu et al., 2010).

2.9. Statistical analysis of data

In this study, data analysis was performed using SPSS software. The mean of treatments was compared using t-test and the presence or absence of significant differences was determined at the level of 5%. Excel 2003 software was used to draw the Figures.

Results And Discussion

According to the Figure 1, it can be stated that the percentage of moisture in canned fish after 6 months from production was the highest comparing to the other experimental groups. The lowest was observed in fresh tuna. The results showed that the percentage of fat in all experimental treatments had a significant difference with each other ($p<0.05$).

Fresh tuna fish had a percentage of protein more than canned fish treatments. The results showed that during the canning process with over time, the protein content of tuna fillets decreased significantly. Canned fish in the 9th and 11th months after production had no significant difference, but with other treatment had a significant difference ($p<0.05$) (Figure 2).

According to the Figure 3, it can be stated that the percentage of moisture in all experimental treatments had a significant difference with each other. The highest percentage of moisture (59%) was observed for canned fish in the 11th month after production and the lowest percentage in the 9th month of the experiment was 50.33% ($p<0.05$).

The percentage of ash during the 6th and 9th months after canning process was lower than the control sample. The highest percentage of ash was observed in the 11th month of the experiment. Statistical analysis of the data showed that there was a significant difference between all experimental treatments ($p<0.05$).

The energy value in canned tuna fillet after 6 months from production was significantly higher than other experimental samples. The lowest energy level was observed for the 11th month of the experiment. Statistical analysis of the data showed that there was no significant difference between the energy value in fresh fish fillets and canned fish in the 9th month of the experiment, but there was a significant difference between other treatments (Figure 5) ($p<0.05$).

According to the Figure 6, the pH level, except for canned fish in the 9th month of the experiment, which had the highest, in the other treatments without significant difference had a constant value ($p<0.05$).

The results of measuring the concentration of heavy metals in fresh and canned tuna fillets after 6, 9 and 11 months after production are shown in the following Figures 7-10:

The Figure7 showed that the iron concentration in canned fish in the 6th month of the experiment was higher than other experimental samples. The lowest content of iron was observed in the control sample. The results showed a significant difference between all experimental treatments ($p<0.05$).

The results of present study in Figure 8 showed that there was a significant difference between the concentration of zinc in all experimental treatments ($p<0.05$). The highest was observed in the 9th month with a concentration of 10.83 (mg / kg) and the lowest was observed in the 11th month of the experiment with a concentration of 5.73 (mg / kg).

The results of the experiment in Figure 9 showed that the concentration of copper in canned tuna fillets over time significantly increased ($p<0.05$). The concentration of this element in the control treatment was higher than the 6 th month of the experiment, but it found significantly lower than other experimental treatments. The highest copper content was observed in canned fish in the 11th month of the experiment ($p<0.05$).

According to the following Figure 10, it can be stated that the concentration of mercury in the 9th and 11th months after canning comparing to the 6th month storage increased, but this increase in concentration was significantly different comparing to the other samples in control and 6 th month storage ($p<0.05$).

In this study, the average concentration of mercury obtained in all samples was lower than the global standard, which was 0.5 mg /kg. Gochfeld & Burger (2004) evaluated 168 canned tuna in terms of mercury concentration. Their results showed that the average total mercury content in tuna fish was 0.456 mg/kg and they stated that the total mercury content was 25% higher than the world standard. The maximum concentration of mercury obtained in their report was 0.956 mg/kg. Emami Khansari, Ghazi Khansari, & Abdollahi, ((2002) stated that the amount of mercury in a sample of canned food investigated in Iran was less than the standard. Although in the present study, the concentration of mercury in canned tuna increased over time, but its amount was lower than the values of international standards, and obtained results of present study were in line with the results obtained from the study of other researchers.

In another study, the concentration of mercury in the analyzed canned fish was 146.65 ppb, which was lower than the global standards of EPA and FDA, which stated that the permissible amount was 1 μg per g (Salar Amoli & Isfahani, 2008) which was consistent with the results of this study. Research on the concentration of heavy metals in canned tuna has results with different yield. Accumulation of heavy metals in fish muscle varies according to ecological and biological conditions as well as metabolic activities of fish (Canli & Atli, 2002). Study of Ikem & Egiebor (2005) showed, the concentration of copper metal in the analyzed canned fish was less than the MAFF standard, which was consistent with the results of present study.

Velayatzadeh, Askari Sari, Beheshti, Hosseini, &, Mahjoub, (2010) investigated the heavy metals in some canned tuna in Iran. Their results showed that the highest amount of iron was 7.63 ± 0.04 mg and 5.36 ±

0.82 mg /kg and the lowest amount of iron was 4.29 ± 0.45 and 2.84 ± 0.42 mg /kg. In the present study, the concentrations of zinc and iron in canned fish showed a significant increase comparing to the fresh samples. Zinc accumulates mainly in the bones and skin, but is also found in significant amounts in the liver, gills and kidneys (Ismaili Sari, 2002). The place of absorption and the mechanism of its transfer to the fish body depends on factors such as the chemical form of the metal (ionic or its salts).

The canning process can change the concentration of heavy metals in the product. Atta, El-Sebaie, Noaman, & Kassab, (1993) reported that the concentration of some heavy metals decreased during the cooking and frying process. A study by Ezzatpanah, Ganjavi, Givianrad, & Shams, (2009) found showed that canning steps, including defrosting, baking, and sterilization, significantly reduced the concentration of heavy metals. In a recent study, the copper content in canned tuna in the 6th month of the experiment and the amount of zinc in the 11th month of the experiment was significantly reduced comparing to the fresh sample ($p<0.05$).

Iron content had the highest among other elements measured in fresh and canned tuna fillets, while mercury was the lowest concentration in the samples. These findings were consistent with other researchers' findings which the element iron had the highest concentration in different organs of the fish (Mahboob et al., 2016), which was in agreed with present study results.

