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Nutritional Value of Fish Soup From Cultured Rainbow Trout (*Oncorhyncus mykiss,* Walbaum, 1792)

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Abstract: This study represents new information on the nutritional value of soup prepared from cultured Rainbow trout (*Oncorhyncus mykiss*). The proximate contents of soup were represented by 87.56% moisture, 7.22% protein, 1.59% crude fat, 0.07% carbohydrate, 1.17% dietary fibre and 2.44% ash. The energy value was calculated as 48.0 kcal/100g. Amino acid values were in the range of 183.5-1128.5mg/100g while mineral contents were varied as 0.6µg/g-19.5mg/g. The value of polyunsaturated fatty acids (PUFA) was higher than saturated fatty acids (SFA). Total PUFA and eicosapentaenoic acid + docosahexaenoic acid (EPA+DHA) were observed as 37.2 and 7.2%, respectively. These values corresponded to the values of 673.3 and 123.2 mg/100g of edible portion of the soup within the same respect. The results of this study demonstrated that a portion of trout soup would almost cover daily recommended n-3 PUFA intake, however, higher amounts are required for the necessary levels of EPA+DHA. The vitamin B12 content was well above the recommended levels. The values of α and β tocopherols were observed as 272.0 and 1131.0 µg/100g (wwb), respectively. This study indicates that trout soup has a good nutritional value for human consumption for a healthy diet.

Keywords: Amino acids, cultured rainbow trout, fatty acid, fish soup, nutritional value, proximate composition.

Gökkuşağı Alabalığından (*Oncorhyncus mykiss,* Walbaum, 1792) Hazırlanan Balık Çorbasının Besin Değeri

Öz: Bu çalışma Gökkuşağı alabalığından (*Oncorhyncus mykiss*) hazırlanan balık çorbasının besin değeri hakkında yeni bilgiler sunmaktadır. Hazırlanan balık çorbasının besin kompozisyonu %87.56 nem, %7.22 protein, %1.59 ham yağ, %0.07 karbonhidrat, %1.17 diyet lifi ve %2.44 kül olarak tespit edilmiştir. Enerji değeri ise 48.0 kcal/100g olarak hesaplanmıştır. Amino asit değerleri 183,5-1128.5mg/100g aralığında iken mineral içerikleri ise 0.6µg/g-19,5mg/g olarak değişim göstermiştir. Çoklu doymamış yağ asitlerinin (PUFA) değeri, doymuş yağ asitlerinden (SFA) daha yüksek olarak belirlenmiştir. Toplam PUFA ve eikosapentaenoik asit + dokosaheksaenoik asit (EPA+DHA) sırasıyla %37.2 ve %7.2 olarak gözlenmiştir. Bu değerler aynı zamanda çorbanın yenen kısmının 673.3 ve 123.2 mg/100g değerlerine tekabül etmektedir. Çalışma sonuçlarına göre, bir porsiyon alabalık çorbasının günlük önerilen n-3 PUFA ihtiyacını hemen hemen karşılayacağı, ancak gerekli EPA+DHA seviyeleri için daha yüksek miktarlara ihtiyaç olduğunu göstermiştir. B12 vitamini içeriği ise önerilen seviyelerin çok üzerinde bulunmuştur. α ve β tokoferol değerleri ise sırasıyla 272.0 ve 1131.0 µg/100g (wwb) olarak belirlenmiştir. Bu çalışma, alabalık çorbasının insanların sağlıklı beslenmesini destekleyici zengin besin içeriğine sahip bir ürün olduğunu ortaya koymaktadır.

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Anahtar kelimeler: Aminoasit, balık çorbası, besin değeri, kültür gökkuşağı alabalığı, yağ asid.

INTRODUCTION

The health benefits of fish are well recognized with the extensive supportive research studies in the literature (Gogus and Smith, 2010). Therefore, any product that originated from fish has a good potential for a healthy diet for human consumption (CFS, 2020). Fish soup is a popular meal worldwide and commonly consumed at restaurants and households for many years. Commercially-prepared soups are usually called 'instant soups'. They are usually manufactured in several types: dried or dehydrated, canned, or treated by freezing. Some consist of a packet of dry soup stock. Different fish species are used to make fish soup. The ingredients of fish soup also vary depending on the consumer acceptability, therefore, nutritional value also changes to a great extent. The percentage of fish and other ingredients used in the fish soup also changes, particularly at the use of restaurants and household productions (Obiakor-Okeke et al., 2014; Zhang et al., 2018). For this reason, it is important to evaluate the nutritional value of fish soups prepared from a specified methodology and ingredients (recipe).

Rainbow trout (*Oncorhynchus mykiss*, Walbaum, 1792) belongs to the *Salmonidae* family. It is anadromous fish lives in coastal streams and stocked in almost all water bodies such as lakes, rivers, and streams, however, it is usually not stocked in water above 25°C or ponds with very low oxygen concentrations. It feeds on a variety of aquatic and terrestrial invertebrates and small fishes in its natural environment. Mature individuals undertake short spawning migrations (FISHBASE, 2020). It is known as one of the most widely introduced fish species in the world and has been introduced into at least 99 countries including Turkey. It has established reproducing populations in many different parts of the world (Stanković et al., 2015). Rainbow trout is the most cultured species in our country with 144 182 tonnes of annual production (approximately 34% of total aquaculture production) in Turkey in 2020 (TÜIK, 2021). World production was reported as 917 896 tonnes in 2019 (FAO, 2020).

Proximate composition and nutritional value of Rainbow trout have been studied in the past by various researchers (Chaiyapechara et al., 2003; Hosseinzadeh Sahafi et al., 2013; Öz and Dikel, 2015). Recently, we obtained that a nutritious fish soup can be produced from brook trout for human consumption suitable for a healthy diet (Kose et al., 2021). Despite limited studies on the nutritional value of fish soup (Ankrah and Dovle, 1973; Chan et al., 1994; Zhang et al., 2018), no study exists on the nutritional value of soup prepared from rainbow trout. Therefore, this study aims to estimate the proximate composition and nutritional value of trou soup in terms of a healthy diet for human consumption.

MATERIAL AND METHOD

Materials

Production of fish soup: Rainbow trout (*O. mykiss*) was obtained from a fish farm which is situated about 35 min drive from the authors' laboratory, Trabzon, Turkey. The fish was transported to the laboratory in ice in Styrofoam boxes. The weight and the sizes of rainbow trout were 30.5-45.1 cm and 700-1000 g, respectively.

Garlic (Taşköprü, Kastamonu), wheat meal (Akmehmet, Samsun), salt (Billur, İzmir), water (Ayder, Rize), vegetables (onion, carrot, garlic, fresh green pepper, fresh tomatoes, fresh celery and fresh parsley), dried bay leaves and fresh lemons were obtained daily from a supermarket situated in central Trabzon, Turkey. They were transferred to the laboratory and kept in cool conditions until use.

Preparations of fish soup: All fish were measured and weighed before use. The fish soup was prepared using our earlier methodology applied to brook trout soup (Kose et al., 2021). However, differences occurred in the ratio of the ingredients as given in Table 1. After cooking, all the ingredients in the soup were homogenized using a blender for 1-3 minutes.

Table 1. Ingredients used in the preparation of fish soup from rainbow trout.

