Nutritional value of fish soup from cultured brook trout (*Salvelinus fontinalis*, Mitchell, 1814)

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Abstract

Keywords:

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Introduction. The aim of this study is to estimate the nutritional value of fish soup from cultured brook trout in terms of a healthy diet for human consumption.

Materials and methods. Fish soup was prepared from 23.65% previously cooked trout mince and 18.76% vegetables, and cooked for 35 mins. The final product was analyzed for the proximate composition, fatty acids and, mineral contents as well as carotenoids and vitamins B1, B2 and B6. Inductively coupled plasma Mass Spectrometer (ICP-MS) was used for mineral content after decomposition of lyophilized samples. Fatty acids methyl esters were separated by gas chromatography by flame ionization detector (FID). High performance liquid chromatography (HPLC) was used for the estimation the contents of vitamins and carotenoids.

Results and discussion. The proximate contents of soup were represented by 87.79% moisture, 8.18% protein, 2.89% crude fat, 1.17% dietary fibre, 0.62% ash and 0.03% carbohydrate. The energy value was calculated as 58.82 kcal/100g. The value of total polyunsaturated fatty acids (Σ PUFA) was higher than the values of total monounsaturated (Σ MUFA) and saturated fatty acids (Σ SFA) and accounted as 43.89, 34.93 and 19.83%, respectively. The main PUFA corresponded to linoleic acid as 27.14% followed by docosahexaenoic acid (DHA) as 7.92%. Total eicosapentaenoic acid+docosahexaenoic acid (Σ EPA+DHA) was observed as 9.21% which was accounted as 239.04 mg/100g soup. The results of this study demonstrated that a portion of trout soup (about 200g) would well cover daily recommended n-3 PUFA intake while slightly higher amount is required for daily EPA+DHA intake. Mineral contents were varied in the range of 1.77–31.52 mg/g (dwb), while the results obtained for vitamin B1, B2 and B6 and for carotenoids were comparable with the data given for different types of soups in literature.

Conclusion. This study indicates that a nutritious fish soup can be produced from brook trout for human consumption suitable for a healthy diet.

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Introduction

Brook trout (*Salvelinus fontinalis*, Mitchill, 1814) belongs to *Salmonidae* family and is distributed to North America. It is native to most of eastern Canada from Newfoundland and Labrador to western side of Hudson Bay; south in Atlantic, Great Lakes, and Mississippi River basins to Minnesota and northern Georgia, USA. It is widely introduced in North America and temperate regions of other continents of the world (FISHBASE, 2020). Brook trout is not a native species of Turkey. It has been introduced from Europe for aquaculture purposes. Today, the species is reared in some rainbow trout farms in eastern Black Sea region (Atasarl Şahin et al., 2011). Although the world production, particularly aquaculturing of brook trout has been increasing, the world production was reported lower than Rainbow trout as 1546.5 tonnes in 2018 (FAO, 2020). However, most countries include this species within the other trout species in their statistical reports, such as Turkey. Therefore, the actual production value is unclear.

Soup is defined as a liquid food usually made by stewing ingredients such as meat, vegetables, and fish often in a stock and with seasoning or a chemical mixture (Kiin-Kabari et al., 2017). Due to health benefits of seafood, proximate composition and nutritional properties of trout have been investigated in the past research (Guillou et al., 1995; Atasarl Şahin et al., 2011; Öz and Dikel, 2015). Therefore, consumption of fish soup has also been advised by some authorities (CFS, 2020).

Despite nutrient database reports of various organisations provide information on nutritional values of various foods including few fish soup products, the actual processing and ingredients of the reported processed foods are not clear. Although limited studies reported the proximate composition and nutritional value of edible muscle for brook trout (Atasarl Şahin et al., 2011), no study exists on the fish soup originated from trout including brook trout.

Therefore, our aim of this study is to estimate proximate composition and nutritional value of fish soup prepared from brook trout in terms of a healthy diet for human consumption.

Materials and methods

Production of fish soup

The type and amount of ingredients used in fish soup were given in Table 1. The weight and the sizes of fish were 17.5–32.7 cm and 162.7–410.5 g, respectively. In total around 17 kg brook trout was used. The other ingredients used were obtained daily from a supermarket situated in central Trabzon, Turkey. They were transferred to the laboratory within an hour and kept in cool conditions until use.