According to study results of Celik & Oehlenschlager (2007), the lowest and highest levels of zinc in canned fish tested in Turkey were in the range of 33.8 - 556 μg/g. Iron content in fish species obtained from Iskenderun, northeast of the Mediterranean Sea, Turkey, was reported in the range of 27.35–0.82 μg/g dry weight (Turkmen et al., 2005). The level of this element in Black Sea fish samples, Turkey, was in the range of 52.9-40.32 μg/g (Tuzen, 2003). One of the reasons for the different amounts of heavy metals in canned fish in different countries was the difference in the environmental conditions of ecosystems and the type of fish species.

Most species of tuna fish have a protein content range 15% to 30%. Tuna fish contains low fat and calories, so it is a great alternative to meats and dairy products that contain saturated fats and trans fatty acids. Seafood proteins have valuable nutritional value. Fish protein contains all the essential amino acids and has highly digestible (Jhaveri, Karakoltsidis, Montecalvo, & Constantinides, 1984). However, the amount of protein varies significantly between species which depends on size, sexual status, feeding season and physical activity. Tuna contains a large amount of protein (27%) and is also rich in essential amino acids.

Fish body composition is a good indicator for its physiological condition, but it takes time relatively to measure. The proximate composition of the body includes the analysis of the contents of water, fat, protein and fish ash. Carbohydrates and non-protein compounds are available in small quantities and are generally regardless for analysis (Cui & Wootton, 1988). The percentage of water in the fish body is a good indicator of the relative contents of energy, proteins and lipids. The lower the percentage of water, the higher the amount of lipids and proteins and the higher the energy of the fish (Dempson, Schwarz, Shears, & Furey, 2004). According to the FAO (2003), moisture and fat contents in fish fillets are inversely related, accounting for approximately 80%, with other components making up the remaining 20%. This inverse relationship has also been reported for marine fish species such as *Pseudosciaena aeneas* and *Johnius carutta*, *Mullus barbatus* (Rao & Rao 2002; Lioret, Maire, Volatier, & Charles, (2007).

In the present study, this relationship was also observed. Aberoumand study (2014) showed that the percentage of protein in fresh yolk tuna fillet was lower than canned fish after 2 months storage, but with over time, the percentage of protein in canned fish fillet decreased comparing to the control treatment. The fat percentage in canned fish was higher than fresh samples. The percentage of canned fish ash in the 2th and 6th months of the experiment was lower than the control treatment, but in the 4th month of storage was significantly increased. The pH of canned samples was also higher than the pH of fresh fish fillets. The energy value of canned fish increased significantly with over time. In Aberoumand study on the Havoor tuna fish, it was reported that the percentage of fat, energy and pH of canned Havoor fish increased significantly comparing to the fresh Havoor, but the percentage of ash and protein decreased during the canning process. In canned Zardeh tuna fish, the percentage of moisture decreased during the experiment. In agreed with their results, in present study, the percentage of fat in canned fish increased significantly compared to fresh samples and the percentage of protein decreased significantly. Changes in moisture and ash contents fluctuated. The energy value in the fillets at the beginning of the test period in canned fish was higher than in the fresh sample, but with over time its value decreased.

Otto Santa Ana., (1996), in another study, entitled changes in the nutritional quality of Albaco fish after canning stated that the percentage of moisture and protein decreased during the canning process, but the percentage of fat increased. In present study, the percentage of fat at the beginning of the canning stage increased from 14.91% in the fresh sample to 21.03% in the 6th month after canning and then decreased to about 17.53% in the 11th month of the experiment. But in all samples, the percentage was higher than fresh fish fillets.

Souci, Fachmann, & Kraut, (2000) reported moisture, protein, fat and ash contents of canned fish fillets after the heat sterilization process. The reported values were 52.5%, 23.8%, 20.9% and 2.3%, respectively, which were consistent with the results of the analysis of composition in canned samples in present study. The reaction of a mixture of water and oil with nutrients, especially at high temperatures during the canning process, led to change the structure of the oil and the nature of nutrients, such as proteins (Kubow, 1992), which led to the significantly difference in the amount of moisture of different samples. In addition, the place and season of fishing, fish size, sexual maturity and spawning period, affect the amount of fat, moisture and protein of the fish (Kubow, 1992).

The lowest percentage of moisture in present study was observed for 9th month after canning, which was significantly lower than the fresh sample ($p<0.05$). Allen (1987) and Frankel (1991) considered the reduction of moisture content during processing as an advantage because it reduced fish sensitive to microbial spoilage and oxidative degradation of unsaturated fatty acids which thus improved the nutritional value of the fish at long time during storage.

The fish species contain high fat have a high nutritional value because of their omega-3 fatty acids, which support a protective effect against coronary heart disease (Alonso, Martínez-González, & Serrano-Martínez, 2003). In present study, the fat content in the canned fish was higher than fresh fish. The one of the reasons for the high percentage of fat in canned samples is the use of oil as filler in canned food. Garcia-arias et al., (2003) also reported that in cooked fish fillets, the moisture content decreased and the fat content increased. Ash indicates the amount of minerals in each food, such as fish (Omotosho, Oboh & Iweala, 2011). Concentrations of minerals and trace elements in total ash in fish vary depends on feeding behavior, increase weight or length, fishing season, environment and ecosystem, and migration even in the same area (Canli & Atli, 2002; Abdallah 2007). Ash content changes during storage due to moisture absorption and protein loss (Hassan, Rahman, Hossain, Nowsad & Hossain 2013). Smaller fish species show higher ash content due to higher bone to meat ratio (Daramola, Fasakin, & Adeparusi, 2007). so the large size of tuna fish can be considered as a reason for the low percentage of ash in present study.

In the present study, pH levels in all samples except the 9th month of the experiment were not significantly different with each other ($p<0.05$). The pH of canned tuna increased significantly after 9 months storage ($p<0.05$). The higher pH values in canned samples may be due to the formation and accumulation of some amino acids and volatile nitrogen compounds such as NH_3 as a result of the breakdown and proteolysis of proteins during heat treatment (El-Sherif, 2001). Czerner, Agustinelli, Guccione, & Yeannes, (2015) studied the effect of canning process on physicochemical properties of *Engraulis anchoita* and found that the pH of the fresh fish was 6.07 which after canning and during storage at room temperature due to the breakdown of protein into basic products such as ammonia, amines and hydrogen sulfide increased to 6.12.