Ingredients	%
Fish mince (Boiled and separated from bones and skin)	17.34
Carrot	4.57
Tomatoes	3.45
Onion	2.29
Green Pepper	3.60
Parsley	0.67
Celery stalk	0.11
Garlic	0.14
White flour (roasted)	0.62
Salt	0.83
Lemon juice	0.92
Water	~65.46
TOTAL (Water loss due to evaporation was not taken into account)	**~100**

**Bay leaves and lemon pieces separated into two or three pieces were added to the product during the first cooking phase and then discarded. The ratio of these amounts is not taken into account.*

Analytical methods

Proximate composition and energy value: The AOAC method numbers of 985 (AOAC, 1995a), 7.009 and 2.507 (AOAC, 1980) were used to analyse moisture, ash and protein contents, respectively. The dietary fibre of the fish soup was analysed using AOAC Official Method 991.43 (AOAC, 1995b). Crude fat content was analysed by using solvent extractor Velp SER 148/6 with petroleum ether (130°C). The Atwater method was applied to calculate the total energy value of the soup (Merrill and Watt 1973).

Metal (Mineral) analysis: Metals (mineral contents) were analysed using an in-house method developed by the authors' analytical chemistry laboratory as described in the earlier study (Kose et al., 2021). All minerals were determined using an Inductively Coupled Plasma - Mass Spectrometer (ICP-MS) (Agilent Technologies, model 7900) against aqueous standards. The mineral concentration is expressed as mg mineral/kg fish dry weight.

Analysis of Fatty Acids: Fatty acid analysis of trout soup was carried out according to the method described by Tufan et al. (2016). The determination of fatty acids was conducted on a Shimadzu 2010 gas chromatograph with the autosampler (Shimadzu, JAPAN) equipped with a split injector (ratio 1:20), a flame ionization detector (FID), and a 100 m SUPELCO (model SPTM-2380, USA) fused silica capillary column (film 0.20 µm, diameter 0.25 mm). The temperatures of the injector detector and the port were held at 260°C. The injected volume was 1 µL. The column temperature was held at 140°C for 5 min, then raised to 240°C at 5°C /min and held at 240°C for 30 min. Fatty acids were identified by comparing the retention times of Fatty acid methyl ester (FAME) with SUPELCOTM 37 component FAME mixture (Cat. No. 47885-U). Three replicate GC analyses were performed for each fish soup sample. Quantification of FAME was carried out by FID detector and using area normalization method. According to the area, the value of each compound, area compositions were detected, and results were shown as FAME%. The amount of mg fatty acid in the edible portion of trout soup was calculated by Greenfield and Southgate (2003) using the following formulae:

FA content (mg FA per 100 g edible portion of fish soup) = [FAME% x FACF x lipid content% (g lipid / 100g food)] / 100;

Where FAME is fatty acid methyl esters, FACF: the lipid conversion factor (fatty acid conversion factor, g FA g^{-1} lipid).

FACF is reported as 0:933 for fish finfish (Weihrauch et al., 19779). All chemicals used were of analytical grade and obtained from Merck (Germany), Sigma-Aldrich (USA) and J.T. Baker (USA).

Vitamin Analysis: Vitamin E (alpha and gamma-tocopherol) was analyzed according to the method described by Prevc et al. (2015). It is an in-house method developed at the author's laboratory in Slovenia. Fish soup samples were subjected to high-performance liquid chromatography (HPLC) analysis after dissolving in 2-propanol. Separation of Vitamin E isomers was carried out using an HPLC (Infinity 1260, Agilent, USA) equipped with the fluorescent detector and OpenLab ChemStation software. The column used was Luna 5 µm PFP (250 mm × 4.6 mm), the flow rate was 1.5 mL/min., the injection volume was 25 µL, the mobile phase was a mixture of methanol-water (92:8 v/v) and the column temperature was 35 °C. The fluorescent detection was applied at the conditions of $\lambda ex = 280$ nm and $\lambda em = 330$ nm. An external standard mixture was used for quantitative measurements. The standard mixture was prepared daily as fresh from Tocopherol set (613424-1SET, Calbiochem, Merck, Darmstadt, Germany) using the concentrations of 0.5–3.5 ppm for α-tocopherol, 0.2–1.5 ppm for β-tocopherol, 0.3–2.6 ppm for γ-tocopherol and 0.2–1.4 ppm for δ-tocopherol. A concentration of approximately 0.5 mg/mL was used for the stock solution. The concentrations were confirmed at a spectrophotometer (Cary 100 UV-Vis spectrophotometer).

For vitamin B12 (cobalamin), the samples were extracted by the modified method from Eitenmiller et al. (2008) and Guggisberg et al. (2012). After the extraction, the solution was passed through an immune affinity column for purification (R-Biopharm Easy-Extract Vitamin B12, 2011). The samples were dissolved in 0.025% trifluoroacetic acid, then vitamin B12 in the samples was determined using the following HPLC (Shimadzu LC20A) conditions. Detection was carried out using a detector at 361 nm UV. The mobile phase was a mixture solution of water (containing (0.025% trifluoroacetic acid) and acetonitrile (87:13)) and the column was a reversed-phase column (ACE, 5 AQ-C18, 5 µm, 4.6x150 mm).

Amino Acid Analysis: Analysis of amino acids was also carried out by the method modified from Dimova (2003) and Gheshlaghi et al. (2008). The samples were derivatized using the solution of phenyl isothiocyanate, then dried. After that, they were dissolved in a 0.02M ammonium sulfate solution. After filtration, the solution was analyzed at the high-speed HPLC (Shimadzu UFLC-20A) system coupled with an Agilent, Eclipse XDB-C18 column (sizes: 5 µm, 4x6x150 mm). The mobile phase was used with different ratios of sodium phosphate tampon solution at pH 6.9 and acetonitrile. The detection was carried out at a UV detector at 254 nm. The detailed analytical conditions were described in Anonymous (2007).

Statistical analysis: The data obtained were subjected to analysis of variance (ANOVA), and if significant differences were found, comparisons among means were carried out by using the Tukey test ($p < 0.05$) by JMP 5.0.1 (SAS Institute Inc., Cary, NC, USA; Sokal and Rohlf, 1987). Data are presented as mean ± standard deviation (SD) of the values obtained from triplicated samples.

RESULTS AND DISCUSSION

The results for proximate composition and energy value of trout soup were given in Table 2. The proximate composition of foods closely relates to a well-balanced diet and health benefits for human consumption. It is well-known that soup consumption prior to main meals is highly common around the world. Therefore, information on the proximate values of soups is valuable for consumers and dieticians in terms of maintaining a daily nutrient balance and energy uptake. Several studies and food databases of different organizations reported that the proximate composition of different types of foods including fish soup highly varies (Ankrah and Dovle, 1973; Chan et al., 1994; Zhang et al., 2018).

Table 2. Proximate composition and energy value of rainbow trout soup.

Analytical parameters	Value (Wet weight bases)
Moisture (%)	87.56 ± 0.02
Protein (%)	7.22 ± 0.04
Crude Fat (%)	1.59 ± 0.01
Carbohydrate (%)	0.07 ± 0.09
Dietary Fibre (%)	1.17 ± 0.00
Ash (%)	2.44 ± 0.21
Energy (kcal/100g)	48.0 ± 0.0

n=3, ±: standard deviation (SD)

These are mainly attributed to the ingredients of soups as in the case of most meals and the techniques used in cooking/preparation. Although proximate composition values, as well as other nutrient components of different types of fish soups, can be obtained from the databases of several organizations and commercial food companies, the type and the ratio of ingredients used in the preparation of soups are often not included in their reports. Therefore, such information has limited value in the identification of their nutritional properties.

