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Determination of the Element Values of Rainbow Trout (*Oncorhynchus mykiss* Walbaum, 1792) Eggs

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ABSTRACT

The objective of this study was to determine the amount of the elements of rainbow trout (*Oncorhynchus mykiss* Walbaum, 1792) eggs obtained from different stations. The study was conducted in 5 different production areas that are producing the most rainbow trout eggs in Turkey. Element analysis (Na, Mg, Al, P, K, Ca, Cr, Mn, Fe, Co, Ni, Zn, As, Se, Cd, Ba, Pb, Hg, and Cu) of rainbow trout eggs were performed using ICP-MS (Inductively Coupled Plasma- Mass Spectrometer). At the end of the study, it was determined that the daily consumption limit for selected elements (Ca, P, Mg, Zn, Mn, Ni and Se) was not exceeded in individuals consuming 100g of rainbow trout eggs per day. The daily intake recommended by the European Communities Commission was determined to be sufficient for the K, Ca, P, Mg, Fe, Zn, Cu and Mn elements in rainbow trout eggs. The Cd and Pb values of rainbow trout eggs obtained from different stations were determined significantly less than the values included in the Turkish Food Codex. The results of this study were thought to be important for both consumers and juvenile rainbow trout producers.

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Gökkuşağı Alabalığı (*Oncorhynchus mykiss* Walbaum, 1792) Yumurtalarında Element Değerlerinin Belirlenmesi

ÖZET

Bu çalışmanın amacı, farklı istasyonlardan elde edilen gökkuşağı alabalığı (*Oncorhynchus mykiss* Walbaum, 1792) yumurtalarının element miktarının belirlenmesidir. Çalışma, Türkiye'de en fazla gökkuşağı alabalığı yumurtası üreten 5 farklı üretim alanında gerçekleştirilmiştir. Gökkuşağı alabalığı yumurtalarının element analizi (Na, Mg, Al, P, K, Ca, Cr, Mn, Fe, Co, Ni, Zn, As, Se, Cd, Ba, Pb, Hg ve Cu) İndüktif Olarak Eşleştirilmiş Plazma-Kütle Spektrometresi (ICP-MS) kullanılarak yapılmıştır. Çalışma sonunda, günde 100g gökkuşağı alabalığı yumurtası tüketen bireylerde seçili elementlerin (Ca, P, Mg, Zn, Mn, Ni ve Se) günlük tüketim limitinin aşılmadığı tespit edilmiştir. AB Komisyonu tarafından önerilen günlük alım miktarları Gökkuşağı alabalığı yumurtalarındaki K, Ca, P, Mg, Fe, Zn, Cu ve Mn elementleri için yeterli olduğu belirlenmiştir. Farklı istasyonlardan elde edilen gökkuşağı alabalığı yumurtalarının Cd ve Pb değerleri, Türk Gıda Kodeksi'nde yer alan değerlerden önemli ölçüde daha düşük olduğu belirlenmiştir. Bu çalışmanın bulgularının hem tüketiciler hem de yavru gökkuşağı alabalığı üreticileri için bilgi edinmede önemli olduğu düşünülmektedir

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INTRODUCTION

The consumption of seafood, which has increased as a trend in recent years, is proof of a nutritious and balanced diet as well as closing the protein deficit of the increasing human population. Scientists recommend the consumption of more seafood in human diets in the prevention and treatment of many diseases such as cardiovascular and cancer (FAO, 2010;

Wesichselbaum et al., 2013). Except for health problems in developing countries, even conscious consumers in developed countries often prefer fish's muscle tissue, which is a combination of many nourishing ingredients (such as polyunsaturated fatty acids, essential amino acids, vitamins, and essential elements) (Chen et al., 2007; Ruxton, 2011). Many studies have reported that not only edible fish muscle tissue but also edible products such as fish egg, fish liver, and fish skin have high nutritional values, and these products are good source of amino acids, fatty acids, and some minerals (Guil-Guerrero et al., 2011; Kaliniak et al., 2015; Rebole et al., 2015; Turan et al., 2019). As the results of these studies, the addition of fish by-products as part of balanced and healthy nutrition may increase the nutritional potential of consumed foods and prevent food waste. Among the fish by-products, fish eggs are particularly prominent and can be processed in different ways including as whole ovaries, individual eggs (caviar), and pâté, pastes, and other products (Bledsoe et al., 2003; DePeters et al., 2013). The most popular form of fish eggs is caviar which is most commonly obtained from sturgeon species, wild and farmed salmonid species, and other species such as mullet, whitefish, cod, herring, etc. (Bledsoe et al., 2003; Bekhit et al., 2009; Ghelichi et al., 2017; Vilgis, 2020).