El-Lahamy & Mohamed (2020) reported canning process decreased the protein content for *Orcynopsis unicolor*, but increased in protein content for *Euthynnus affinis*. El-Dengawy El-Shehawy, Kassem, El-Kadi, & Zeinab (2012) reported the chemical composition of 16 samples of canned fish (canned tuna, canned sardine, canned Mackerel) and observed that moisture percentages in all canned fish samples ranged between 52.41±0.035 to 78.53±0.142%, which was in agreed with present study. Sajib, Subrata, Mahmudul, Shuvra,& Riadul, et al. (2015) studied the effect of canning process on the chemical composition of chela (*Laubuka dadiburjori*) and reported that moisture, protein, lipid, ash and carbohydrate contents of fresh fish were 76.56±1.62, 13.74±1.22, 4.25±0.85, 2.37±0.56 and 1.41±0.79 respectively. After canning process these contents changed to 67.15±1.69, 16.68±0.88, 5.46±0.34, 8.15±0.83 and 1.35±0.07 for moisture, protein, lipid, ash and carbohydrate respectively, while in present study moisture after 9 months from canning process changed from 52.5% in fresh sample to 50.33%. Ash content after 11 months storage of product, changed from 1.11% in fresh sample to 1.22%. Protein content, step by step, changed from 22.66% in fresh sample to 18.33% in the final product after 11 months storage. Fat content afterv6 months storage changed from 14.91% to 21.03%.

Conclusion

The concentrations of the heavy metals iron, zinc, copper and mercury in canned tuna fish were higher than in fresh tuna fillets, but due to that these amounts were less than the permitted levels and international standards, its limited consumption will not be harmful for human consumption. On the other hand, due to the accumulation and transfer of these metals to the human body and its destructive effects on health, we must find a way to minimize the concentration of these metals in produced products. Analysis of the chemical composition of the samples also showed that although the protein content of canned samples was reduced comparing to the fresh fish, but overall the nutritional value of canned fish was maintained at an acceptable level which provide the human body needs to these nutrients.

Consumption of tuna may cause serious problems for consumers in Iran. Consumption of mercury and its methylated form can reach levels above intolerable levels and thus lead to chronic poisoning. Therefore, because these products are widely consumed, it is desirable that appropriate control programs be presented by the competent authorities at the community level. In addition, continuous monitoring on mercury concentrations in tuna products is essential for food safety.

Declarations

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CONFLICTS OF INTEREST

The authors do not have any conflict of interest.

