Food Science and Technology 3(4): 56-60, 2015
DOI: 10.13189/fst.2015.030402 http://www.hrpub.org

Comparison of Body Compositions and Fatty Acid Profiles of Farmed and Wild Rainbow Trout (*Oncorhynchus mykiss)*

Mustafa OZ[1,*], Suat Dikel[2]

[1]Department of Fisheries and Diseases, Faculty of Veterinary Medicine, Aksaray University, Turkey
[2]Department of Aquaculture, Faculty of Fisheries, Cukurova University, Turkey

Copyright © 2015 by authors, all rights reserved. Authors agree that this article remains permanently open access under the terms of the Creative Commons Attribution License 4.0 International License

Abstract In this study, body composition and fatty acid profiles were compared between farmed and wild rainbow trout; the latter escaped from farms to nature and fed natural food. The total crude protein, lipid, ash, dry matter and fatty acid composition of fish meat were determined. The results indicated that the wild rainbow trout contained a significant higher amount of crude protein, ash, dry matter, total saturated fatty acids (SFA) and eicosapentaenoic acid (EPA); and a lower amount of lipid, total monounsaturated fatty acids (MUFA), total polyunsaturated fatty acids (PUFA), and docosahexaenoic acid (DHA) compared with the farmed rainbow trout.

Keywords Body Composition, Fatty Acid Profiles, Wild Rainbow Trout

1. Introduction

Fish oils contain n-3 polyunsaturated fatty acid (PUFA), particularly, eicosapentaenoic acid (EPA; C20:5 n3) and docosahexaenoic acid (DHA; C22:6 n3) [1, 2]. The importance of the long-chain PUFA has gained attention due to the prevention of human coronary artery disease [3, 4, 5, 6, 7, 8], improvement of retina and brain development [9], reduce the risk of heart attacks in adults [10], and also decrease incidence of breast cancer, rheumatoid arthritis, multiple sclerosis, psoriasis and inflammation [11, 4, 12].

Variations in lipid and fatty acid compositions between and within fish species, depend on many factors such as food availability, season, environmental temperature, geographic location, sex, diet and age, physical and chemical properties of water, rearing conditions, physical activity and nutritional habits of the animal have been well documented by numerous authors [13, 14, 15, 16, 17, 18]. Therefore, the fatty acid composition of fish absolutely differs from feeding conditions.

Fatty acid composition is major factors that determine the quality and flavor aspects of fish meat [19, 20, 21]. (Rainbow trout is one of the most commonly raised species in Turkey and around the world. Moreover, Turkey is one of the foremost trout producers of Europe. Rainbow trouts are being raised at almost every region of Turkey. Natural populations of trout which escape from farms to nature occur in these regions, It is important to investigate differences in proximate composition between wild and farmed fish due to variations in feeding conditions. Thus, the aim of the study was to investigate and compare fatty acid profile and body composition of rainbow trout living in natural and cultural conditions.

2. