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ARAŞTIRMA MAKALESİ **RESEARCH PAPER**

Investigation of Some Biochemical Parameters and Mineral Values in the Blood of Rainbow Trout Growing in Dam and Sea Water [*]

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Abstract: In this study, it was aimed to investigate the effects of the difference in the breeding environment (pH, temperature, salinity, oxygen content and saturation) of rainbow trout grown in dam and sea water on the levels of some minerals (calcium, magnesium, zinc, iron) and biochemical parameters in the serum. The study material consisted of 20 rainbow trout (*Oncorhynchus mykiss*) weighing about 800-1000 gr in the dam water of Samsun (Derbent Dam) and the Black Sea water (Yakakent). Blood samples were taken from both groups on the same day in December and the pH, temperature, oxygen content and saturation levels of the waters were determined by YSK oxygen meter, and salinity was determined by refractometry. Total protein (TP), albumin (Alb), cholesterol (TK), glucose (Glu), urea, creatinine (Cre), uric acid (UA), aspartate transaminase (AST), alanine aminotransferase (ALT), triglyceride (TG), calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn) and ALT, AST enzyme activities were determined by spectrophotometric method in an autoanalyzer. The salt, oxygen, and saturation levels of the sea water were found to be higher than those of the dam water, while the pH and temperature were similar. It was determined that TP, Alb, Alb/Glo, TK, TG, UA and Ca levels in rainbow trout raised in the dam were significantly higher than those raised in the sea ($P<0.05$). Glu, UA, Cr, Mg and Fe levels were found to be higher in the blood serum of the rainbow trout raised in the sea ($P<0.05$). Zn, urea, AST and ALT levels of rainbow trout raised in sea and dam were similar. The differences in the salinity and dissolved oxygen levels of the water in fish farming caused changes in some biochemical parameters in fish, and it was concluded that the choice of fish according to the nutritional environment in fish consumption may be important in diseases related to human lifestyle (obesity, gout, diabetes and hyperlipidemia).

Keywords: Biochemical parameters, mineral, rainbow.

Baraj ve Deniz Suyunda Yetiştirilen Gökkuşağı Alabalığının Kanındaki Bazı Biyokimyasal Parametreler ve Mineral Değerlerinin Araştırılması

Öz: Bu çalışmada, baraj ve deniz suyunda yetiştirilen gökkuşağı alabalığının yetiştirme ortamındaki (pH, sıcaklık, tuzluluk, oksijen içeriği ve doygunluk) farklılığın serumda bazı mineraller (kalsiyum, magnezyum, çinko, demir) ile biyokimyasal parametre düzeyine etkisinin araştırılması amaçlandı. Çalışma materyalini Samsun'da baraj suyu (Derbent Barajı) ve Karadeniz suyu (Yakakent) içinde yaklaşık 800-1000 gr ağırlığında 20 adet gökkuşağı alabalığı (*Oncorhynchus mykiss*) oluşturdu. Aralık ayında aynı günde her iki gruptan kan örnekleri alındı ve suyun pH, sıcaklık, oksijen içeriği ve doygunluk düzeyi YSK oksijen ölçer ile tuzluluk ise refraktometri ile belirlendi. Toplam protein (TP), albümin (Alb), kolesterol (TK), glukoz (Glu), üre, kreatinin (Cre), ürik asit (UA), aspartat transaminaz (AST), alanin aminotransferaz (ALT), trigliserit (TG) kalsiyum (Ca), magnezyum (Mg), demir (Fe) ve çinko (Zn) ile ALT, AST enzim aktiviteleri spektrofotometrik yöntemle otoanalizörde belirlendi. Deniz suyunun tuzluluk, oksijen ve doygunluk düzeylerinin baraj suyundan daha yüksek olduğu ve pH ile sıcaklığın birbirine yakın olduğu gözlendi. Barajda yetiştirilen gökkuşağı alabalığında TP, Alb, Alb/Glo, TK, TG ve Ca düzeylerinin denizde yetiştirilenlere göre önemli ölçüde yüksek olduğu belirlendi ($P<0.05$). Denizde yetiştirilen Gökkuşağı alabalığının kan serumunda Glu, UA, Cre ve Mg düzeyi daha yüksek bulundu ($P<0.05$). Deniz ve barajda yetiştirilen gökkuşağı alabalığının Zn, üre, AST ve ALT düzeyleri benzer bulundu. Balık yetiştiriciliğinde suyun tuzluluk ve çözünmüş oksijen seviyesindeki farklılık balıklarda bazı biyokimyasal parametrelerde değişikliklere neden olduğu ve bunun sonucunda insan yaşam tarzına bağlı hastalıklarda (obezite, gut, diyabet ve hiperlipidemi), balık tüketiminde balıkların beslenme ortamına göre tercihin önemli olabileceği kanaatine varıldı.

Anahtar kelimeler: Biyokimyasal parametreler, gökkuşağı alabalığı, mineral.

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INTRODUCTION

Fish is a low-cost, high-nutrient, low-cholesterol source of animal protein (Odoh et al., 2019). Fish should be ingested on a regular basis (i.e. 1–2 servings weekly), according to the World Health Organization (WHO, 2020) and the American Heart Association (AHA, 2020). As a result, increasing the supply of protein-based foods for an ever-growing population through sustainable fish farming is necessary to ensure food security (Onyekuru et al., 2019).