The rainbow trout (*Oncorhynchus mykiss*) is the most successful cultivated species, with 814 thousand tons of production in commercial intensive aquaculture, in the world (FAO, 2018). The rainbow trout culture is the main aquaculture industry in Turkey and continues to grow and develop year by year. By virtue of the trend in scientists' recommendations to human diets by extension, the increase in consumption increased the production of rainbow trout. While some of the producers focus on juvenile production and aquaculture rearing of single-sex fish stock, the vast majority treat trout eggs as a by-product /a waste-product. Salmonid species eggs are very preferable after sturgeon caviar in the world and salmon caviar is one of the most popular products because of its relative abundance, attractive color, and distinctive taste. Caviar from salmonids often comes from pink salmon, coho salmon, rainbow trout, red salmon, chum salmon, and chinook salmon. Salmon egg varies in color from bright orange to dark red, which is why it is often called red caviar, but salmon caviar is known as ikura In Japan, which derives from Russian word икра (ikra) which means caviar or fish egg in general (Anonymous 2021a). Red caviar/ikura, which is consumed in high amounts especially in the Far East countries, America and Russia, has started to create a new trend in our country's fisheries sector. For this reason, some of the rainbow trout eggs used in juvenile fish production have started to take place in fish markets by using different processing methods. Production and consumption amounts of rainbow trout eggs, which have recently taken their place in the fish market, are not reflected in our country's statistics. Therefore, there are few studies highlighting the nutritional quality of rainbow trout eggs in our country. (Baki et al., 2019a; 2019b). In the world, studies on fish eggs generally focused on egg quality, productivity, and egg biochemical composition (Brooks et al., 1997; Wirth et al., 2000; Bekhit et al., 2009; Gürel İnanlı et al., 2010; Intarasirisawat et al., 2011; DePeters et al., 2013; Hossain et al., 2014). While element/mineral content research on fish eggs are more recent (Sobhanardakani, 2017; Topuz et al., 2017; Simionov et al., 2019; Turan et al., 2019), the combined assessment of the basic food composition is very significant in terms of both nutritional value and toxicological effects due to the impact of minerals and trace elements on human health. In the study, two objectives were selected in determining the selected elements of rainbow trout eggs obtained from different stations: (1) to determine of element values of rainbow trout eggs for producers producing rainbow trout juvenile, (2) to informed consumers about the rainbow trout eggs produced in our country can take place as a new product in the world aquaculture market.

MATERIAL and METHOD

The rainbow trout eggs were collected in 5 different production areas (I station: 36°45'59.55"N and 29°24'12.22"E Muğla-Fethiye; II station: 36°58'41.94"N and 29°13'9.92 "E Denizli-Çameli; III station: 38°57'54.89"N 36°40'18.17"E Kayseri-Pınarbaşı; IV station: 37°58'58.65"N and 38°0'52.89"E Malatya-Sürgü and V station: 41°27'14.35"N and 35°51'24.08"E Samsun-Ladik) which produces the most rainbow trout eggs in Turkey from December 2017 to January 2018.

Element analysis was determined in the laboratories of Sinop University Scientific and Technological Researches Center (SUBITAM). Rainbow trout egg samples digested using a microwave digestion system (Milestone Systems, Start D 260) with Suprapur® HNO_3 (nitric acid) according to meat, texture, fish, and similar samples HPR-FO-67 method (Milestone). Element analysis (Na, Mg, Al, P, K, Ca, Cr, Mn, Fe, Co, Ni, Zn, As, Se, Cd, Ba, Pb, and Cu) of rainbow trout eggs were performed using ICP-MS (Inductively Coupled Plasma-Mass Spectrometer) (Agilent Technologies, 7700X) method by accredited SEM laboratory. Data quality was checked by the analysis of standard reference materials (UME CRM 1201-UME CRM 1204) (Table 1). These results are expressed in mg kg $^{-1}$of rainbow trout eggs (mg.kg^{-1}).

RESULTS and DISCUSSION

Compared to other freshwater fish, farmed rainbow trout production is of great potential and much of the information gained with the this species egg especially relating to its hatchling production and productivity. To determine the ability to use rainbow trout eggs when viewed as food, knowledge of the nutritional and physicochemical properties were required. Besides, apart from the predicted difference in egg efficiency, there was no information available on the physicochemical components and elements of rainbow trout eggs for human consumption. The concentrations of four macro-elements (Na, Mg, K, Ca) and five micro-elements (Zn, Mn, Fe, and Cu) of rainbow trout eggs at various stations in Turkey are shown in Table 2.