Preparations of ingredients

All fish were first measured and weighed before using. After prewashing, they were cut into 2–4 pieces depending on the sizes and then placed into chilled water containing 5% salt for 30 mins. Then, they were washed again and transferred in a sieve (stainless Steel 18/8, Large Colander: 250 x 90 mm) and enclosed to keep ingredients.

The vegetables were cleaned from their skins and other unwanted parts (e.g. stem/stalk of green pepper and parsley, and spoiled parts), then washed and drained. They were chopped and weighed before using. The lemons were freshly squeezed to obtain fresh juices just before cooking. The wheat flour was kept in oven at 200–250 °C until it started browning.

Preparation of fish soups

The ingredients were separated into two groups, namely fish (containing fish heads, skins, flesh and bones) and vegetables (garlics, onions, fresh carrots, fresh tomatoes and fresh green peppers) are placed in enclosed stainless-steel sieves separately (Table 1). Then, they were transferred into a boiler (Stainless Steel 18/10, 28×18 cm) containing tap water. Then, the boiler containing fish and vegetables were placed on an industrial type heater (340×550×740 mm, LPG, 3.8Kw). Bay leaves and lemon pieces were added into water to provide some aroma into the soup and they were taken out after the first cooking step.

Table 1

Ingredients used in the preparation of fish soup from of brook trout

Ingredients	%
Fish mince (Boiled and separated from bones and skin)	23.65
Carrot	5.91
Tomatoes	3.65
Onion	3.68
Green Pepper	3.50
Parsley	0.71
Garlic	0.71
White flour (roasted)	0.60
Salt	0.69
Lemon juice	1.18
Water	55.72
TOTAL	~100 (Water loss due to evaporation was not taken into account)

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 considered.

The cooking was carried out in three different steps. First cooking was completed in 20 mins at about 93 ± 3 °C and stopped. The fish was taken out onto a container (Stainless Steel 18/10, 80x40cm) which was previously cleaned and sterilized in an oven at 250 °C for 1 hour. The flesh of fish was separated from the bones and skin in hygienic conditions, then weighed into an aluminium foil before adding back to the boiler. The bay leaves and lemon pieces were removed from the boiler while the vegetables were freed into the water in boiler. The cooking was continued further for about 5 mins and stopped. All the vegetables were blended into small pieces using a blender (Arçelik K8525, Turkey) to get an even mixture. The fish mince obtained from previously cooked fish was added into the broth of homogenized vegetables. Later, chopped fresh parsley, lemon juice and salt were added into the mixture. The roasted wheat flour was dissolved in cold water was also fortified into the soup mixture. The second cooking step took place for 10 mins at 93 ± 3 °C. All the ingredients in the soup was homogenized using the same blender for 1–3 mins.

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) (Tufan et al., 2016). The Atwater method was applied to calculate total energy value of the soup (Merrill and Watt, 1973).

Metal (Mineral) analysis

The samples were transferred to the laboratory in frozen form. The fish soup samples were lyophilized using a lyophilizer (ALPHA 1-4, CHRIST, Germany). Then, the samples were decomposed by microwave method and analysed for metals using inductively coupled plasma Mass Spectrometer (ICP-MS). About 0.5 g of lyophilized sample was weighed into a TFM vessel (Microwave oven ETHIOS E – touch control) and treated with 6 mL of HNO₃ (65% Fluka-Sigma, Germany) and 2 mL of hydrogen peroxide (30%, Belinka) was added. The vessels were closed and transferred into the microwave oven. The microwave digestion program was carried out under two steps as 1st step included 10 mins ramp time at 180°C with 1000-Watt microwave power, then 2nd step with 10 mins hold time at 180°C with 1000-Watt microwave power. Then the vessels were cooled, the digested solutions were transferred into the 25 mL volumetric flasks and made up to volume with MQ water (for chromatography, > 18,2 MΩ/cm, Aldrich, Germany). Dilution according to the desired concentration range was made before measurements. Multi element standard solution (Merck KGaA, Germany) for calibration was used in metal analysis. A blank digest is carried out in the same way. All minerals were determined using an 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