The geographic location and existing natural resources of Turkey provide suitable opportunities for fisheries and aquaculture production. Turkey is surrounded by the Black Sea, Aegean and The Mediterranean Seas and surrounds the Marmara Sea, an interior sea, each having specific characteristics and different production potentials. There are 33 river systems 26 of which are major, 200 natural lakes, 822 dam lakes and 507 ponds (DGSHW 2019). Rainbow trout originally inhabited the Pacific coast of North America. Rainbow trout is the most common member of the *Salmonidae* family in Europe, and found both in the wild and in trout farms. Its adaptability to water conditions and economic value has made it an important subject for scientific studies (Çalta, 1999). In the physiological diagnosis of fish, plasma biochemical parameters are generally used to determine their general health status (Davis, 2004; Kavitha et al., 2012). Blood electrolytes are widely used in the determination of physiological status of fish, toxicity tests and control of health status (Çelik, 2006). The carbohydrate content in fish is usually very low and is considered practically zero (Payne et al., 1999; Anthony et al., 2000). Fish contain between 18-20% of good quality protein, and the protein in fish is an excellent source of nutrients due to its amino acid composition and digestibility (Louka et al., 2004). Calcium (Ca), component of bones and teeth, regulates of nerve and muscle functions. It regulates some important physiological and biochemical events such as blood coagulation, membrane integrity, enzyme reactions, hormones (Murray et al., 1993). Magnesium (Mg) is an intracellular electrolyte that affects muscle and nerve stimulation and response. Muscle function, including muscle contraction, is highly dependent on the availability of Mg (Murray et al., 1993; Adam, 2000). Cholesterol is an important sterol that acts as a precursor to physiologically active compounds, including sex hormones, adrenal corticoids, bile acids, and vitamin D (Sheen, 2000). Cholesterol has been reported to be an essential nutrient for good growth and survival of crustaceans (Holme et al., 2006). High alanine aminotransferase (ALT), aspartate aminotransferase (AST) activity in the blood usually indicates the weakened or damaged normal liver function in fish species (Kim & Lee, 2009). Zinc (Zn) is necessary for the proper functioning of the immune system and the activation of more than 80 enzymes, DNA and RNA, protein, insulin and sperm synthesis (Alloway, 2009). Iron (Fe) is the element that has an important function in respiratory events. Hypochromic anemia usually occurs in fish due to Fe deficiency (Akyurt, 1994). It is known that seasons, disease and osmoregulation, stress, toxic factors, salinity, temperature, nutritional status, pH and water quality are effective to the blood electrolytes in fish (Chen et al., 2002). In this study, it was aimed to determine the ALT and AST enzyme activities, mineral levels, and some blood biochemical parameters in the blood serum of rainbow trout raised in dam and sea water.

MATERIAL AND METHOD

Determination of pH, temperature, salt, oxygen content and saturation levels of dam and sea water: The pH levels of the dam water (Derbent Dam) and Black Sea water (Yakakent), where rainbow trout are raised in December, were determined with a pH meter. The oxygen content, oxygen saturation and temperature levels of the water were determined with the YSK oxygenmeter device (YSI PRO 20 Polarographic Do Field Electrode Portable Oxygen Meter 10). The salinities of the water were determined with a refractometer.

Experimental animals: This study was conducted by Ondokuz Mayıs University, Faculty of Veterinary Medicine, Department of Biochemistry, with the approval of Ondokuz Mayis University Animal Experiments Local Ethics Committee (dated 01.03.2019, 2019/10).

The study material consisted of 20 rainbow trout (*Oncorhynchus mykiss*) weighing approximately 800-1000 g, which were grown for feeding in the dam water (Derbent Dam) and the Black Sea water (Yakakent) in Samsun.

Two groups were formed in the study. Group 1 consisted of 10 rainbow trout, which were grown in cages in the dam water and collected post-harvest blood. Group 2, on the other hand, consisted of 10 rainbow trout, which were grown in cages in seawater and blood drawn after harvest.

The blood, which is the study material, was obtained from both groups on the same day in December. Trout grown in sea water until harvest time, 3.5 nautical miles from Samsun Yakakent port, in HDPE cages with 22 meters' diameter, in nets of 15+1 depth and with ready-made pellet feed (crude protein 45%, crude oil 20%, crude ash 9.5%, raw cellulose 1.6%, Ca 1.8%, P 0.7%). Samples were obtained from diploid rainbow trout fed 24 h before harvest in December by blood sampling from each postharvest. Trouts grown in the dam water were fed with ready-made pellet feed (crude protein 45%, crude oil 20%, crude ash 9.5%, crude fiber 1.6%, Ca 1.8%, P 0.7%) until harvest time in Derbent Dam. Postharvest blood was drawn from each diploid rainbow trout fed 24 hours prior to sampling.

Blood collection from the fish was performed approximately 12 h after the feeding was ended. After harvesting, the blood samples of 20 rainbow trout (*Oncorhynchus mykiss*) grown in dam and sea water were taken from the gill region of the fish with a syringe and transferred to glass tubes to obtain serum (Watson et al., 1989). The blood samples taken were centrifuged at +4 C^o for 10 minutes at 1550 x g (Nüve NF800R) on the same day, and their serum was removed and divided into aliquots. The serums were stored at -20 °C until used in the analysis.

Determination of Ca, Mg, Fe and Zn levels in serum of rainbow trout: Ca, Mg, Fe, Zn levels were measured spectrophotometrically in an autoanalyzer (Biosistem A25, Spain) using the Biosistem kit (Barbour & Davisdon, 1988).

Determination of TP, Alb, TK, TG, Urea, UA, AST, ALT levels: The levels of Ca, Mg, Fe, Zn, TP, Alb, TK and TGs in blood serum were measured by spectrophotometric method using an autoanalyzer device. TK, TP, UA and urea levels were directly measured with an autoanalyzer (Biosistem A25, Spain) using the Biosystem kit (Fossati et al., 1980; Sacks, 1999).

Determination of Alb levels: The amount of Alb in blood serum was measured in an autoanalyzer device using the Biosistem-ALB autoanalyzer kit. Quantitative 3,3',5,5'-tetrabraom, cresol sulfonphtlalein (BCG) binding in serum was used to determine the amount of Alb in blood serum samples using the kit (Grant & Kachmar, 1976).

Calculation of Alb/Glo ratio: Glo was found by subtracting Alb from TP value and Alb/Glo ratio was calculated by dividing Alb level by Glo.

Statistical evaluation: Data analysis was performed using the Statistical Package for the Social Sciences for Windows 22.0 (SPSS 22) (IBM, New York, USA). The datas were tested for normality with the Kolmogrov-Smirnov Test, homogeneity tests with the Levene Test and Mann-Whitney U test, and the t test. Differences were considered significant at $P < 0.05$. All variables were expressed as mean and standard error (SE) (Rao, 1973).

RESULTS

Breeding and feeding conditions of rainbow trout in sea and dam water: Temperature, pH, oxygen content, salinity and saturation levels of sea and dam water in which rainbow trout grown are presented in the table (Table 1).

Table 1. pH, salinity, temperature, oxygen contents, and saturation rates of dam and sea water.

	Sea water	Dam water
pH	8.4	8.6
Heat (ºC)	12	11
Oxygen Amount(mg/dL)	9.57	7.4
Saturation (%)	88.77	67.26
Salinity (‰)	18	0.68

Some biochemical parameter levels in fish blood serum: The mean and standard error values (mean±SE) of TP, Alb, Glo, Alb/Glo levels in the sera of the groups are presented in Table 2.