Table 1. Detection limit and certified values of elemental concentrations for the elements measured by using ICP-MS.
Çizelge 1. ICP-MS'de ölçülen elementler konsantrasyonları için tespit limiti ve referans değerleri.

Elements *(Elementler)*	**Detection Limits** *(Tespit Limiti)*	**Certified Values** *(Referans Değerleri)*	**Uncertainty** *(Belirlenemeyen)*
Na	0.3475 μg kg^{-1}	3.13 mg kg^{-1}	0.11 mg kg^{-1}
Mg	0.04953 μg kg^{-1}	0.867 mg kg^{-1}	0.033 mg kg^{-1}
Al	0.7579 μg kg^{-1}	0.102 mg kg^{-1}	0.005 mg kg^{-1}
P	0.9819 μg kg^{-1}	96.4 μg kg^{-1}	5.7 μg kg^{-1}
K	3.453 μg kg^{-1}	0.410 mg kg^{-1}	0.028 mg kg^{-1}
Ca	14.95 μg kg^{-1}	3.91 mg kg^{-1}	0.14 mg kg^{-1}
Cr	0.1405 μg kg^{-1}	34.6 μg kg^{-1}	1.2 μg kg^{-1}
Mn	0.1534 μg kg^{-1}	14.5 μg kg^{-1}	0.5 μg kg^{-1}
Fe	0.4728 μg kg^{-1}	45.6 μg kg^{-1}	2.7 μg kg^{-1}
Co	-	9.60 μg kg^{-1}	0.30 μg kg^{-1}
Ni	0.01052 μg kg^{-1}	16.8 μg kg^{-1}	0.7 μg kg^{-1}
Cu	0.178 μg kg^{-1}	83.1 μg kg^{-1}	2.6 μg kg^{-1}
Zn	4.277 μg kg^{-1}	0.104 mg kg^{-1}	0.005 mg kg^{-1}
As	0.054 μg kg^{-1}	6.50 μg kg^{-1}	0.38 μg kg^{-1}
Se	0.4686 μg kg^{-1}	-	-
Cd	0.002222 μg kg^{-1}	3.95 μg kg^{-1}	0.15 μg kg^{-1}
Hg	0.01648 μg kg^{-1}	49.9 μg kg^{-1}	2.6 μg kg^{-1}
Ba	0.02665 μg kg^{-1}	0.313 mg kg^{-1}	0.014 mg kg^{-1}
Pb	0.04605 μg kg^{-1}	14.7 μg kg^{-1}	0.4 μg kg^{-1}

All analysis results were presented as mean values±SE. Statistical analysis was done by using the IBM SPSS 21 statistical package program. The differences between the results were tested by one-way analysis of variance (ANOVA). The differences between the values were compared with Tukey's multiple comparison tests at the $p<0.05$ level of significance.

Table 2. Macro and micro-elements of rainbow trout eggs in different station in Turkey (mg kg-1)
Çizelge 2. Türkiye'deki farklı istasyonlarından elde edilen gökkuşağı alabalığı yumurtalarının makro ve mikro elementleri (mg kg^{-1})

Elements *(Elementler)*	**I. station** *I. istasyon*	**II. station** *II. istasyon*	**III. station** *III. istasyon*	**IV. station** *IV. istasyon*	**V. station** *V. istasyon*
Macro *(Makro)* (mg kg^{-1})					
Na	1491.04±20.68^{bc}	1395.83±13.03^{a}	1688.71±25.33^{d}	1430.05±9.93^{b}	1347.06±6.50^{a}
Mg	645.22±7.31^{a}	660.38±6.24^{b}	711.66±15.06^{d}	694.06±6.45^{bc}	663.90±5.82^{b}
K	2554.26±29.23^{b}	2501.29.94^{b}	2421.04±28.76^{a}	2735.50±24.27^{bc}	3046.54±20.61^{d}
Ca	485.32±7.43^{a}	480.62±3.83^{a}	668.31±11.46^{c}	530.36±4.19^{b}	506.21±6.57^{ab}
Micro *(Mikro)* (mg kg^{-1})					
Zn	34.59±2.49^{bc}	31.89±2.04^{ab}	27.84±1.85^{a}	34.88±2.41^{b}	34.23±2.37^{b}
Mn	1.32±0.10^{a}	2.81±0.26^{b}	4.77±0.39^{c}	2.25±0.18^{b}	1.67±0.16^{a}
Fe	10.31±0.73^{a}	12.13±0.88^{b}	12.76±0.88^{b}	15.14±1.28^{c}	15.04±1.08^{c}
Ni	0.04±0.01^{a}	0.03±0.01^{a}	0.08±0.01^{b}	0.04±0.01^{a}	0.05±0.01^{a}
Cu	1.54±0.07^{a}	1.42±0.05^{a}	1.75±0.09^{b}	2.11±0.01^{c}	1.97±0.10^{bc}

Values in the same rows marked with different letters are significantly different ($p<0.05$).