Past studies demonstrated that moisture contents of soups highly depend on their consistency and affect the ratios of other components such as protein and ash contents. Various researchers reported moisture contents of different types of soups in a wide range depending on dried, condensed and ready-to-eat soups (Chan et al., 1994; Obiakor-Okeke et al., 2014; Zhang et al., 2018; USDA, 2019; Kose et al., 2021). Ready-to-eat soups contained moisture contents usually between 80 and 89%, while lower values were attributed to condensed soups (Obiakor-Okeke et al., 2014). The moisture content obtained in this study was found within the values obtained in the literature indicating the thickness of it was similar to commercial soup products. The moisture contents of the soup from brook trout (Salvelinus fontinalis) obtained in our earlier study (Kose et al., 2021) and smoked trout soup obtained by Tolasa et al. (2012) closely supported this study. A wide range of moisture contents in between 73 and 98% was reported for different types of fish soups by different studies (Ankrah and Dovle, 1973; Zhang et al., 2018).

Limited data exist on nutrient values of trout soup. Tolasa et al. (2012) reported slightly higher protein content as 9.76% in soup prepared from smoked trout although fat content was close to the results obtained in the current study. In our earlier study, slightly lower values were determined for the brook trout soup (Kose et al., 2021). Similarly, the values of protein, fat and ash contents reported by different studies and food databases for varying types of fish soups also varied (Chan et al., 1994; Obiakor-Okeke et al., 2014; USDA food database, 2019). Also, calorie value of fish soup can change based on the ingredients, their amount, and type. The calorie value of the fish soup prepared in this study was determined as 48 kcal/100g. When calculated as a portion, 96 kcal/serving was determined. The energy values of some fish soups with different fish species content commercially vary between 37-94 kcal/100g and are similar to the values we found in the study (URL-1; URL-2; URL-3). Due to its low calorie value, fish soup prepared in this study can be accepted as suitable for low calorie diets.

Amino acids, particularly essential amino acids are necessary for growth and maintenance, and therefore, they must be included in the human diet. Amino acids like aspartic acid, glycine, and glutamic acid are also known to play a key role in the process of wound healing (Erkan et al., 2010). Table 3 shows amino acid values obtained for the rainbow trout soup.

Table 3. Amino acid values of rainbow trout soup.

The types of Amino acid	Value (mg/100 g)
L-Alanine (Ala)	353.0 ± 2.8
L-Arginine (Arg)	454.5 ± 2.1
L-Aspartic Acid (Asp)	751.0 ± 7.1
L-Phenylalanine (Phe)	312.0 ± 0.0
Glycine (Gly)	432.5 ± 0.7
L-Glutamic Acid (Glu)	1128.5 ± 4.9
L-Histidine (His)	316.0 ± 1.4
L-Isoleucine (Ile)	264.5 ± 3.5
L-Lysine (Lys)	1074.5 ± 0.7
L-Leucine (Leu)	528.5 ± 2.1
L-Methionine (Met)	183.5 ± 0.7
L-Proline (Pro)	330.5 ± 0.7
L-Serine (Ser)	356.0 ± 2.8
L-Threonine (Thr)	525.0 ± 2.8
L-Tyrosine (Tyr)	235.0±12.7
L-Valine (Val)	236.5 ± 2.1

n=3, ±: standard deviation (SD).

Among 16 amino acids, the highest amount found in trout soups was L-glutamic acid as 1128.5 mg/100g and the lowest value represented by L-methionine as 183.5 mg/100g. The values of essential amino acids were obtained over the amount of 500 mg/100 g for lysine, leucine and threonine. Therefore, the results indicate that trout soup is a good source of amino acids, particularly for the essential amino acids except for tryptophan. Limited information exists for amino acid values of fish soup in the nutrition databases. However, a few studies investigated the levels of amino acids in different types of soups. Similarly, Zhang et al. (2018) also obtained lower amino acid levels in two types of fish soups. The differences may be attributed to the high moisture contents of the analyzed soups by Zhang et al. (2018). Recently, Jeyakumari et al.

(2016) reported the most common amino acids found in fish soups incorporated with carrageenan as threonine, glutamic acid, proline, alanine, isoleucine, phenylalanine, tyrosine, histidine, lysine and arginine. Their results show some similarities with this study

The Health benefits of fatty acids in fish soup are mostly related to its contents of highly unsaturated fatty acids, particularly, omega-3 fatty acids. The fatty acid values were presented in Table 4 as FAME% and mg/100 g in trout soup.