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Figures

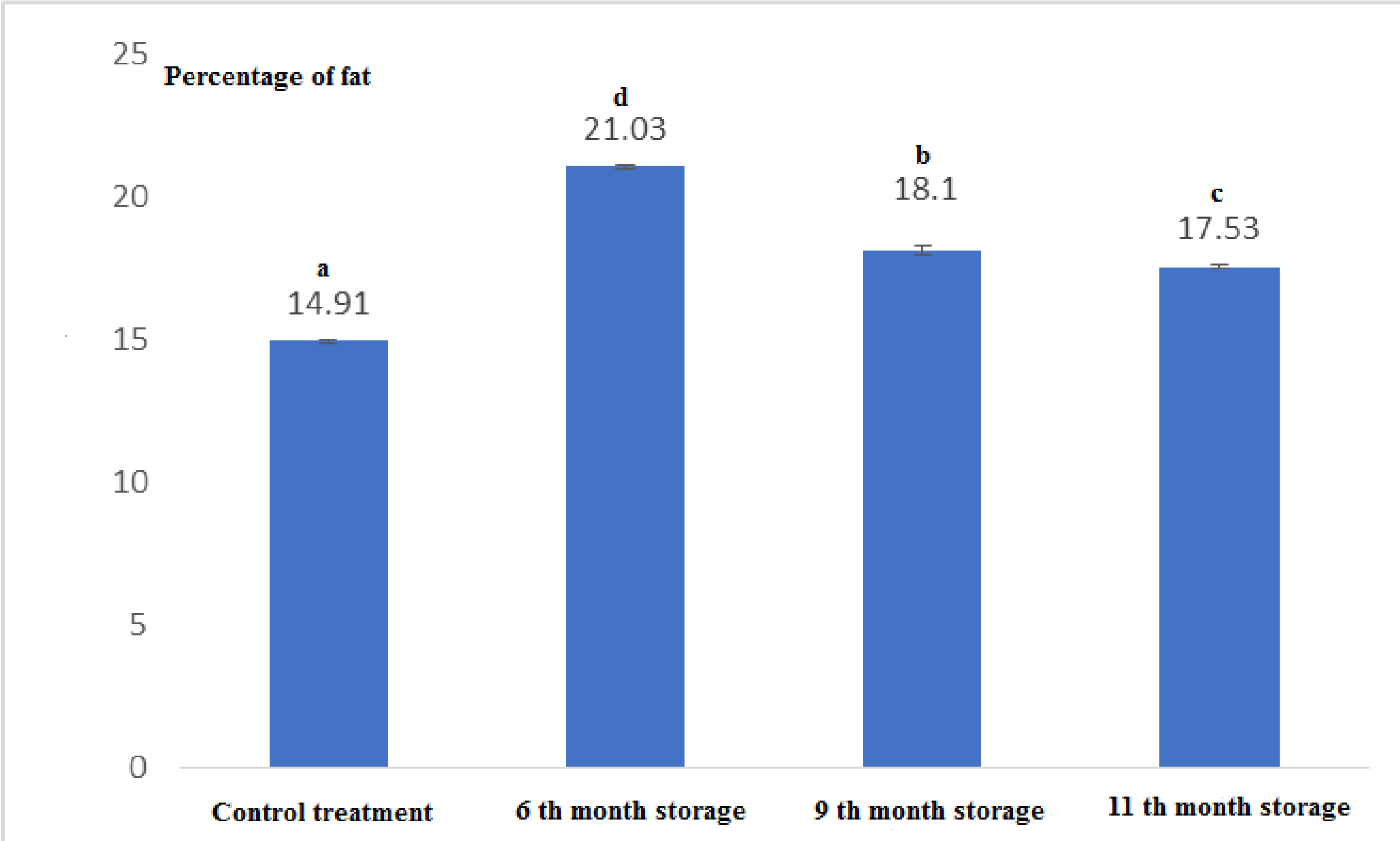

Figure 1

Percentage of fat in fresh and canned tuna fillets

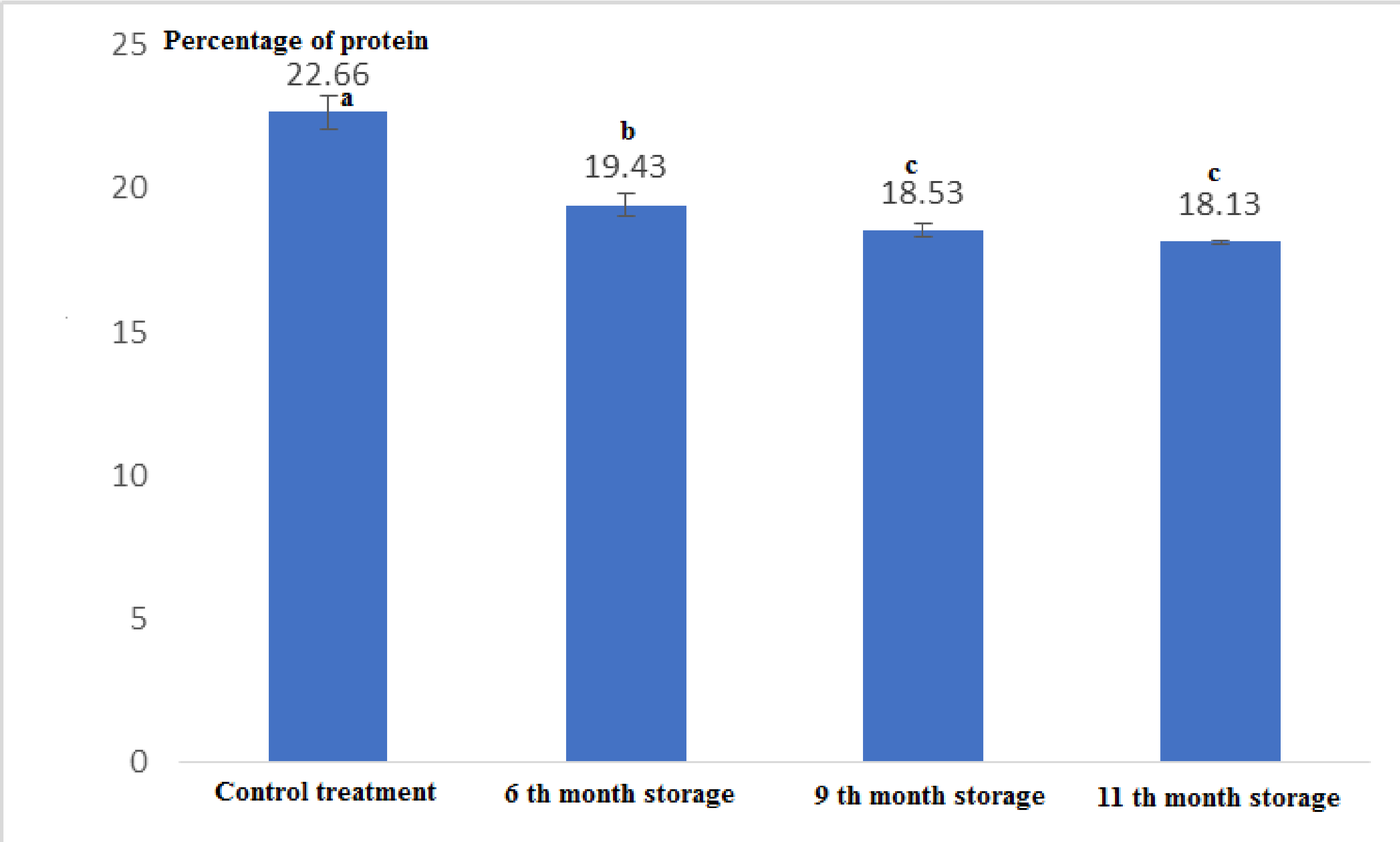

Figure 2