It determined that macro-elements of rainbow trout eggs in the different stations were, K>Na>Mg>Ca, respectively and the statistical difference between values was important ($P<0.05$). Micro-elements of rainbow trout egg Zn, Mn, Ni and Cu were 27.84-34.88 mg kg^{-1}, 1.32-4.77, 0.03–0.08 and 1.42-2.11 mg kg^{-1}, respectively and the statistical difference between values was important ($p<0.05$). When macro and micro-elements between stations are examined, the highest macro-elements were at III (Na, Mg, and Ca) and V stations (K), while the highest micro-elements were at stations III (Mn and Ni) and IV (Zn, Fe, and Cu). Table 3 outlines the macro and micro-elements analysis of eggs of various fish species. When this table was assessed, the macro-elements' values were lower than in the current study in the mature eggs of Chinook salmon (Bekhit et al., 2009) and the eggs of rainbow trout (Skalecki et al., 2020). In other research, K was the most common among macro-element values in other marine fish eggs that could be eaten as human food. (*Tenualosa ilisha*: Hossain et al., 2014; *Merlangus merlangus euxinus*: Turan et al., 2019; *Psetta maxima maeotica*: Simonov et al., 2019). In a macro-element analysis of three distinct sturgeon (*Huso huso, Acipenser gueldenstaedhi*, and *Acipenser stellatus*) eggs (caviar), it was recorded that Na was the most abundant macro-element (Wang et al., 2008). In this analysis of Wang et al (2008), it was determined that the value of Na macro elements of three distinct sturgeon caviar was higher than the value in our study and that the values of Mg, K, and Ca were lower. In the study, the values of Zn, Mn, Fe, Ni, and Cu, identified as micro-elements in rainbow trout eggs from different stations, ranged from 27.84±1.85-34.88±2.41, 1.32±0.10-4.77±0.39, 10.31±0.73-15.14±1.28, 0.03±0.01-0.08±0.01, and 1.42±0.05-2.11±0.01 mg kg^{-1} respectively these findings were close to the values of micro-elements calculated by Skalechi et al. (2020) in their trout egg analysis. As a result of the elemental study of mature Chinook salmon eggs, it was confirmed that the values of Fe and Ni were high and the values of Zn, Cu, and Mn were in similar ranges (Bekhit et al., 2009) (Table 3). As a part of the phospholipids that create the membrane lipid bilayer, P plays an essential role in both the bones and the cell membranes. The P deficiency in the body causes muscular defects and improvements in bone mineralization, as well as cardiac, cardiovascular, neurological, and metabolic disorders (Ghosh and Joshi, 2008). In the elemental analysis carried out in the present research, it was determined that P was the most detected element in rainbow trout eggs. As can be seen from Table 3, it has been calculated that the intake of 100 g of rainbow trout by the European Communities satisfies the necessity of 65.97-75.14% P. The P value in this study was higher than *Oncorhynchus tshawytscha* eggs (Bekhit et al., 2009) and lower than *Acipenser transmontanus* eggs relative to other experiments of fish eggs (DePetters et al., 2013).

Table 3. Essential, Non-essential and other specified elements of rainbow trout eggs in different station in Turkey (mg kg^{-1})

Çizelge 3. Türkiye'deki farklı istasyonlardan elde edilen gökkuşağı alabalığı yumurtalarında esansiyel, esansiyel olmayan ve diğer elementler(mg kg^{-1}*)*