A modified method of Park and Goins (1994) was used to analyse fatty acids of fish soup. Before esterifying of fatty acids and analysis by GC-FID, the soup samples were lyophilized to remove the water. Esterification of fatty acids was performed according to the procedure developed by Park and Goins (1994). The method consists of *in situ* transesterification without prior extraction of fat from the sample. About 0.2 g of each anhydrous sample was weighed into a test tube with a stopper and added 300 µL dichloromethane (CH₂Cl₂) and 3 mL of freshly prepared 0.5 M sodium hydroxide (NaOH) in methanol. Tubes were purged with nitrogen to prevent the oxidation from the air and closed by stoppers. Well mixed content was heated for 10 mins at 90°C in a thermal block. In that time the hydrolysis of fats expired. After heating, tubes were rapidly cooled under running water. Then, 3 mL of 12 % boron trifluoride-methanol solution (BF₃.CH₃OH) was added to each tube, re-purged with nitrogen, and heated for 10 mins in thermal block at the temperature of 90°C. In that time the transesterification expired. Then, 3 mL of deionized water and 1.5 mL of hexane were added in cooled tubes. Methyl esters were extracted in a non-polar solvent by shaking for 1 min. The reaction mixture was centrifuged for 10 mins at 2000 rpm. The hexane layer was separated from the aqueous phase and was transferred to the bottle

with a Pasteur pipette, which was further purged with nitrogen. Until analysis it was stored at -20°C.

Methyl esters of fatty acids were separated by gas chromatograph Agilent 6890 and detected by flame ionization detector (FID). Capillary chromatographic column Omegawax 320 was used. The column was silica with stationary phase of polyethylene glycol (30 m x 0.32 mm x 0.25 µL). Injection volume was 10 µL. Split injection mode with ratio 30:1 was used. For instrument calibration mix standard NuCheck 85 was used. Argon was used as a carrier gas with flow rate 1.5 mL/min. Flow rate of make-up gas (nitrogen) and fuel gas (hydrogen) was 30 mL/min. The injector temperature was 250°C and the detector temperature was 290°C. Temperature program of separation had set up the initial temperature of the column at 170°C, which was heated with a rate of 1°C/min till 215°C. After 9 min at the maximum temperature there was cooling with a rate of 5°C/min till 170°C.

The amount of mg fatty acid in edible portion of trout soup was calculated by Greenfield and Southgate (2003) using the following formulae:

FA content (mg FA per 100g 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 (Weihrach et al., 1977).

Vitamin Analysis

For vitamin B₁ and B₂, the samples were extracted according to the method used by Esteve et al. (2001), for vitamin B₆, the method used according to Kall (2003). About 5-30 g samples were transferred into an Erlenmeyer with the size of 100 mL. Then, 60 mL of 0.1N hydrochloric acid (HCl) was added. The mixture was autoclaved at 121 °C for 30 min. Then it was cooled at room temperature before adjusting the pH at 4.5 using 2.5 M sodium acetate solution. After addition of 100 mg taka-diastrase and 5 mg acid phosphatase enzyme onto samples, they were incubated at a shaking water bath at 45°C for 3 hours for the extraction of vitamin B₁ and B₂ and for 18 hours for the extraction of vitamin B₆. Then, the samples were cooled down to room temperature. The extract was made up to 100 ml using 0.1N HCl and filtered using a qualitative filter paper. The solution was derivatised for the analysis of vitamin B₁. Twenty-five ml of filtered extract was transferred into polyethylene tubes and then 1.5 mL potassium ferricyanide solution was added. The pH was adjusted to 7.0-7.1 using Orto-phosphoric acid, then the solution was filtered through 0.45 µm filtrate before injection to HPLC.

Fluorescent detector was used for the analysis. HPLC conditions used for vitamin B₁ was as follows; Wavelength: Excitation: 366 nm and Emission: 445 nm, injection volume: 20-50 µl, the flow rate: 1mL/mins and the total analysis time was 25 mins. HPLC conditions used for the analysis of vitamin B₂ was as follow; mobile phase: water: methanol (75:25 v:v), wavelength: Excitation: 445 nm and Emission: 525 nm, injection volume: 20-50 µL, flow rate: 1 mL/mins, total analysis time was 20 mins. The HPLC conditions of the vitamin B₆ was as follows; Wavelength: Excitation: 290 nm and Emission: 395 nm, extraction volume: 50 µL, flow rate: 1 mL/mins, column temperature: 25°C, and total analytical time was 40 mins.