Table 4. Fatty acid composition of rainbow trout soup.

Fatty Acids	FAME (%)	FAME (mg/100g)
C14:0 (Myristic acid)	1.4±0.1	23.49
C15:0 (Pentadecanoic acid)	0.0±0.0	0.00
C16:0 (Palmitic acid)	12.5±0.1	215.45
C17:0 (Margaric acid)	0.1±0.0	1.72
C20:0 (Arachidate acid)	0.6±0.1	9.74
C22:0 (Eicosanoic acid)	1.2±0.1	21.20
∑SFA (Saturated Fatty Acids)	**15.8±0.2**	**271.60**
C14:1 (Myristoleic acid)	0.2±0.0	3.44
C15:1 (Cis-10-Pentadecanoic acid)	2.1±0.0	36.10
C16:1 (Palmitoleic acid)	0.1±0.0	1.72
C17:1 (Cis-10-Heptadecanoic acid)	4.1±0.0	70.48
C18:1n-9 (Oleic acid)	31.9±0.3	548.36
C20:1 (Eicosenoic acid)	0.0±0.0	0.00
C22:1n-9 (Erucic acid)	0.6±0.0	10.31
C22:1n-11 (Cetoleic acid)	0.2±0.1	2.87
∑MUFA (Monounsaturated Fatty Acids)	**39.2±0.3**	**673.28**
C18:2n-6 (Linoleic acid)	26.3±0.5	452.67
C18:3n-6 (Gama-linoleic acid)	1.3±0.1	21.77
C18:3n-3 (Linolenic acid)	1.6±0.1	28.08
C20:2n-6 (Eicosadienoic acid)	0.2±0.0	3.44
C20:3n-6 (Homo- γ -Linolenic acid)	0.4±0.0	6.88
C20:3n-3 (Eicosatrienoic acid)	0.1±0.0	1.72
C20:5n-3 (Eicosapentaenoic acid)	1.1±0.1	18.34
C22:2n-6 (Docosadienoic acid)	0.1±0.0	1.72
C22:6n-3 (Docosahexaenoic acid)	6.1±0.0	104.86
∑PUFA (Polyunsaturated Fatty Acids)	**37.2±0.5**	**639.47**
∑n3 (Omega-3)	8.9±0.1	152.99
∑n6 (Omega-6)	28.3±0.4	486.48
∑n3/∑n6 (Omega-3/Omega-6)	0.3±0.0	0.31
∑n6/∑n3 (Omega-6/Omega-3)	3.2±0.1	3.18
∑EPA+DHA	**7.2±0.1**	**123.20**
Unidentified	***7.8±0.5***	-

n=3, ±: standard deviation (SD).

Total saturated (SFA), monounsaturated (MUFA), and polyunsaturated fatty acids (PUFA) were obtained as 15.8, 39.2 and 37.2%, respectively.

These values corresponded to the values of 271.6, 673.3, and 639.5 mg values in 100 g of trout soup in the same respect. Therefore, the results showed that trout soup has good nutritional value in terms of fatty acids since it contains a higher amount of ∑PUFA compared to ∑SFA. The major SFA in trout soup was palmitic acid as 12.5%, which accounted for 215.5 mg/100 g of soup. Oleic acid was the most abundant MUFA determined as 21.9% (548.4 mg/100 g of the soup). Although high PUFA values were obtained in trout soup, the highest amount was found for linoleic acid as 26.3% followed by docosahexaenoic acid (DHA) as 6.1%. Previous studies indicated that fatty acid values of farmed trout are highly affected by its diet (Trbović et al., 2012), and it contains higher n-6 fatty acids, particularly linoleic acid (Guillou et al., 1995). Similarly, high levels of omega 6 were determined in different types of vegetable oils (Strobel et al., 2012). Therefore, high levels of omega 6 were also expected in trout soup used in this study due to being of farmed origin. The percentages of total eicosapentaenoic acid + docosahexaenoic acid (∑EPA+DHA) in trout soup were found as 7.1% which corresponded to 123.2 mg/100 g. The ratios of n3/n6 and n-6/n-3 have been suggested as a useful indicator for comparing relative nutritional values of oils. Varying levels were suggested for n-3/n-6 as low as 0.2 and up to 1, while The UK Department of Health recommends an ideal ratio of n6/n3 of 4.0 at maximum (HMSO, 1994). The result relating to the n-3/n-6 ratio was found as 0.3 in this study. However, a higher value was obtained for the ratio of n-6/n-3 as 3.2 although it was within the suggested level.