Elements *(Elementler)*	**I. station** *I. istasyon*	**II. station** *II. istasyon*	**III. station** *III. istasyon*	**IV. station** *IV. istasyon*	**V. station** *V. istasyon*
Essential *(Esansiyel) (mg kg*$^{-1}$*)*					
Ca	485.32±7.43^{a}	480.62±3.83^{a}	668.31±11.46^{c}	530.36±4.19^{b}	506.21±6.57^{ab}
Cu	1.54±0.07^{a}	1.42±0.05^{a}	1.75±0.09^{b}	2.11±0.01^{c}	1.97±0.10^{bc}
Fe	10.31±0.73^{a}	12.13±0.88^{b}	12.76±0.88^{b}	15.14±1.28^{c}	15.04±1.08^{c}
K	2554.26±29.23^{b}	2501.29.94^{b}	2421.04±28.76^{a}	2735.50±24.27^{bc}	3046.54±20.61^{d}
Mg	645.22±7.31^{a}	660.38±6.24^{b}	711.66±15.06^{d}	694.06±6.45^{bc}	663.90±5.82^{b}
Mn	1.32±0.10^{a}	2.81±0.26^{b}	4.77±0.39^{c}	2.25±0.18^{b}	1.67±0.16^{a}
Na	1491.04±20.68^{bc}	1395.83±13.03^{a}	1688.71±25.33^{d}	1430.05±9.93^{b}	1347.06±6.50^{a}
Zn	34.59±2.49^{bc}	31.89±2.04^{ab}	27.84±1.85^{a}	34.88±2.41^{b}	34.23±2.37^{b}
P	4618.26±65.16^{a}	4626.42±47.01^{a}	4917.78±82.41^{b}	5089.45±36.94^{bc}	5259.57±42.07^{c}
Non-Essential ***(Esansiyel olmayan) (mg kg***$^{-1}$***)***					
As	0.05±0.01^{a}	0.07±0.01^{a}	0.07±0.01^{a}	0.06±0.01^{a}	0.10±0.01^{a}
Cd	0.01±0.01^{a}	0.01±0.01^{a}	0.01±0.01^{a}	0.01±0.01^{a}	0.01±0.01^{a}
Ni	0.04±0.01^{a}	0.03±0.01^{a}	0.08±0.01^{b}	0.04±0.01^{a}	0.05±0.01^{a}
Other ***(Diğer) (mg kg***$^{-1}$***)***					
Al	0.30±0.06^{ab}	0.28±0.03^{a}	0.50±0.03^{c}	0.27±0.032^{a}	0.39±0.14^{b}
Cr	BDL	0.03±0.01^{a}	0.02±0.01^{a}	0.01±0.01^{a}	BDL
Co	0.02±0.01^{a}	0.01±0.01^{a}	0.03±0.01^{a}	0.03±0.01^{a}	0.04±0.01^{a}
Se	0.97±0.01^{c}	0.54±0.01^{a}	0.67±0.05^{b}	0.91±0.01^{c}	0.97±0.03^{c}
Cd	0.01±0.01^{a}	0.01±0.01^{a}	0.01±0.01^{a}	0.01±0.01^{a}	0.01±0.01^{a}
Hg	BDL	BDL	BDL	BDL	BDL
Ba	0.24±0.01^{c}	0.16±0.01^{b}	0.17±0.01^{b}	0.19±0.01^{bc}	0.04±0.01^{a}
Pb	0.04±0.01^{a}	0.03±0.01	0.05±0.01^{a}	0.04±0.01^{a}	0.04±0.01^{a}

Values in the same rows marked with different letters are significantly different ($p < 0.05$).
BDL: Below Detection Limit

Table 4 shows the essential, non-essential, and other specified elements of rainbow trout eggs. The highest essential elements of the eggs obtained at all stations were determined as P> K> Na> Mg> Ca, respectively. The highest essential elements in rainbow trout eggs were at III. (Ca, Mg, Mn and Na), IV. (Cu, Fe, and Zn), and V. (K and P) stations, respectively. The statistical difference among non-essential elements in rainbow trout eggs obtained from different stations was not significant ($p>0.05$). The Se was the highest in the I and V. stations (0.97±0.01 mg kg^{-1}). The Pb, Cd, As, Co, and Cr values were below 0.1 mg kg^{-1} at all stations. The Cr could not be detected in the rainbow trout eggs obtained from the I. and V. Stations. As a result of the elemental analysis, the Hg value could not be determined in rainbow trout eggs. The Se is toxic in high amounts but is important in animals and humans as a micronutrient. Myocardial infarctions were associated with reduced levels of Se and higher mortality rates from cardiovascular disease. Also, low Se levels were associated with an increased risk of cancer and kidney failure. (Holben and Smith, 1999).

Tablo 4. Values of micro and macro-elements of distinct fish eggs (mg kg^{-1})
Çizelge 4. Farklı balık yumurtalarının mikro ve makro element değerleri (mg kg^{-1})

Species	Na	Mg	K	Ca	Reference
O. mykiss	1347.06-1688.71	645.22-711.66	2421.04-3046.54	480.62-668.31	In present study
O. mykiss					Topuz et al., (2017)
O. mykiss	404	547	1714	547	Skałecki et al., (2020)
O. tshawytscha	596.1	584.7	1698.7	428.3	Bekhit et al., (2009)
T. ilisha	700-1280	400-1030	1680-2450	1000-1240	Hossain et al., (2014)
K. pelamis	1074.93	456.91	2397.56		Intarasirisawat et al., (2011)
T. tonggol	826.26	691.46	2184.22		
E. affinis	768.25	486.33	2194.34		
P. maxima maeotica	1599.5	228.5	3011	86.2	Simionov et al., (2019)
M. merlangus euxinus	635.90-1199.13	188.67-365.96	3236.52-6150.05	112.36-192.58	Turan et al., (2019)
H. huso	7886-14840	230.1-259.7	1327-1603	56.8-96.8	Wang et al., (2008)
A. gueldenstaedti	8795-12014	232.7-263.8	1126-1791	97.1-173.9	
A. stellatus	9863-13463	146-266	1017-1423	102.7-151.6	
H. huso					Wirt et al., (2002)
Ac. stellatus					
A. gueldenstaedti					
A. baeri					
A. persicus					Sobhanardakani, (2017)
A. transmontanus	1032-6964	594-690	3578-4078	311-313	DePeters et al., (2013)
C. tarichi					Oğuz and Yeltekin, (2014)