Table 2. TP, Alb, Glo, Alb/Glo levels in blood serum of rainbow trouts raised in dam (Group 1) and sea water (Group 2).

	Group 1	Group 2	P
TP (g/L)	6.49±0.1	5.54±0.14	0.705
Alb (g/L)	2.48±0.07	2.01±0.01	0.01**
Glo (g/L)	4.11±0.16	5.04±0.16	0.705
Alb/Glo	0.62±0.03	0.57±0.02	0.279

*P<0.05, ** P<0.01

It was determined that TP (P>0.05), Alb level (P<0.05) and Alb/Glo ratio (P>0.05), in blood serum of rainbow trout raised in dam water were higher than rainbow trout raised in sea water, but Glo level was lower (P> 0.05). The mean and standard error values (mean±SE) of Glu, TK, TG, UA, Cre, AST and ALT levels in blood serum of rainbow trout raised in dam and sea water in Samsun are presented in Table 3 and Figure 1.

Table 3. Some biochemical parameter levels in blood serum of rainbow trouts raised in dam (Group 1) and sea water (Group 2).

	Group 1	Group 2	P
Glu (mg/dL)	67.6±11.21	135.3±20.74	0.014*
TK (mg/dL)	563.62±37.85	300.6±18.93	0.001***
TG (mg/dL)	189.77±14.82	106.9±7.86	0.003**
Urea (mg/dL)	6.33±0.5	6.3±0.47	0.966
UA (mg/dL)	1.15±0.08	1.84±0.11	0.001***
Cre (mg/dL)	0.15±0.06	0.61±0.12	0.011*
ALT (U/L)	24±3.55	24.4±7.23	0.413
AST (U/L)	207±14.71	169.28±13.12	0.083

*P<0.05, ** P<0.01, *** P<0.001

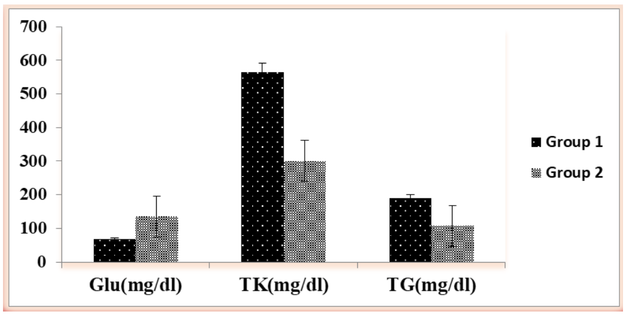

Figure 1. Glu, TK, TG levels in blood serum of rainbow trout raised in dam (Group 1) and sea water (Group 2).

The Glu level in the blood serum of rainbow trout raised in the sea was statistically significantly greater than the Glu level in the blood serum of rainbow trout raised in the dam (P<0.05). Rainbow trout grown in dam water had considerably greater TK and TG levels than those bred in sea water (P<0.001).

The level of urea in rainbow trout farmed in dam and sea water did not alter, according to the findings. When rainbow trout raised in sea water were compared to those raised in dam water, the UA level was found to be statistically substantially higher (P<0.05). It was determined that AST and ALT enzyme activities were close to each other in rainbow trout raised in dam and sea water, and the difference was not statistically significant.

Some mineral levels in serum: The mean and standard errors (mean±SE) of Ca, Mg, Fe, Zn levels in blood serum of rainbow trout raised in dam (Group 1) and sea (Group 2) water are presented in Table 4.

Table 4. Ca, Mg, Fe, Zn levels in blood serum of rainbow trout raised in dam (Group 1) and sea water (Group 2).

	Group 1	Group 2	P
Ca (mg/dL)	37.81±4.45	22.6±1.8	0.026*
Mg (mg/dL)	5.2±0.32	7.33±0.91	0.029*
Fe (µg/dL)	53.5±12.9	83.8±16.06	0.155
Zn (mg/dL)	1.421±163.3	1.371±66.13	0.183

*P<0.05

When rainbow trout grown in dam water were compared to rainbow trout farmed in sea water, the Ca level was found to be statistically substantially higher (P<0.05). The Mg level in rainbow trout farmed in sea water was found to be statistically substantially higher than in rainbow trout farmed in dam water (P<0.05). Rainbow trout farmed in sea water had a higher Fe level than rainbow trout farmed in dam water, and rainbow trout farmed in dam water had a higher Zn level than rainbow trout farmed in sea water, but the difference was not statistically significant.

It was determined that although the Ca and Zn mineral level distribution was lower in the blood serum of rainbow trout raised in dam (Group 1) water, Mg and Fe levels were higher than those raised in sea water (Figure 2).

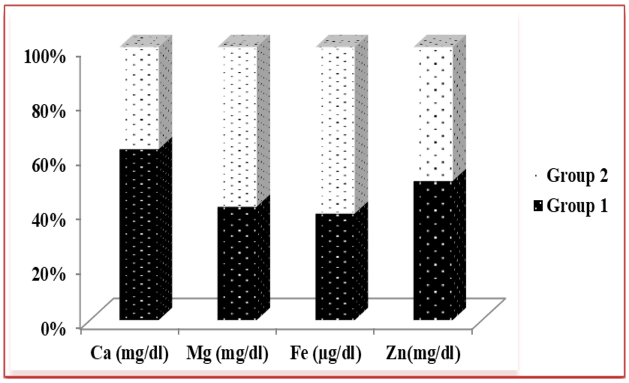

Figure 2. Percent distribution of Ca, Mg, Fe, Zn levels in blood serum of rainbow trout raised in dam (Group 1) and sea water (Group 2).

Total Mg and Fe levels in blood serum of rainbow trout raised in sea water were higher than those raised in dam water.