Various health benefits of omega-3 fatty acids, particularly, EPA and DHA have been reported (Gogus and Smith, 2010). Therefore, different health institutions have recommended daily intake of n-3 PUFA and EPA + DHA in varying rates within the range of 0.2-0.45g and 0.5-1.0g, respectively. The results of this study demonstrated that a portion of trout soup (about 200 g) would almost cover daily recommended n-3 PUFA intake, however, higher amounts are required for the necessary levels of EPA+DHA. Kose et al. (2021) obtained slightly higher EPA and DHA levels in brook trout soup, therefore, the values were also accounted as higher in the mg of edible soup in comparison to this study.

Limited research has been carried out relating to fatty acid contents of fish soup (Chan et al., 1994; Udari et al., 2015; Jeyakumari et al., 2016) while no study exists on the soup from Rainbow trout. Recently, higher SFA and PUFA and lower MUFA values were obtained for brook trout soup (Kose et al., 2021). Different studies reported the percentages of PUFA were lower than SFA and MUFA values in different fish soups (Chan et al., 1994; Jeyakumari et al., 2016; Zhang et al., 2018; USDA, 2019). Udari et al. (2015) investigated the fatty acid profile of fish soup powder from *Sardinella longiceps*. Although EPA and DHA values in this study were closed to their results, they obtained lower ∑PUFA and MUFA levels against higher SFA values in their fish soup. The differences may have been attributed to the other ingredients used in the soup preparations since they used a high ratio of cornflour and milk powder in their product. They also demonstrated that boiling and frying decreased the fatty acid values (Udari et al., 2015). Therefore, the contribution of omega-3 fatty acids of trout may have been reduced during the cooking of fish soup in the present study.

Table 5 shows the mineral contents of the trout soup. Minerals are reported to play a key role in biological processes and metabolism.

Table 5. Mineral contents of rainbow trout soup (dry weight bases).

Minerals	Values
Sodium (Na) (mg/g)	19.50±1.7
Potassium (K) (mg/g)	7.75±0.8
Magnesium (Mg) (mg/g)	0.72±0.02
Calcium (Ca) (mg/g)	2.41±0.7
Iron (Fe) (μg/g)	18.50±1.7
Copper (Cu) (μg/g)	1.60±0.1
Zinc (Zn) (μg/g)	15.20±0.6
Barium (Ba) (μg/g)	0.60±0.4

n=3, ±: standard deviation (SD). The values of minerals named Li, Be, B, Al, V, Mn, Cr, Co, Ni, Cu, Ga, Rb, Sr, Mo, Ag, Cd, Te, Tl and U were reported to be below the detection limit (1ng/g(ppb).