Tablo 4. Values of micro and macro-elements of distinct fish eggs (mg kg^{-1}) (continue)
Çizelge 4. Farklı balık yumurtalarının mikro ve makro element değerleri (mg kg^{-1}) (devamı)

Species	Zn	Mn	Fe	Ni	Cu	Reference
O. mykiss	27.84-34.88	1.32-4.77	10.31-15.14	0.03-0.08	1.42-2.11	In present study
O. mykiss	140.28	18.46	98.16		8.15	Topuz et al., (2017)
O. mykiss	29.4	1.7	11.2		1.2	Skałecki et al., (2020)
O. tshawytscha	32.44	3.76	36.04	0.17	2.51	Bekhit et al., (2009)
T. ilisha	42.16-45.61	2.03-2.18	33.85-35.24		1.23-1.24	Hossain et al., (2014)
K. pelamis		0.34	70.22		12.72	Intarasirisawat et al., (2011)
T. tonggol		0.8	55.24		12.48	
E. affinis		0.78	122.17		34.35	
P. maxima maeotica	39.1	0.16	15.1	0.08	0.7	Simionov et al., (2019)
M. merlangus euxinus	31.15-58.15	0.79-2.29	28.00-142.03	0.18-0.41	1.15-2.15	Turan et al., (2019)
H. huso	19.0-22.0	0.8-1.2	19.4-128.2	0.01-0.01	0.7-1.0	Wang et al., (2008)
A. gueldenstaedti	20.7-24.0	1.0-1.3	24.0-155.1	0.01-0.03	1.2-1.6	
A. stellatus	20.4-23.2	0.9-1.4	21.6-55.6	0.01-0.01	1.0-1.4	
H. huso	11.58-11.60				1.2-1.45	Wirt et al., (2002)
Ac. stellatus	10.29-11.60				1.55-1.61	
A. gueldenstaedti	12.0-12.43				1.37-1.47	
A. baeri	10.54				1.69	
A. persicus	12.9-21.1	0.01-0.02	63.50-79.20			Sobhanardakani, (2017)
A. transmontanus	54.6-59.4	1.10-2.93	67.3-70.6		8.3-9.4	DePeters et al., (2013)
C. tarichi	26.313	1.281	40.96	0.67	1.462	Oğuz and Yeltekin, (2014)

Seafood was a strong source of Se according to the USDA National Nutrient Database (Ralston, 2008) and it was observed that fish Se was extremely bioavailable (Fox et al., 2004). The National Institutes of Health Office of Dietary Supplements recommended a maximum intake of 400 µg d^{-1} Se. In the current analysis, while the Se values for rainbow trout eggs were lower than those for other fish species described in Table 5, it was observed that they did not reach the overall limit recommended by the Dietary Office of the National Institutes of Health.

Tablo 5. Other element values defined in eggs of different fish species (mg kg^{-1})
Çizelge 5. Farklı balık yumurtalarında tanımlanan diğer element değerleri (mg kg^{-1})

Species	As	Cd	Al	Cr	Co	Reference
O. mykiss	0.05-0.10	0.01-0.01	0.28-0.50	0-0.03	0.01-0.03	in present study
O. tshawytscha	0.15		1.93		0.01	Bekhit et al., (2009)
T. ilisha						Hossain et al., (2014)
P. maxima maeotica	0.18	0.03				Simionov et al., (2019)
M.merlangus euxinus	0.90-1.36	0.02-0.02	1.03-6.78	0.12-0.27	0.03-0.06	Turan et al., (2019)
H. huso	0.24-1.16	0.01-0.01	0.1-0.7	0.01-0.01	0.01-0.02	Wang et al., (2008)
A. gueldenstaedti	1.08-1.59	0.01-0.01	0.5-1.9	0.01-0.01	0.01-0.02	
A. stellatus	0.87-1.56	0.01-0.01	0.2-0.8	0.01-0.01	0.01-0.01	
H. huso		<0.005				Wirt et al., (2002)
A. stellatus		<0.005				
A. gueldenstaedti		<0.005				
A. baeri		<0.005				
A. persicus				0.19-0.35		Sobhanardakani (2017)
A. transmontanus	3.25					DePeters et al., (2013)
C. tarichi					0.392	Oğuz and Yeltekin (2014)