DISCUSSION

The production of rainbow trout (*Onchorynchus mykiss*, Walbaum 1792) in aquaculture in natural lakes, large dam lakes, rivers and seas is increasing day by day. Fish can derive minerals from the diet and ambient water. Blood parameter indicators are accepted as indicators of physiological and health status of fish in response to nutritional supplements (Kader et al., 2010). Fish farming conditions and water content can cause bioaccumulation of metals in fish (Baldisserotto et al., 2005). It is very difficult to compare metal concentrations in the same tissue of two different species and in different tissues of the same species due to factors such as different feeding habits, differences in aquatic environment, growth rates of species, and tissue types analyzed (Yilmaz et al., 2010). In a study, it was reported that the level of elements and harmful metals in the carp body might varied depending on the culture method; water quality and feed type (Borucka-Jastrzebska & Protasowicki, 2006). In this study, it was aimed to determine and compare the effects of the different habitats (pH, temperature, salt, oxygen content and saturation) of rainbow trout reared in dam and sea water on the levels of some mineral (Ca, Mg, Zn, Fe) and biochemical parameters (TK, urea, Cre, UA, ALT, AST, TG) in the serum. Water temperature affects all aspects of metabolism. High temperatures affect fish health and fish welfare by increasing metabolic rate, alkalinity, acidity and pH (Ross & Ross, 2002). Based on these datas, it was reported that water temperature may have an effect on fish growth (Dikel, 2009). The province of Samsun, where this study was conducted, has a rich water potential with its rivers, lakes and dam lakes, and the Kızılırmak Delta, which has an international importance, constitutes an important water treasure of this region. In the province of Samsun, rainbow trout is produced in cages created in the sea, as well as trout in net cages belonging to different enterprises in Derbent Dam Lake. Derbent Dam is one of the most important dams on Kızılırmak, between the coordinates of 41º 25' 6" N, 35º 49' 52" E, 15 km south-west of Bafra district center (Anonymous, 2002). It has been reported that the temperature of the waters where trout farming will be carried out should be below 20 ºC (Çelikkale, 1994). In our study, blood samples were taken from rainbow trout farmed in dam and sea water in December. The pH and temperature values of the dam and sea waters were 8.6-11 ºC, 8.4-12 ºC, respectively. In a previous study, it was reported that the pH in Derbent Dam Lake varied between 7.1 and 8.6, and the average value was 7.98. It has been reported that the pH value should be between 6.5 and 8.5 in the waters where trout farming will be carried out (Çelikkale, 1994) and it is appropriate to breed trout in lakes with a pH of 8 (Atay, 1987). The pH of the dam and sea water was obtained as an example in our study is slightly alkaline, and the water quality is suitable for trout farming. In a study, it was reported that the pH of Derbent dam water was 8. The temperature was 8.1 ºC and the amount of dissolved oxygen was 10.3 in December (Taş, 2006). In our study, it was determined that the amount of dissolved oxygen in December was 7.4 mg/dl. The ideal pH range varies per species; however, for fish culture, the pH range of 6.5-9.0 is widely accepted (Zweig et al., 1999). An increase or decrease in pH disrupts acid-base balance, ion regulation and ammonia excretion (Wood, 2001).

Alkaline conditions (pH > 9) may contribute to fish mortality through gill damage, decreased plasma ion concentrations and decreased NH3 elimination (Lease et al., 2003) Salinity refers to the amount of salt dissolved in water. The salinity in water is due to NaCl rather than chloride (Cirik & Gökpınar, 1993). Plasma ion values and mortality rates were compared in rainbow trout (Oncorhynchus mykiss) after a direct transfer of approximately 18 ppt from fresh water to Black Sea water. ±10 mM/l) was much higher. Therefore, most of the fish died, possibly as a result of inability to adapt to seawater (Gorie, 1992). In the study investigating plasma ion values and mortality rate, plasma Na+ concentrations were measured in rainbow trout (Oncorhynchus mykiss) after direct transfer from fresh water to Black Sea water, and it was found to be much higher in sea water than in rainbow trout grown in fresh water (Yigit et al., 2004). In December, when the study samples were collected, the salinity ratio of the dam water was 0.68 ‰ and that of sea water was 18 ‰. It was observed that there was a positive relationship between the dissolved oxygen amount and the salinity ratio. Parallel to our study, it was determined that the salinity ratio in the Black Sea ranged between 17-20 ‰ (Svennevig et al., 1996). In the study conducted by Agiragac and Buyukhatipoglu (1998) in the Black Sea, the temperature, dissolved oxygen, salinity and pH samples taken from the Black Sea water between 29 December and 2 March were reported to be 9.41±0.93 ºC, 7.61±0.4 mg/lt, 18.51±0.83 ‰, 8.15±0.01, respectively. In a study by Cirik and Cirik (1999), it was reported that while the salt concentration of water increased, the amount of dissolved oxygen decreased. The solubility of oxygen in water can be increased by factors such as decreases in temperature, wavy surface of the lake, high moisture content, seasonal differences. Stanek et al. (2014) reported that the average Ca contents of fishes were 3.175, 0.516 and 2.498 g/kg in Gorecreckie, Strzeszynskie and Wedromierz lakes, respectively. In the study performed on juvenile tilapia (*Oreochromis niloticus x O. aureus*), grass carp (*Ctenopharyngodon idella*) and Atlantic salmon, it was observed that the Ca level in the plasma was not affected by dietary Ca supplementation, and Ca homeostasis was provided (Berntssen et al., 2003). In another study, when Ca was added to the diet of Japanese sea bass, it was observed that the serum Ca concentration increased significantly, and reached to a maximum level (7.71 mmol/L) (Song et al., 2016). It was concluded that the plasma Ca level of various fish species can vary significantly with dietary Ca levels (Urasa & Wendelaar Bonga, 1987). In a study, it was observed that tilapia larvae were not affected by environmental Ca levels during development or growth stages. It was reported that the body Ca content in the low Ca groups constituted approximately 90-95% of the high Ca groups, and adaptation to the low Ca environment was achieved by stimulating Ca uptake. Kulkarni (2015) determined the blood Ca levels as 9.00±0.30 mg/dL (Bheema), 8.69±0.50 mg/dL (Kagina) and 8.39±0.45 mg/dL (Saradgi) in his study of Notopterus notopterus fish living in different waters. In a study conducted with male and female rainbow trout, Ca levels were 6.8±0.6, 6.7±0.9 mg/dL (P>0.005), respectively (Charoo et al., 2013). Manera (2006) determined a higher Ca level as 9.92 mg/dL in his study. In our study, it was found that Ca level of the blood serum in rainbow trout farmed in dam and sea water was different. It was determined that the rainbow trout reared in dam water was higher than the rainbow trout farmed in sea water, and this high level was statistically significant (P<0.05). Similarly, in the study, it was stated that while fish can meet their needs through uptake mechanisms in waters with high Ca or in sea water, they can't meet the requirements of fish in waters with low Ca or fresh waters, and the Ca level in the diet should be increased to meet fish requirements (Vonck et al., 1998). Studies in low Ca environments have shown an increase in the Ca carrying capacity of teleosts (McCormick et al., 1992). It was observed that weight gain decreased in rainbow trout fed with a diet with low Ca content, and the skeletal structure of salmonids was impaired at low pH and low Ca levels (Baldisserotto et al., 2004). After acute thermal stress, plasma total protein levels, as well as chloride, sodium, calcium, and potassium ion concentrations, increased somewhat in the experimental group (Balta et al., 2017). Unlike mammals, fish obtain a significant part of their daily Ca requirement by directly absorbing Ca from the aquatic environment, especially from the gills. Since the salinity of sea water and Ca level is higher than fresh water, it was thought that the Ca level in the blood serum of rainbow trout, which is grown in the sea, may be lower in order to ensure the ion balance.