Analysis of Carotenoids

The method of Konings and Roomans (1997) was used to analyze carotenoids. Five gram of homogenized fish soup was taken into a mortar and crushed (mashed). Then 50 ml

of extraction solution (methanol/tetrahydrofuran (1:1) was added and mixed. The solution was transferred into 100 ml volumetric measuring flask, then the rest of the sample in the mortar was cleaned with the extraction solution and added to previous solution. Later, it was adjusted to 100 ml with the extracted solution. The sample was filtered using a standard filter paper, the filtrate was then filtered again using 0.45 µm filter prior to injection to HPLC. The HPLC conditions were as follows; Mobile Phase: Methanol: Tetrahydrofuran (95:5), Detector: UV, Wavelength: 450 nm, Injection volume: 20 µl, flow rate: 0.8 ml/min, Analytical time: 20 mins.

Results and discussion

Table 2 shows the results for proximate composition and energy value of fish soup prepared from cultured brook trout.

Table 2

Proximate composition and energy value of trout soup

Analytical parameters	Value (Wet weight bases)
Moisture (%)	87.79±0.81
Protein (%)	8.18±0.31
Crude Fat (%)	2.89±0.18
Carbohydrate (%)	0.03±0.88
Dietary Fibre (%)	1.17 ± 0.00
Ash (%)	0.62±0.13
Energy (kcal/100g)	58.82±0.88
	Values (Dry Weight bases)
Dry Matter (%)	12.21±0.81
Protein (%)	65.96±0.69
Crude fat (%)	22.24±1.34

± SD

Past studies demonstrated that the moisture contents of soups highly depend on their consistency and affect the ratios of other components such as protein and ash contents (Chan et al., 1994; Obiakor-Okeke et al., 2014; Zhang et al., 2018; USDA, 2020). Moisture contents of dried soups were reported as below 10% (Venugopalan and James, 1969; Rahman et al., 2012; Priscilla and Viganini, 2017) although the values were over 90% after their dilution prior to use. Moisture contents of ready to eat soups were usually between 80 and 89%, while lower values were reported for condensed soups (Obiakor-Okeke et al., 2014). The moisture content obtained in this study was within the values obtained in the literature indicating the thickness of it was similar to commercial soup products. Although Tolasa et al. (2012) reported similar amount of moisture content for fish soup prepared from smoked Rainbow trout trimmings, they obtained higher protein content and lower lipid value in comparison to the current study. Lower moisture contents were reported by different studies for different types of fish soups (Lied and Julshamn, 1986; Chan et al., 1994). Zhang et al. (2018) reported very high levels (around 98%) for the fish soups prepared from Crucian carp and snakehead fish. USDA food database (2020) reported two different home-prepared/made fish soups contained 84.0 and 96.6% water.

Chan et al (1994) reported higher protein content as 10.4% protein for bouillabaisse soup. However, lower values were obtained by different studies (Lied and Julshamn, 1986). USDA food database (2020) reported as 2.26 and 7.4% protein content for two different home-prepared/made fish soups. Tümerkan (2015) incorporated fish into dried soups and showed that addition of fish meat can increase protein contents of the soups.

The fat content of fish soups not only depend on the fish species used in the soup, the ingredients, particularly the addition of oil or butter during cooking can also change the fat composition of final product. The fat content of brook trout soup was obtained in the current work was higher than the values reported by USDA food database (2020) for two different home-prepared/made fish soups. Lied and Julshamn (1986) found higher values of fat and carbohydrate contents responding to higher energy values as 143.5 kcal/100g for fish soup sold in Norwegian markets. Proximate composition of traditional fish soups served in Nigeria were reported higher than this study since the soup was a condensed soup with a moisture content lower than 60% (Obiakor-Okeke et al., 2014). Similarly, much higher proximate composition can also be expected to find for dried/soup powders (Venugopalan and James, 1969; Jeyakumari et al., 2016; Fasogbon et al., 2017; Kiin-Kabari and Akusu, 2017). Our results also proved high values of protein and fat contents when calculated as dry weight bases (dwb). 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 3 as FAME% and mg/100 g in trout soup.

The results showed that trout soup has good nutritional value in terms of fatty acids since it contains higher amount of total polyunsaturated fatty acids (Σ PUFA) in comparison to total saturated fatty acids (Σ SFA). The highest value was represented by oleic acid followed by linoleic acid. Various health benefits of omega-3 fatty acids, particularly, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) have been reported (Gogus and Smith, 2010).