Percentage of protein in fresh and canned tuna fillets

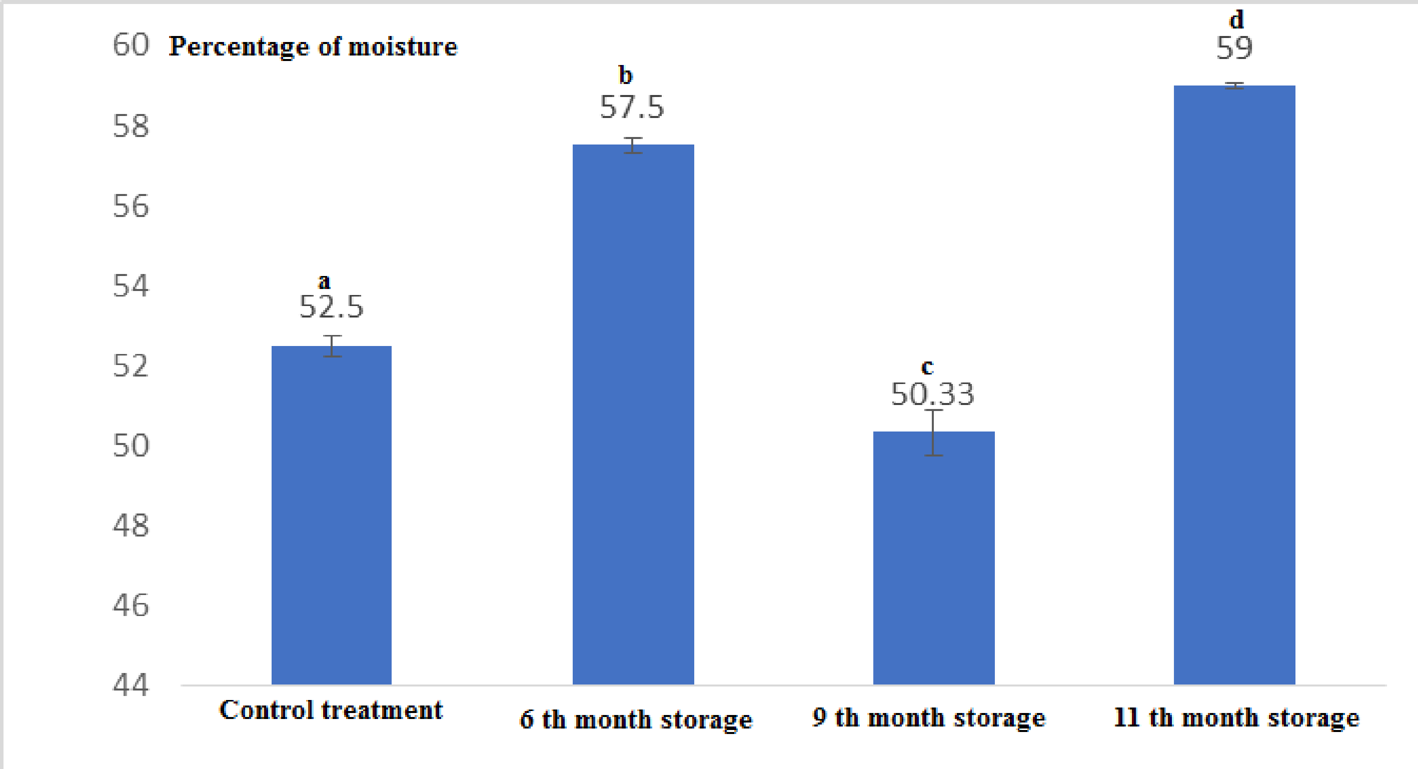

Figure 3

Percentage of moisture in fresh and canned tuna fillets

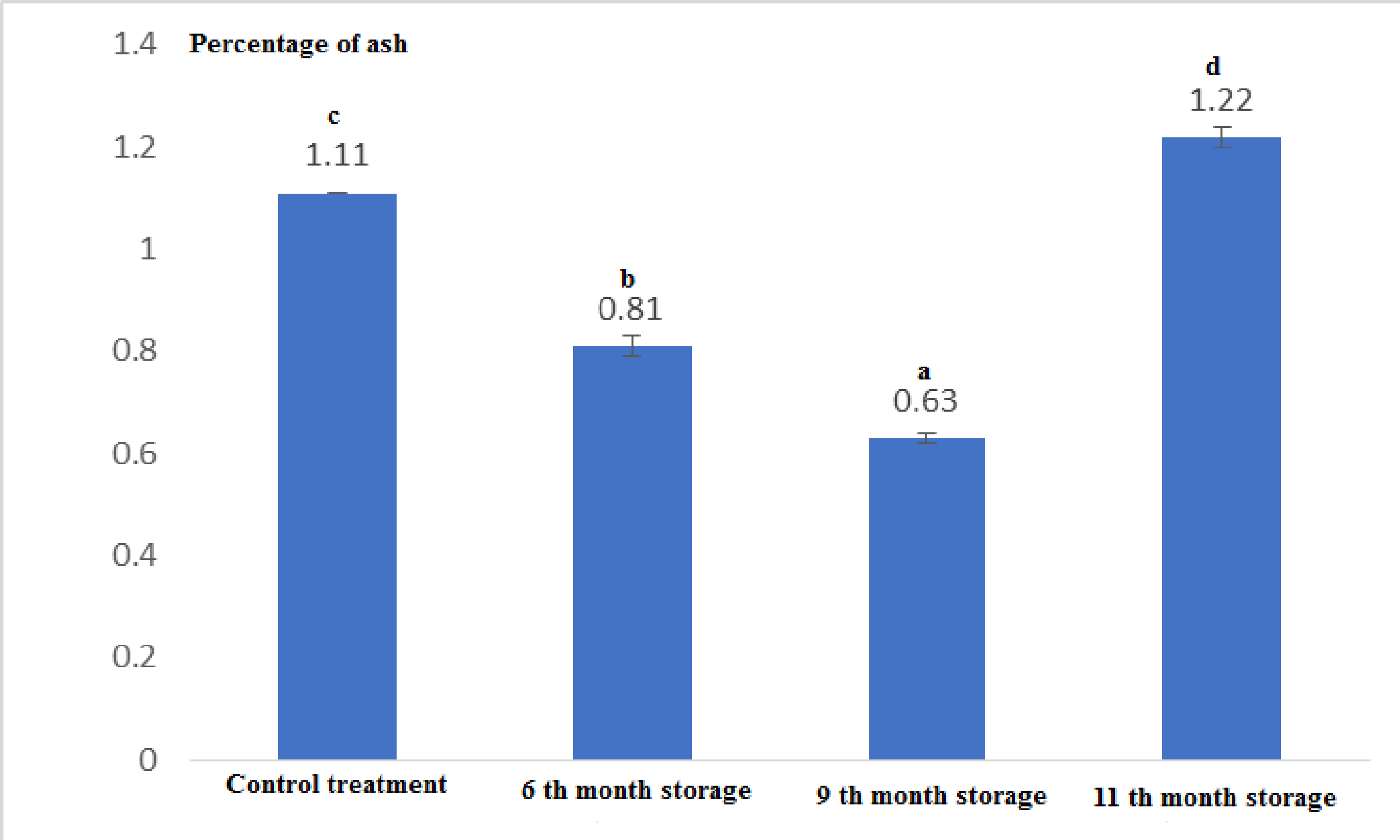

Figure 4