Charoo et al. (2013) reported in their study that the Mg concentrations of male and female rainbow trout were 4.1±0.6, 3.6±0.7 mg/dL, respectively. In another study, the Mg concentration in rainbow trout was found to be 3.1 mg/dL (Hrubec, 1999; 2000). In our study, it was determined that the Mg level was statistically significantly higher (P<0.05) in rainbow trout reared in sea water than dam water. For this reason, it was thought that the consumption of rainbow trout raised in sea water could be protected from diseases such as eclampsia, preeclampsia, and cardiac arrhythmia by providing a better intake of Mg mineral, which is necessary for muscle contraction and energy formation. It has been reported that the level of Zn for rainbow trout in hard water (390 mg $CaCO_3$/L) is 27 times more toxic than soft water (31 $CaCO_3$ / L) (Bradley & Sprague, 1985). It was observed that the amount of Zn was higher in brown trout in soft water than in hard water (Spry & Wood, 1988; Everall et al., 1989). It has been reported that the amount of Zn in waters with close pH values is less affected by water quality than many other metals (Stumm & Morgan, 1966; Bradley & Sprague, 1985; Alsop et al., 1999). Zn is a very common metal in fresh waters due to its relatively high solubility. In our study, it was determined that the Zn level in rainbow trout farmed in dam water was slightly higher than in rainbow trout farmed in sea water, but this difference was not statistically significant (P>0.05). It has been stated that if the fish are exposed to the toxic effect of Zn during their juvenile period, they will not be able to have a productive breeding period, so the fish may face the extinction of the new generation (Sönmez & Cetinkaya, 2003). In our study, it was observed that the Zn level of rainbow trout grown in sea water was lower in blood serum than those raised in dam water, and this result suggested that the seawater is cleaner for aquatic organisms to grow.

Fe is an important element with essential roles in cellular biochemistry and metabolism. Fe takes an active role in both oxidation-reduction reactions and electron transport system. Fe deficiency usually causes hypochromic anemia in fish. Quantitative Fe requirement of many fish species is not yet known. It is reported that the need for Fe in eels is 17 mg/kg. In a study, it was observed that when iron sulfate was added to the water containing aquarium fish, the growth of the fish accelerated (Akyurt, 1994).

The increase in TP, Alb and Glo ratios in fish is an indication of a weakened immune system (Al-Dohail et al., 2009). Manera (2006) found an Alb level of 1.38±0.05 (g/dL) in rainbow trout with an average weight of 240 g. Also, Velisek (2004) reported a value of 0.4 g/dL. In our study, we determined that TP level and Alb/Glo ratio in the blood serum of rainbow trout were higher than those of sea-raised rainbow trout, and Glo level was lower (P>0.05). We determined that there was a statistically significant increase in Alb level in rainbow trout raised in dam water compared to rainbow trout farmed in sea (P<0.001). Kopp et al. (2011) reported that the increase in water temperature and chloride increased the Alb and TP content in the plasma. Also; it was reported that with the increase in nitrogen, P and dissolved oxygen levels, the levels of Alb and TP decreased. There was an inverse relationship between them. In our study, it was determined that although the dissolved oxygen amount in sea water was higher than in dam water, the amount of Alb and TP was lower than in rainbow trout raised in dam water. Torre et al. (2000) reported that the decrease in the protein level in the tissues may be due to the fact that the fish provide the energy necessary to overcome the stress caused by the metal effect by the stimulation of protein catabolism. In a study conducted with *Cyprinus carpio*, it was suggested that the decrease in the amount of protein may be due to the use of the catabolic products of muscle tissue proteins in protein synthesis in the liver and for this purpose the free amino acids to pass into the circulatory system (Cicik, 1995). The Alb level was lower in rainbow trout raised in sea water. According to the Alb level, it was thought that the digestibility of rainbow trout grown in sea water could be easier, and those with digestive system problems could consume rainbow trout raised in the sea more easily.

One of the main physiological indicators measured in most scientific experiments is the blood glucose concentration, which expresses the general health of the fish. It is an essential source of energy and carbon for most vertebrates, including fish. Glucose is obtained from food, but since fish can't make it, it is necessary to use dietary carbohydrates e.g. mammals use glucose produced by the processes of gluconeogenesis and glycogenolysis (Polakof et al., 2012; Kamalam et al., 2016). Glu level varies depending on size, age, nutrition and reproductive status (McDonald, 1992). Charoo et al. (2013) were determined the Glu levels as 5.6±0.7, and 4.0±0.8 mg/dL in male and female rainbow trout, respectively. In our study, the Glu amount of rainbow trout grown in sea water was found to be significantly higher than those grown in dam water (P<0.05). The amount of Glu in the blood serum is a significant indicator for the stress level of the fish. It was thought that the high Glu level of rainbow trout grown in the sea may be caused by environmental conditions and stress factors.

Serum TK levels vary within fish species due to changes in the diet and sexual development of the fish (McDonald, 1992). In our study, it was determined that TK and TG levels were statistically significantly higher in rainbow trout raised in dam water compared to those raised in sea water (P<0.001). When evaluated in terms of coronary heart disease risks, it was concluded that rainbow trout grown in the dam should not be preferred in those with cardiovascular disease risk due to their high TK and TG values.

Cre is found in muscle, brain and blood in free form, as well as in the form of creatine phosphate creatinine. Cre is excreted by the kidney in fish, and an increase in Cre concentration is interpreted as an indicator of kidney failure (Shell, 1961). Charoo et al. (2013) were found the Cre concentration as 0.46-0.9 mg/dl in male rainbow trout. Besides; Rehulka (2004) reported that the Cre concentration was 0.31, 0.41 and 0.46 mg/dL in rainbow trout, trout and brown trout, respectively. Also, Manera (2006) reported a serum Cre concentration of 0.29 (mg/dL) for rainbow trout. A decrease in TP, Kre, TG, TK activity levels and an increase in serum ALT and AST activities were observed in cold water Atlantic salmon (Waagbo et al., 1988). Racicot et al. (1975) drew attention to the increase in activity in AST and ALT values in *Aeromonas* infections in rainbow trout. As a result of our study, there was no significant difference in ALT and AST activity in rainbow trout grown in sea and dam water.