BDL: Below Detection Limit

Tablo 5. Other element values defined in eggs of different fish species (mg kg^{-1}) (continue)
Çizelge 5. Farklı balık yumurtalarında tanımlanan diğer element değerleri (mg kg^{-1}) (devam)

Species	Se	Hg	Ba	Pb	Reference
O. mykiss	0.54-0.97	BDL	0.16-0.24	0.03-0.05	in present study
O. tshawytscha					Bekhit et al., (2009)
T. ilisha					Hossain et al., (2014)
P. maxima maeotica					Simionov et al., (2019)
M.merlangus euxinus	0.84-1.71	0.04-0.05	0.10-0.45	0.14-0.26	Turan et al., (2019)
H. huso	1.0-1.8	0.01-0.07	0.01-0.38	0.01-0.01	Wang et al., (2008)
A. gueldenstaedti	1.2-2.1	0.01-0.01	0.14-0.52	0.01-0.01	
A. stellatus	1.4-2.4	0.01-0.02	0.12-0.43	0.01-0.01	
H. huso				0.10-0.11	Wirt et al., (2002)
A. stellatus				0.09-0.15	
A. gueldenstaedti				0.06-0.08	
A. baeri				0.06	
A. persicus		1.39-1.50	0.71-1.17		Sobhanardakani (2017)
A. transmontanus	2.7-10		0.5-4.6		DePeters et al., (2013)
C. tarichi				2.485	Oğuz and Yeltekin (2014)

BDL: Below Detection Limit

The K was essential for the equilibrium of water and electrolytes and the proper functioning of cells, including nerves. Increased dietary intake of K was associated with a drop in blood pressure, as it promotes Na loss in the urine. It is thought that an increase in K intake will counteract the effect of some of the Na in the diet, thereby helping to improve cardiovascular health. Although several fish species are considered to be K sources, fish only contribute a small percentage of K to the UK diet. (Gregory et al., 2000; Henderson et al., 2003). The amount of K in rainbow trout eggs was determined in the present analysis to be consistent with the daily intake values of the Commission of the European Communities (Table 6). The Cd, Pb, and Hg in animals are non-essential metals with toxicity; these metals can pose a human health risk by intake of seafood (Bat et al., 2020). Cd and Hg can be harmful to most fish and wildlife, particularly to freshwater species (Robertson et al., 1992). The Pb is a non-essential element and it was well documented that can cause neurotoxicity and many other adverse health effects (Garcia-Leston et al., 2010).

While the Cd and Pb seen in this study were significantly smaller than those of the Turkish Food Codex recommended (Official Gazette of Republic of Turkey, 2009), the Hg value could not be determined in rainbow trout eggs. Aside from evaluating all this literature, when all this element analyzes are evaluated, it is thought that the differences between the stations were from the feed ingredients used in broodstock feeding and the spring waters used in the hatchery. When the elements found in rainbow trout fillet and the elements in eggs are compared, Fe, K, Zn, Hg and Cd elements in rainbow trout fillet are higher than eggs; Ca, Mg, P, Na, Mn, Cu and Pb elements were low. (Yardım and Bat, 2020; USDA, 2021). Despite the differences found, both egg and fillet from rainbow trout are a good source of analyzed elements.

Table 6. Meeting the daily recommended allowances for selected elements by a 100g portion of rainbow trout eggs
Çizelge 6. Günlük tavsiye edilen element düzeyleri ile 100g'lık gökkuşağı alabalığı yumurtalarında seçili elementler ile karşılanması

Minerals *(Mineraller)*	Study results (mg 100g^{-1}) *(Mevcut Çalışma)*	RDA EU $^{-1*}$ *(GTE AB^{-1**})*	Meeting the norm (%) *(Miktarın karşılığı %)*
K	250.12-491.7	2000mg	12.50-24.60
Ca	48.52-66.83	800mg	6.07-8.35
P	461.82-525.98	700mg	65.97-75.14
Mg	64.52-71.16	375mg	17.21-18.98
Fe	1.03-1.51	14mg	7.36-10.79
Zn	2.78-3.48	10mg	27.8-34.48
Cu	0.14-0.21	1mg	14.00-21.00
Mn	0.13-0.47	2mg	6.50-23.50

*RDA Commission Directive 2008/100/EC of 28 October 2008, (Anonymous, 2021b)
**GTE AB, Avrupa Birliği tarafından Günlük tavsiye edilen element düzeyleri

The regular quantities of the elements needed for adults as determined by the Commission of the European Communities and the values determined in this study are contrasted in Table 6.