Total EPA+DHA values were calculated as 9.21% which corresponds to 239.04mg/100g of edible portion of trout soup. 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 compared to n-3 PUFA, particularly linoleic acid (Atasara Şahin et al., 2011; Yeşilayer and Genç, 2013). Therefore, high levels of omega 6 were also expected in trout soup used in this study as its being farmed origin. 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; Gogus and Smith, 2010). Both values were found within the suggested levels indicating the benefits of trout soup for healthy diet. 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 (Gogus and Smith, 2010). The results of this study demonstrated that a portion of trout soup (about 200g) would well cover daily recommended n-3 PUFA intake while slightly higher amount is required for daily EPA+DHA intake. Chan et al (1994) and USDA (2020) reported percentages of PUFA levels were lower than SFA and MUFA values in different fish soups.

Table 3

Fatty acid composition of brook trout soup

Fatty Acids	FAME (%)	mg/100g of soup
C14:0 (Myristic acid)	1.59±0.02	41.25±3.14
C15:0 (Pentadecanoic acid)	1.59±0.02	5.72±0.35
C16:0 (Palmitic acid)	13.39±0.04	347.84±20.75
C17:0 Heptadecanoic acid)	0.21±0.00	5.46±0.34
C18:0 (Stearic acid)	4.22±0.04	109.68±5.80
C20:0 (Eicosanoic acid)	0.20±0.00	5.20±0.32
ΣSFA (Saturated Fatty Acids)	19.83±0.05	515.13±30.71
C14:1 (Myristoleic acid)	0.20±0.01	5.21±0.56
C16:1 (Palmitoleic acid)	2.82±0.04	73.39±5.50
C18:1n-9 (Oleic acid)	31.54±0.17	819.59±55.02
C22:1n-11 (Cetoleic acid)	0.37±0.00	9.61±0.60
ΣMUFA (Monounsaturated Fatty Acids)	34.93±0.21	907.80±61.67
C18:2n-6 cis (Linoleic acid)	27.14±0.14	705.16±47.18
C18:3n-6 (Gama-linoleic acid)	0.66±0.01	17.07±1.20
C18:3n-3 (Linolenic acid)	1.92±0.01	49.79±3.02
C18:4n-3 (Stearidonic acid)	0.45±0.01	11.61±0.87
C20:2n-6 (Eicosadienoic acid)	1.29±0.01	33.59±1.94
C20:3n-6 (Homo- γ -Linolenic acid)	0.92±0.01	23.80±1.19
C20:3n-3 (Eicosatrienoic acid)	0.76±0.23	19.74±5.89
C20:4n-6 (Arachidonic acid)	0.76±0.03	19.72±0.58
C20:4n-3 (Eicosatetraenoic acid)	0.28±0.00	7.27±0.45
C20:5n-3 (Eicosapentaenoic acid)	1.30±0.02	33.67±1.58
C22:5n-3 (Clupanodonic acid)	0.51±0.01	13.15±0.53
C22:6n-3 (Docosaheptaenoic acid)	7.92±0.28	205.37±5.74
ΣPUFA (Polyunsaturated Fatty Acids)	43.89±0.39	1139.94±63.61
ΣEPA+DHA	9.21±0.30	239.04±7.32
Σn-3 (Omega-3)	13.13±0.47	340.60±12.97
Σn-6 (Omega-6)	30.11±0.09	782.27±50.88
Σn3/Σn6 (Omega-3/Omega-6)	0.44±0.02	
Σn6/Σn3 (Omega-6/Omega-3)	2.30±0.09	
Unidentified	1.35	

± SD

Jeyakumari et al. (2016) reported that the highest fatty acid profile of carrageenan and fish soup were corresponded to SFA followed by MUFA. The results of Zhang et al. (2018) also showed similar trend by obtaining high values of ΣSFA and ΣMUFA in comparison to low values of ΣPUFA in two different fish soups. Udari et al. (2015) obtained slightly higher EPA and lower DHA values for fish soup powder from *Sardinella longiceps*.

Table 4 shows mineral contents of the fish soup prepared from cultured brook trout. Minerals are reported to play a key role in biological processes and metabolism. Therefore, they are considered as nutrient minerals related to specific health benefits (Zhang et al., 2018).