Blood urea nitrogen is related to the amount of nitrogenous residues removed by the kidney and is used as an indicator of gill and kidney function. In fish, urea is the second most important waste product after ammonia. In our study, it was determined that the urea level did not change in rainbow trout farmed in dam and sea water. It was determined that the UA level was statistically significantly higher ($P<0.001$) in rainbow trout raised in sea water compared to those raised in dam water. It was thought that the higher UA values of rainbow trout grown in sea water compared to the other group may be due to the kidney function disorders of the fish grown in this group or the high salinity of the sea water. Besides the type of fish, blood electrolyte values; It can also be affected by gender, spawning, nutritional status, water pollution, water temperature, salinity, seasons, disease, toxic substances, stress and hypoxic conditions. Thus, as the effects of these factors are investigated, standardization of electrolytes and properties in fish blood, and therefore fish health control criteria, can be developed (Çelik, 2006). Aquaculture is important for the country's economy due to its contribution to human nutrition, employment creation, raw material supply to the industry and high export potential. It is thought that this study will contribute to aquaculture activities by determining the differences between some biochemical parameters and mineral levels of sea water and dam water environment in rainbow trout farming.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

REFERENCES

Adam, B. (2000). *Temel Biyokimya*, Nobel Yayın Dağıtım Ltd. Şti. Ankara,1 52s.

Agirağac, C. & Buyukhatipoglu S. (1998). Sinop yöresinde denizde ağ kafeslerde farklı yemlerle yapılan gökkuşağı alabalığı (*Oncorhynchus mykiss* W. 1792) yetistiriciligi üzerine bir araştırma. *Journal of Veterinary and Animal Sciences*, ***22***, 191-195.

Akyurt, İ. (1994). Balık beslemede mineraller. *Atatürk Üniversitesi Ziraat Fakültesi Dergisi,* ***25***(3),445-453.

Al-Dohail, M.A, Hashim, R. & Aliyu-Paiko, M. (2009). Effects of the probiotic, *Lactobacillus acidophilus*, on the growth performance, haematology parameters and immunoglobulin concentration in African Catfish (*Clarias gariepinus*, Burchell 1822) fingerling. *Aquaculture Research*, ***40***(14), 1642-1652.

Alev, V. & Dikel, S. (2003). Tilapia- a successful second crop to trout. *Fish & Shellfish Immunology*, ***17***(1), 12-14.

Alloway, B.J. (2009). Soil factors associated with zinc deficiency in crops and humans. *Environmental and Geochemical Health*, ***31***, 537-548.

Alsop, D.H., McGeer, J.C., McDonald, G. & Wood, C.M. (1999). Costs of chronic waterborne zinc exposure and the consequences of zinc acclimation on the gill: zinc interactions of rainbow trout in hard and soft water. *Environmental Toxicological and Chemistry*, ***18***, 1014-1025.

American Heart Association (AHA) Eating Fish Twice a Week Reduces Heart Stroke Risk. (2020). Available online: https://www.heart.org/en/news/2018/05/25/eating-fish-twice-a-week-reduces-heart-stroke-risk.

Anonymous, D.S.Y. (2002). VII. Bölge Müdürlüğü, İşletme ve Bakım Şube Müdürlüğü Raporu, Samsun.

Anthony, J.A., Roby, D.D. & Turco, K.R. (2000). Lipid content and energy density of forage fishes from the Northern Gulf of Alaska. *Journal of Experimental Marine Biology and Ecology*, ***248***, 53-78.

Atay, D. (1987). *İçsu Balıkları ve Üretim Tekniği*. Ankara Üniversitesi Ziraat Fakültesi Yayınları, Yayın No: 1035, Ankara.

Baldisserotto, B, Chowdhury, M.J. & Wood, C.M. (2005). Effects of dietary calcium and cadmium on cadmium accumulation, calcium and cadmium uptake from the water, and their interactions in juvenile rainbow trout. *Aquatic Toxicology, **72***(1), 99-117.

Baldisserotto, B., Kamunde, C., Matsuo, A. & Wood, C.M. (2004). A protective effect of dietary calcium against acute waterborne cadmium uptake in rainbow trout. *Aquatic Toxicology, **6***, 57-73.

Balta, Z.D, Akhan, S. & Balta, F. (2017). The physiological stress response to acute thermal exposure in Black Sea trout (Salmo trutta labrax Pallas, 1814). *Turk. J. Vet. Anim. Sci.*, ***41***, 400-406.

Barbour, H.M. & Davisdon, W. (1988). Studies on measurement of plasma magnesium: application of the Magon dye method to the "Monarch" centrifugal analyzer. *Clinical Chemistry, **34***(10), 2103-2105.

Berntssen, M.H.G., Waagbo, R., Toften, H. & Lundeby, A.K. (2003). Effects of dietary cadmium on calcium homeostasis, Ca mobilization and bone deformities in Atlantic salmon (*Salmo salar L.*) parr. *Aquaculture Nutrition, **9***(3), 175-183.

Borucka-Jastrzebska, E. & Protasowicki, M. (2006). Levels of selected metals in tissues and organs of 5-month-old carp (*Cyprinus carpio L.*). *Acta Scientiarum Polonorum, **5***(2), 3-16.

Bradley, R.W. & Sprague, J.B. (1985). Accumulation of zinc by rainbow trout as influenced by pH, water hardness and fish size. *Environmental Toxicology and Chemistry, **4***, 685-694.

Çalta, M. (1999). Changes in the whole body mineral concentration of the rainbow trout (*Oncorchynchus mykiss Walbaum*) yolk-sac fry exposed to various combinations of aluminium and calcium concentrations in two different acidic water. *Journal of Zoology, **23***, 293-298.

Çelik, E.Ş. (2006). Bazı balık türleri için kan elektrolitlerinin standardizasyonu. *Erciyes Üniversitesi Fen Bilimleri Enstitüsü Dergisi, **22***(1-2), 245-255.

Çelikkale, M.S. (1994). İçsu balıkları ve yetiştiriciliği. *Karadeniz Teknik Üniversitesi Basımevi*, ***2***(2), 419.

Çelikkale, M.S., Düzgüneş, E. & Okumuş, İ. (1999). Türkiye su ürünleri sektörü; potansiyeli, mevcut durumu, sorunları ve çözüm önerileri, İstanbul.