In the study, it was determined that consumption of 100g rainbow trout eggs met the daily macro-element need at the lowest 6.07-8.35% (Ca) and the highest 17.21-18.98% (Mg). This situation did not change much for micro-elements, and it was determined that 100g of rainbow trout egg consumption met the lowest daily micro-element requirement at 7.36-10.79% (Fe) and the highest 27.8-34.48% (Zn). The most striking in this table 6 as well, the proof of the high P content of rainbow trout eggs is that they meet the daily P requirement by 65.97-75.14%. The suggested daily intake amounts for the EU were sufficient for the selected elements in rainbow trout eggs.

Table 7. The daily Tolerable Upper Intake Levels (UL), for selected minerals by a 100g portion of rainbow trout eggs (Life-Stage Group 19-70 years)
Çizelge 7. 100g'lık gökkuşağı alabalığı yumurtalarındaki bazı minerallerin Günlük Tolere Edilebilir Üst Alım Seviyeleri (UL) (19-70 yaş)

Minerals *(Mineraller)*	Study results (mg 100g-1) *(Mevcut Çalışma)*	UL* *TÜS***	Meeting the norm % *(Miktarın karşılığı %)*
Ca	48.52-66.83	2500 mg d^{-1}	1.94-2.67
P	461.82-525.98	4000 mg d^{-1}	11.54-13.15
Mg	64.52-71.16	350 mg d^{-1}	18.43-20.33
Zn	2.78-3.48	40 mg d^{-1}	6.95-34.8
Mn	0.13-0.47	11 mg d^{-1}	1.18-4.27
Ni	0.003-0.008	1 mg d^{-1}	0.3-0.8
Se	0.05-0.10	400 µg d^{-1}	1.25-2.5

*DRIs National Institutes of Health Office of Dietary Supplements (Anonymous 2021c)
**TÜS Günlük Tolere Edilebilir Üst Alım Seviyeleri

Daily Tolerable Upper levels for the selected elements (Ca, P, Mg, Zn, Mn, Ni, and Se) in 100g of rainbow trout eggs for the 19-70 age group are given in Table 7. The seven elements (Ca, P, Mg, Zn, Mn, Ni, and Se) were chosen from the National Institutes of Health Office of Dietary Supplements for the ages of 19-70. In this study, the elements determined in rainbow trout eggs and included in the National Institutes of Health Office of Dietary Supplements list were determined to remain within tolerable limits.

A Tolerable Upper Intake Level (UL) was the highest level of daily nutrient intake that was likely to pose no risk of adverse health effects to almost all individuals in the general population (Table 7). In the absence of a UL, extra caution must be warranted in consuming levels above recommended intakes. Members of the general population should be advised not to routinely exceed the UL. The UL was not meant to apply to individuals who were treated with the nutrient under medical supervision or to individuals with predisposing conditions that modify their sensitivity to the nutrient. In this study, it was established that the daily consumption cap for selected minerals was not surpassed by individuals eating 100 g of rainbow trout eggs per day.

Bekhit et al., (2009) stated that the difference in the composition of the mineral with the maturity of the fish eggs suggests that the degree of maturity of the salmon egg plays an important role in deciding the quantity of critical mineral present in the final product and depending on the minerals involved.

However, it must be recognized that, as shown by Bechtel et al., (2007), processing before being eaten as a portion of food can alter the mineral content, so final products need to be individually assessed. This research analyses the quantities of elements contained in Turkey as raw products of rainbow trout eggs. The findings of this study are also important for both consumers and juvenile fish farmers to gain information.

CONCLUSION

Consumer understanding of the nutritional benefits of fish consumption is increasingly growing. To raise awareness of the need to diversify the diet with other fish products such as fish eggs, a natural and unprocessed product, further information is, however, necessary. The use of trout eggs, which are widely consumed in the world and a new market for our country, as food creates a new trend. In this study, as a result of the elemental analysis of rainbow trout eggs in our country, it has been determined that it is suitable for use as food. In additionally, the egg of rainbow trout was found to cover the requirements of the consumer groups for the analyzed elements especially K, Ca, Mg, Fe, Zn, Cu, Mn, and P. However, more studies should be conducted with the number of elements found in rainbow trout eggs and these studies and products should reach the consumer. Thus, in the new market for rainbow trout eggs, it is believed that our country will not be foreign-dependent on this issue.

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Statement of Conflict of Interest

Authors have declared no conflict of interest.

Author's Contributions

The contribution of the authors is equal

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