Percentage of ash in fresh and canned tuna fillets

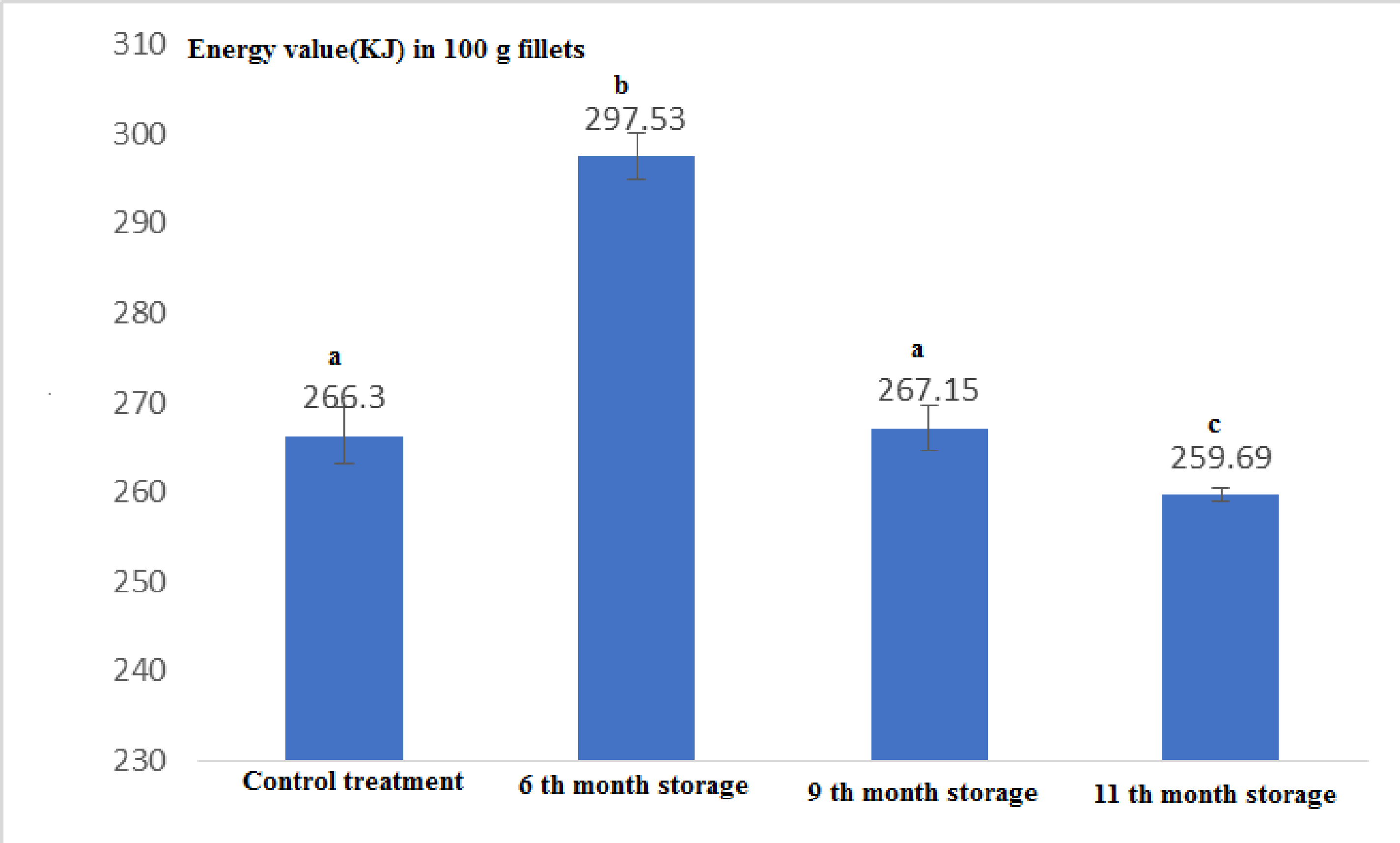

Figure 5

Energy value in fresh and canned tuna fillets

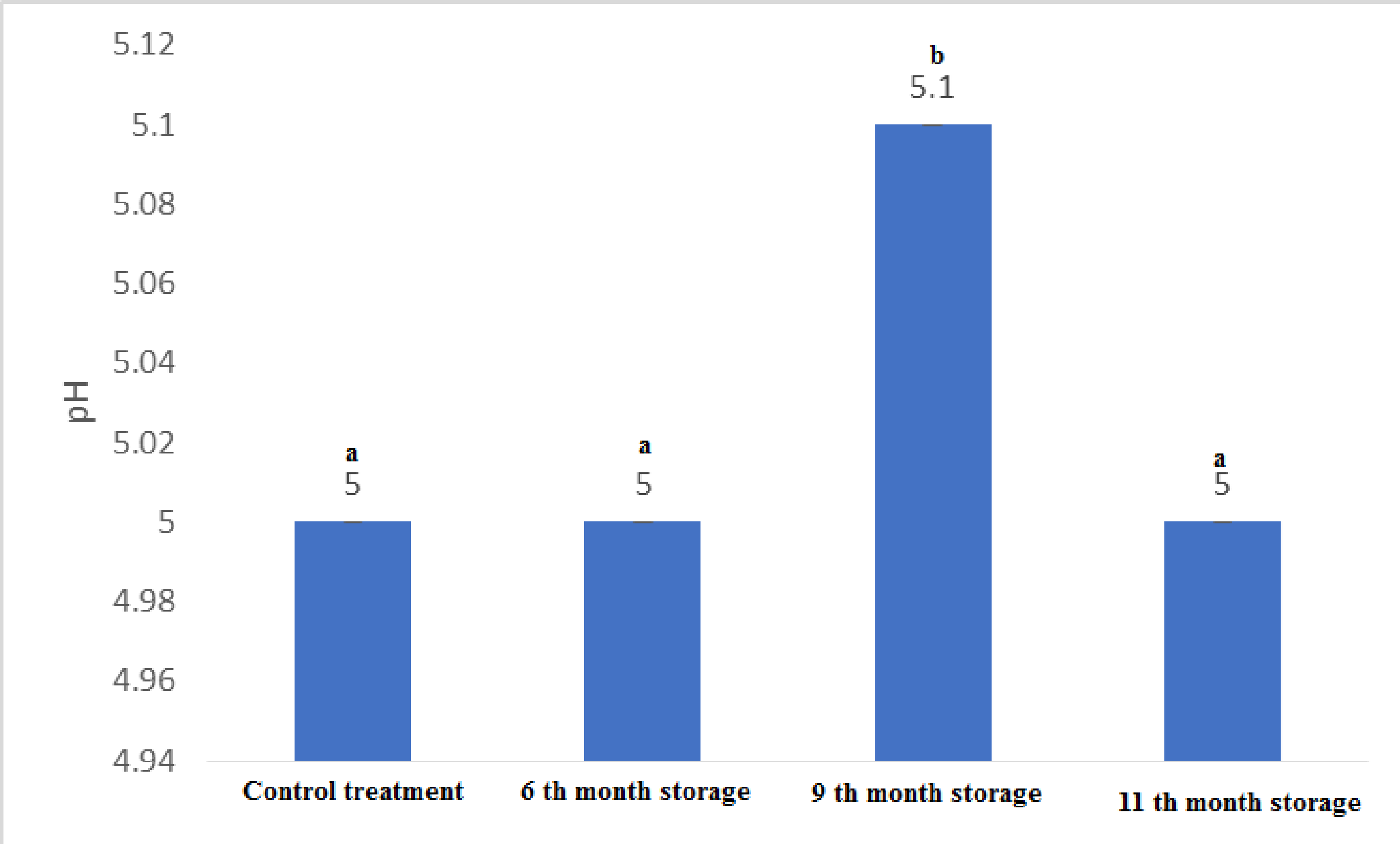

Figure 6