For example, it is known that iron (Fe) is involved in haematopoiesis, which is an important component of heme iron in erythrocytes, and its deficiency easily leads to anaemia and other symptoms. Zinc (Zn) deficiency can cause metabolic dysfunction and decreased immune functions, leading to infection by bacteria, viruses and fungi, growth retardation and premature and poor wound healing. Therefore, they are considered nutrient minerals related to specific health benefits (Zhang et al., 2018). In this study, the highest value was obtained for sodium (Na) as 19.5 mg/g (dwb) followed by potassium (K), calcium (Ca) and magnesium (Mg). Trace amounts were found for copper (Cu), Zn, Fe and barium (Ba). Other analyzed minerals were below the detection limits. The high amount of Na level was related to the addition of salt to the trout soup during cooking. Food Standards Agency (2002) has reported twice higher amounts of Na level in instant soup powder. High Na intake is not recommended for health risks that arise from high salt intake. Therefore, 1500 mg Na intake was advised by the health authorities for adults and lower amounts were suggested for children (National Academies of Sciences, 2019). The Na content obtained in this study was well below the upper limit given by this mineral. Low levels of other minerals can be related to their initial values of raw materials and processing methods used in this study as supported by other researchers (Marimuthu et al., 2012; Kose et al., 2021).

Mineral contents obtained in this study were higher than several types of fish soups obtained by different researchers with some exceptions (Chan et al., 1994; Obiakor-Okeke et al. 2014; Zhang et al., 2018; USDA, 2019). However, recently lower values were obtained for the soup made from brook trout except for Ca and Fe (Kose et al., 2021).

Vitamins are also important nutrient elements in foods relating to different health functions (National Institute of Health, US, 2017). Vitamin B12 is required for proper red blood cell formation, neurological function and DNA synthesis. Recommended dietary allowance was reported as 2.4 µg for people over 14 years old and 0.4-1.8 µg for the children below 14 years old and various illnesses were reported with its deficiency (Institute of Medicine, 1998). The vitamin B12 content obtained in the current study was found as 1560.0±0.01 µg/100g (wet weight bases) which was well above the recommended levels indicating the nutritional benefits of trout soup.

National Institute of Health, US (2017) reported that vitamin E acts as an antioxidant, helping to protect cells from the damage caused by free radicals of the human body, and promotes the immune system. Vitamin E contents of the soup were obtained as 1131±0.01 µg/100g for α- tocopherol and 272±0.01 µg/100 g for γ- tocopherol (wwb). The recommended value for vitamin E for adults is known as 15 mg per day (National Institute of Health, US, 2017). Vitamin contents in fish can vary according to species, age and body parts (Mendéz and Abuín (2012). Although lipid-soluble vitamins are more stable to heat compared to water-soluble ones, several studies demonstrated that most vitamins could degrade during the cooking period (Jakobsen and Knuthsen, 2014). USDA (2019) reported 0.53-0.69 µg/100 g for vitamin B12 and 0.17-0.34 mg/100 g for Vitamin E (alpha-tocopherol) in the restaurant and homemade fish soups. Although Vitamin E value obtained in the present study was lower than the recommended level by National Institute of Health, US (2017), the value was found higher than various soups including chicken, different vegetables and fish soups as reported by Chan et al. (1994), Food Standards Agency (2002) and USDA (2019).

It is also thought that the amounts of vitamins, minerals and amino acids may differ depending on the diet of the fish used (aquaculture or fishing) and the vegetables/additives used in the soup.

In conclusion, this study represents new information on the nutritional proximate composition and nutritional value of cultured trout soup. The moisture content obtained in this study was found within the values reported in the literature indicating the thickness of it was similar to commercial soup products although some differences in the other values. The results showed that trout soup is a good source of amino acids, particularly for the essential amino acids except for tryptophan. The values of fatty acids demonstrated that a portion of trout soup (about 200 g) would almost cover daily recommended n-3 PUFA intake, however, higher amounts are required for the necessary levels of EPA+DHA. The highest mineral content was obtained for Na followed by K, Ca and Mg. Significant amounts of Vitamin B_{12} and E were also obtained in the trout soup. The values obtained in this study indicate that soup prepared from cultured Rainbow trout has good nutritional value and therefore, it is suggested for a healthy diet for human consumption.

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