Charoo, S.Q., Chalkoo, S.R. & Qureshi, T.A. (2013). Sexual differentiation in blood biochemistry of Rainbow Trout (*Oncorhynchus mykiss*). *Cloud Publications International Journal of Advanced Fisheries and Aquatic Science, **1***, 32-38.

Chen, C.Y., Wooster, G.A., Getchell, R.G., Bowser, P.R. & Timmons, M.B. (2002). Blood chemistry of healthy, Nephrocalcinosis-Affected and Ozone-Treated Tilapia in A Recirculation System, with Application of Discriminant Analysis. *Aquaculture, **21***, 89-102.

Cicik, B. (1995). *Cyprinus carpio'da Bakır, çinko ve bakır + çinko karışımında solungaç, karaciğer ve kas dokularındaki metal birikiminin nicel protein, glikojen ve kandaki bazı biyokimyasal parametreler üzerine etkileri*. Doktora Tezi, Çukurova Üniversitesi Fen Bilimleri Enst. Biyoloji ABD, Adana, 107s.

Cirik, S. & Cirik, Ş. (1999). *Limnoloji*. III. Baskı, Ege Üniversitesi Su Ürünleri Fakültesi Yayınları No: 21, Ege Üniversitesi Basımevi, İzmir.

Cirik, S. & Gökpınar, Ş. (1993). *Plankton Bilgisi ve Kültürü*. Ege Üniversitesi Su Ürünleri Fakültesi Yayınları No: 47, Ege Üniversitesi Basımevi, İzmir.

Davis, K.B. (2004). Temperature affects physiological stress responses to acute confinement in sunshine bass (*Morone chrysops x Morone saxatilis*). *Comparative Biochemistry and Physiology Part A: Molecular and Integrative Physiology, **139***, 433-440.

DGSHW. (2019) State Hydraulic Works Archive Data, General Directorate of State Hydraulic Works, Ankara, Turkey (in Turkish).

Dikel, S. (2009). Su Sıcaklığının balık yetiştiriciliğine etkisi. *Alınteri Zirai Bilimler Dergisi*, ***16***, 42-49.

Everall, N.C., Macfarlane, N.A.A. & Sedgwick, R.W. (1989). The effects of water harness upon the uptake, accumulation and excretion of zinc in the brown trout, *Salmo trutta L. Jornal of Fish Biology, **35***, 881-892.

Fossati, P., Prencipe, L. & Berti, G. (1980). Use of 3,5 -dichloro -2 hydroxybenenesulfonicacid / 4 aminophenazone chromogenic system in direct enzymic asay of uric acid in serum and urine. *Clinical Chemistry, **26***, 227-231.

Gorie S. (1992). Growth of the rainbow trout Oncorhynchus mykiss during experimental feeding with Oregon moist pellets in sea water. *Nippon Suisan Gakkaishi*, 58, 359.

Grant, G.H. & Kachmar, J.F. (1976). The proteins of body fluids. *Fundemental Clinical Chemistry, **1***, 4.

Holme, M.H., Zeng, C.S. & Southgate, P.C. (2006). The effects of supplemental dietary cholesterol on growth, development and survival of mud crab, Scylla serrata, megalopa fed semi-purified diets. *Aquaculture, **261***, 1328-1334.

Hrubec, T.C. (1999). Differences between plasma and serum samples for the evaluation of blood chemistry values in rainbow trout, channel catfish, hybrid tilapias and hybrid stripped bass. *Journal of Aquatic Animal Health, **11***, 116-122.

Hrubec, T.C. (2000). *Haematology of fish. Schalm's Veterinary Haematology*. 5th Ed. Lippincott Williams and Wilkins, Philadepphia PA, 1120-1125.

Kader, M.A., Koshio, S., Ishikawa, M., Yokoyama, S. & Bulbul, M. (2010). Supplemental effects of some crude ingredients in improving nutritive values of low fishmeal diets for red sea bream, Pagrus major. *Aquaculture, **308***,136-144.

Kamalam, B.S., Medale, F, Panserat, S. (2016) Utilisation of dietary carbohydrates in farmed fishes: New insights on influencing factors, biological limitations and future strategies. Aquaculture (in press, available online; DOI: 10.1016/j.aquaculture.2016.02.007)

Kavitha, C., Ramesh. M., Kumaran, S.S. & Lakshmi, S.A. (2012). Toxicity of Moringa oleifera seed extract on some hematological and biochemical profiles in a freshwater fish *Cyprinus carpio*. *Experimental & Toxicologic Pathology Official Journal of the Gesellschaft Fur Toxikologische Pathologie*, ***64***, 681-687.

Kim, S.S. & Lee, K.J. (2009). Dietary protein requirement of juvenile tiger puffer (Takifugu rubripes). *Aquaculture*, ***287***, 219-222.

Kopp, R., Mares, J., Lang, S., Brabec, T. & Zikova, A. (2011). Assessment of ranges plasma indices in rainbow trout (*Oncorhynchus mykiss*) reared under conditions of intensive aquaculture. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, ***6***, 181-188.

Kulkarni, R.S. (2015). Comparative studies on blood electrolytes of the fresh water fish, Notopterus notopterus from three aquatic bodies. *International Letters of Natural Sciences*, ***40***, 1-5.

Lease, H.M., Hansen, J.A., Bergman, H.L. & Meyer, J.S. (2003). Structural changes in gills of Lost River suckers exposed to elevated pH and ammonia concentrations. Comp. Biochem. *Physiol*., ***134***, 491-500.

Louka, N.F., Juhel, V., Fazilleau, G. & Loonis, P. (2004). A novel colorimetry analysis used to compare different drying fish processes. *Food Control*, ***15***, 327-334.

Manera, M. (2006). Assessment of the blood chemistry normal ranges in Rainbow Trout. *Journal of Fish Biology*, ***69***, 1427-1434.

McCormick, S.D., Hasegawa, S. & Hirano, T. (1992). Calcium uptake in the skin of a freshwater teleost. *Proceedings of the National Academy of Science*, ***89***, 3635-3638.

McDonald, D.G. (1992). *Chemical properties of the blood*. In: W.S. Hoar, D.J. Randall and A.P. Farell (Eds). Fish Physiology, Academic Press Inc., San Deigo, CA, 55-133.