pH values in fresh and canned tuna fillets

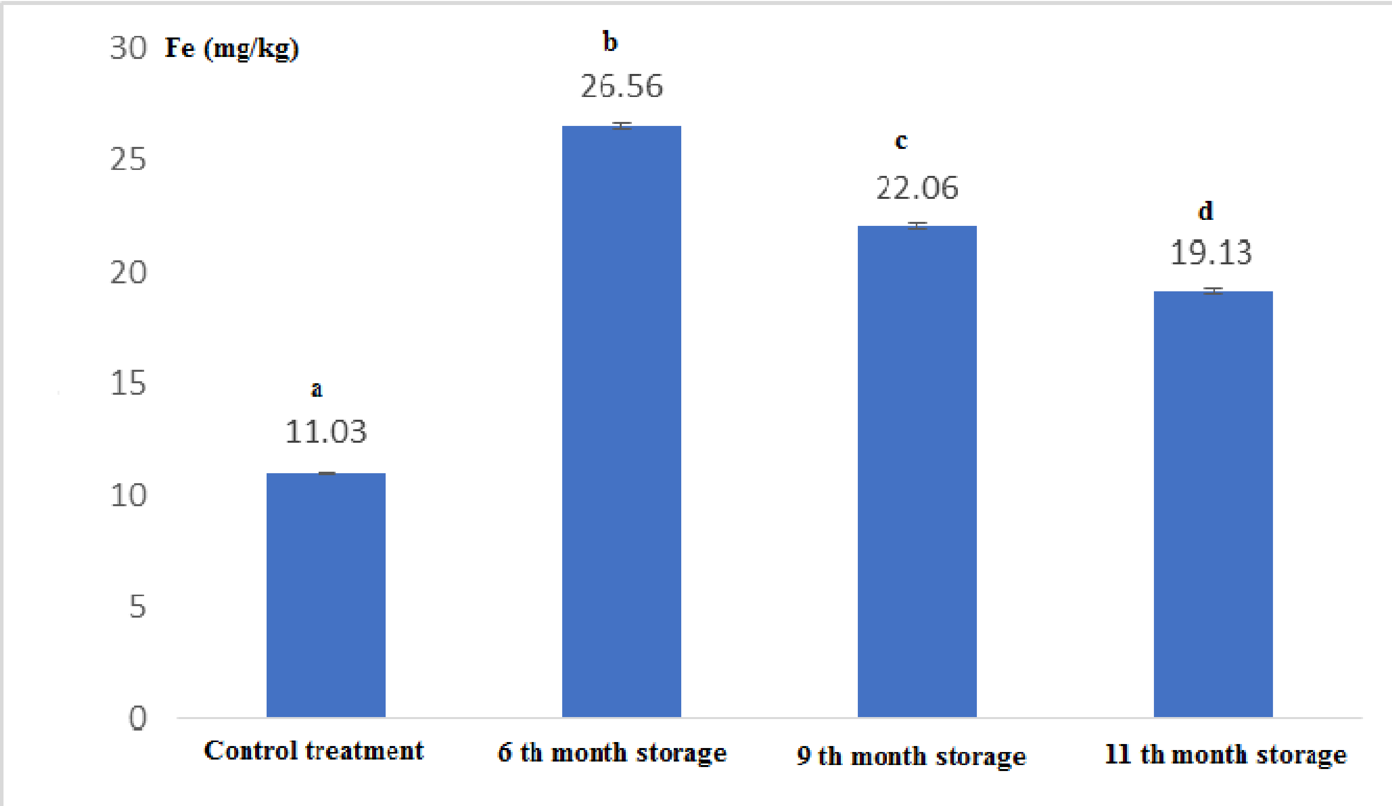

Figure 7

Concentration of iron in fresh and canned tuna fillets

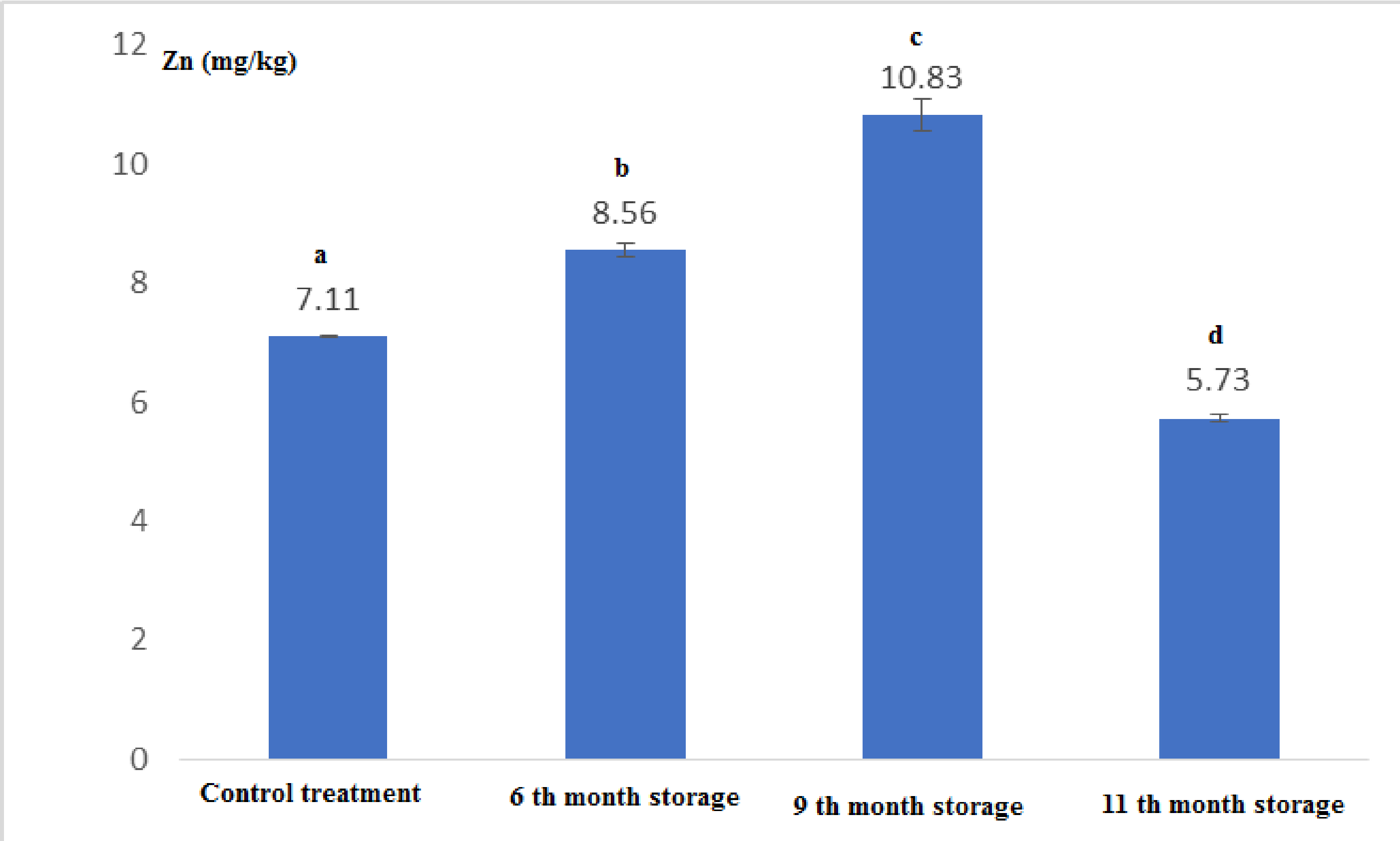

Figure 8