Table 4

Mineral contents of trout soup (dry weight bases)

Minerals	Values
Sodium (Na) (mg/g)	31.52±2.45
Potassium (K) (mg/g)	11.93±0.85
Magnesium (Mg) (mg/g)	0.91±0.014
Calcium (Ca) (mg/g)	1.38±0.147
Iron (Fe) (µg/g)	12.12±1.13
Copper (Cu) (µg/g)	1.77±0.16
Zinc (Zn) (µg/g)	15.30±0.43
Barium (Ba) (µg/g)	3.77±2.09

n=3, SD: standard deviation.

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 are reported to be below the detection limit (1ng/g(ppb)).

In this study, the highest value was obtained for sodium (Na) followed by potassium (K), calcium (Ca) and magnesium (Mg). Trace amounts were found for copper (Cu), Zn, Fe and barium (Ba). 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 risk 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 Academy of Sciences, 2019). The Na content obtained in this study was well below the upper limit given by this mineral since the values in the current study represents dry weight bases. 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, 2020) while higher Ca, Fe and Mg contents were reported for some dried soup containing fish (Fasogbon et al., 2017; Priscilla and Vigasini, 2017).

Table 5 represents the values of carotenoids and vitamins of trout soup.

Table 5

Values of carotenoids and vitamins of trout soup

Vitamins	Values (mg/100g)	Carotenoids	Values (µg/100g)
B1 (Thiamine)	0.0175±0.001	Lutein	109.5± 4.9
B2 (Riboflavin)	0.0245±0.001	Beta carotene	342.5± 27.6
B6	0.0745±0.002	Lycopene	82.5± 4.9

± SD

Vitamins are also important nutrient elements in foods relating to different health functions (Lee et al., 2000; National Institute of Health, 2017). Thiamine and riboflavin are important for the growth, development, and function of the cells in the body while vitamin B₆ is need for more enzyme reactions involved in metabolism. Vitamin B₆ is also involved

in brain development during pregnancy and infancy as well as immune function. Average daily recommended amounts were reported as in the range of 0.2–1.4 mg thiamine, 0.3–1.6 mg for riboflavin, and 0.1–2.0 mg for vitamin B₆ depending on the age of humans (National Institute of Health, 2020). Although the amounts for the relating vitamins were determined the below the recommended values, the results obtained for thiamine and riboflavin in this study closely supported the values obtained for various types of soups including chicken, fish and different vegetables soups as reported by Venugopalan and James (1969), Chan et al. (1994) and USDA (2020). Food Standards Agency (2002) reported higher value for Vitamin B₆ and beta carotene with some exceptions. Therefore, this study suggests that trout soup has good contribution for the mentioned vitamins to the human diet. Lied and Julshamn (1986) determined higher riboflavin and thiamine contents in fish soup sold in Norwegian fish market.

Carotenoids are compounds of great dietary importance not only as precursors of Vitamin A, but also as molecules that take part in cell protection and consumer attraction due to the visual colour they provide to food. Epidemiological studies that strongly suggest that consumption of carotenoid-rich foods reduces the incidence of cancers, cardiovascular diseases, age-related macular degeneration, cataracts, diseases related to low immune function and other degenerative diseases (Perera and Yen, 2007; Pal and Bhattacharjee, 2019). National Institute of Health (2020) recommended 700 µg of retinol activity equivalents (RAE) for adult woman and 900 µg of RAE for adult man. Perera and Yen (2007) pointed out that the retinol equivalency for β-carotene and other provitamin A carotenoids differ much and they reported 12 µg of dietary beta-carotene is equivalent to 1 µg of retinol (12:1 RAE). Therefore, our results suggest high contribution to the daily amount of RAE for human consumption.

USDA (2020) has not observed any beta carotene, lycopene and lutein values in various fish soups, they found higher lycopene values in Mexican style fish and vegetable soup, and found lower values of beta carotene and lutein in comparison to the present study. Higher carotene values were also found compared to the data reported by different food database (Chan et al., 1994; Food Standards Agency, 2002). However, National Institute of Health (2020) reported higher contents of beta carotene in various vegetable soups containing, particularly carrot. Therefore, higher values are likely to arise from high percentages of vegetable ingredients in the relating soup products.

Conclusion

The values obtained in this study indicate that soup prepared from cultured brook trout has good nutritional value and therefore, it is suggested for a healthy diet for human consumption.

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