Murray, R.K., Mayes, P.A., Granner, D.K. & Rodwel, V.W. (1993). *Harper'in Biyokimyası* (Menteş D. ve Ersöz B. çev.), s. 913, Barış Kitabevi, İstanbul.

Odoh, V.U., Abuh, O.O., Haruna, M.M., Yisa, M.A., & Bids, A.A. (2019). Medically Important Parasites of *Clarias garipienus* (Catfish) in Nigeria. *Advances in Biotechnology and Microbiology*. ***15***(1), 555904.

Onyekuru, N.A., Ihemezie, E.J., & Chima, C.C. (2019). Socioeconomic and Profitability Analysis of Catfish Production: a case study of Nsukka Local Government Area of Enugu State, Nigeria. *Agro-Science*, ***18*** (2): 51-58

Payne, S.A., Johnson, B.A. & Otto, R.S. (1999). Proximate composition of some North-Eastern Pacific forage fish species. *Fish Oceanography*, ***8***(3), 159-177.

Polakof S., Panserat S., Soengas J.L. & Moon T.W. (2012). Glucose metabolism in fish: a review. *J Comp Physiol B*, ***182***, 1015-1045

Racicot, J.G., Gaudet, M. & Leray, C. (1975). Blood and liver enzymes in rainbow trout (*Salmo gairdneri*) with emphasis on their diagnostic use: Study of CCl4 toxicity and a case of Aeromonas infection. *Journal of Fish Biology*, ***7***, 825-835.

Rao, C.R. (1973). *Linear statistical inference and its applications* (2nd Ed.): John Wiley. New York.

Rehulka, J. (2004). Red blood cell indices of rainbow trout in aquaculture. *Aquaculture Research*, ***35***, 529-546.

Ross, B. & Ross, L.G. (2002). *Anaesthetic and seductive for aquatic animals*. 2nd Edition, Blackwell Science Ltd.

Sacks, H. (1999). Max Weber's ancient judaism. *Theory, Culture and Society*, ***16***(1), 31-39.

Sheen, S.S. (2000). Dietary cholesterol requirement of juvenile mud crab Scylla serrata. *Aquaculture*, ***189***, 277-285.

Shell, E.W. (1961). Chemical composition of blood of smallmouth bass. *Fishery Bulletin of the Fish and Wildlife Service*, ***57***, 36.

Song, J.Y., Zhang, C.X., Wang, L., Song, K., Hu, S.C. & Zhang, L. (2016). Effects of dietary calcium levels on growth and tissue mineralization in japanese seabass, lateolabrax japonicus. *Aquaculture Nutrition*, ***23***(3), 637-648.

Sönmez, M. & Çetinkaya, O. (2003). Çinkonun (Zn^{+2}) inci kefali (*Chalcalburnus tarichi Pallas 1811*) üzerindeki akut toksisitesi. *XII. Ulusal Su Ürünleri Sempozyumu*, 413-418, Elazığ.

Spry, D.J. & Wood, C.M. (1988). Zinc influx across the isolated, perfused head preparation of the rainbow trout (*Salmo gairdneri*) in hard and soft water. *Canadian Journal of Fish Science*, ***45***, 2206-2215.

Stanek, M., Andrzejewski, W., Janicki, B., Mazurkiewicz, J. & Waszak, I. (2014). Conte nt of calcium and phosphorus in the meat, gills and liver of perch (*Perca fluviatilis L.*) from the Wielkopolska Lakes District (Poland). *Journal of Elementology*, ***19***, 507-518.

Stumm, W. & Morgan. J.J. (1966). *Aquatic chemistry. Chemical equilibria and rates in natural waters*. 3rd edn. Wiley, New York.

Svennevig, N., Curr, C., Lien, E., Apostolov, A., Nikoleishvilid, T.A., Abrosimova, N., Memisoğlu, C., Serobada, I., Cosssiett, C., Jenkinss, G. & Canakci, F. (1996). Marina aquaculture in the Black Sea Region: Current Status and Development Options. *Black Sea Environmental Series*, ***2***, 133-180.

Taş, B. (2006). Derbent baraj gölü (Samsun) su kalitesinin incelenmesi, *Ekoloji*, ***15***(61), 6-15.

Urasa, F.M. &Wendelaar Bonga, S.E. (1987). Effects of calcium and phosphate on the corpuscles of Stannius of the teleost fish, *Cell Tissue Research*, ***249***, 681-690.

Velisek, J. (2004). Anaesthesis of Rainbow Trout (*Oncorhynchus Mykiss*) With 2-Phenxyethanol: Acute Toxicity and Biochemical Blood Profile. *Acta Veterinaria*, ***73***, 379-384.

Vonck, A.P.M.A., Wendelaar Bonga, S.E. & Flik, G. (1998). Sodium and calsium balance in mozambique tilapia, *Oreochromis mossambicus*, Raised at Different Salinities. *Comparative Biochemistry and Physiology*, ***2***, 441-449.

Waagbo, R., Sandnes, K., Espelid, S. & Lie, Q. (1988). Haematological and biochemical analyses of Atlantic salmon, *Salmo salar L.* suffering from coldwater vibriosis (Hitra disease). *Journal of Fish Diseases*, ***11***, 417-423.

Watson, C.F., Baer, K.N. & Benson, W.H. (1989). Dorsal gill incision: A simple method for obtaining blood samples in small fish. *Environmental Toxicology and Chemistry*, ***8***, 457-461.

Wood, C.M. (2001). *Toxic responses of the gill.* In: Schlenk, D., Benson, W.H., Eds. Target Organ Toxicity in Marine and Freshwater Teleosts. Taylor and Francis, London. 1-89.

World Health Organization (WHO). (2020). Population Nutrient Intake Goals for Preventing Diet-Related Chronic Diseases. Available online: https://www.who.int/nutrition/topics/5_population_nutrient/en/index13.html.

Yigit, M., Ergün, S. & Türker, A. (2004). Changes In Blood Ion Levels And Mortality Rates In Different Sized Rainbow Trout (Oncorhychus Mykiss) Following Direct Transfer To Sea Water. *Israeli Journal of Aquaculture-Bamidgeh*, ***56***, 20360.

Yılmaz, A.B., Sangün, M.K., Yağlıoğlu, D. & Turan, C. (2010). Metals (major, essential to non-essential) composition of the different tissues of three demersal fish species from Iskenderun Bay, Turkey. *Food Chemistry*, ***123***, 410-415.

Zweig, R.D., Morton, J.D. & Stewart, M.M. (1999). *Source Water Quality for Aquaculture*. Th e World Bank, Washington, DC.