Concentration of zinc in fresh and canned tuna fillets

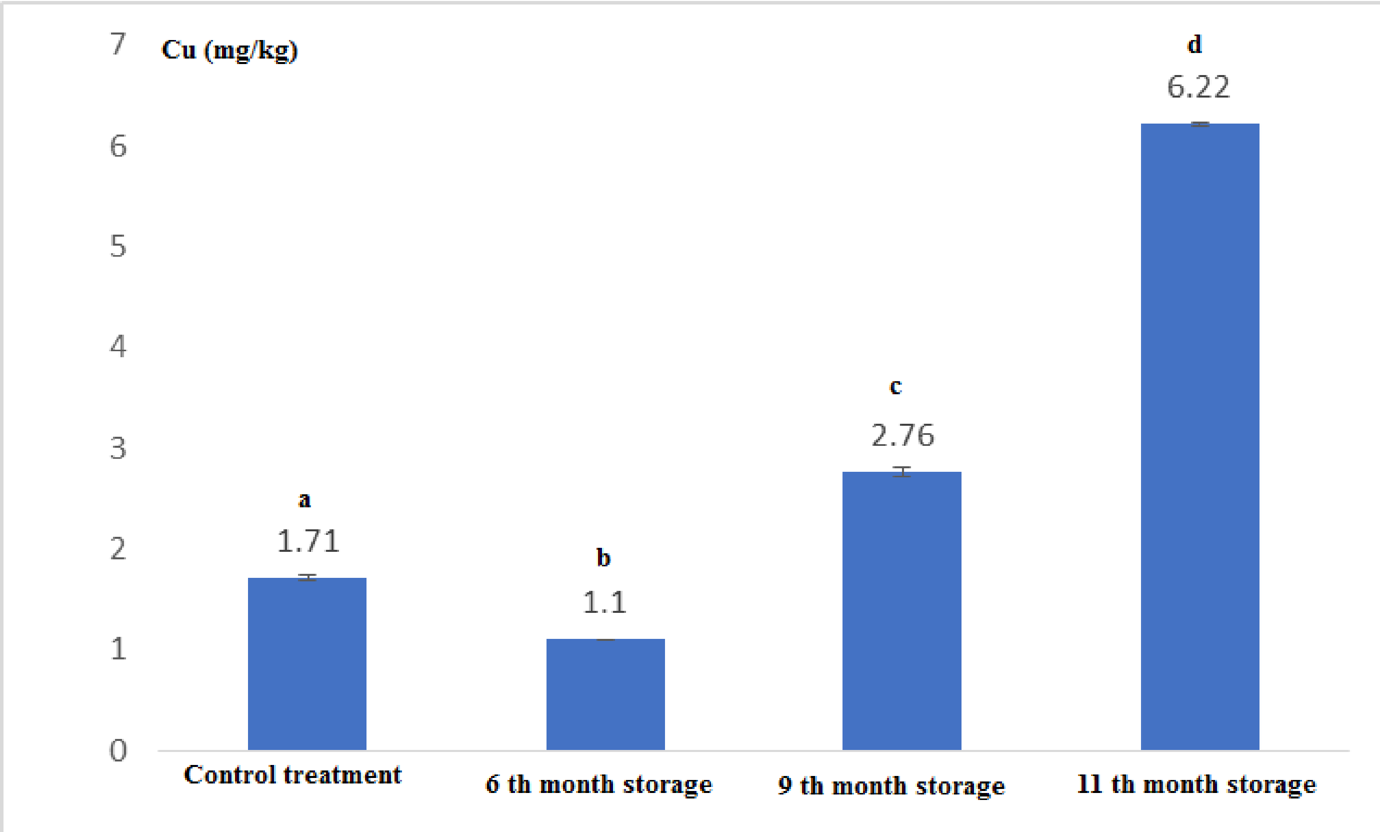

Figure 9

Concentration of copper in fresh and canned tuna fillets

Figure 10

Concentration of mercury in fresh and canned tuna fillets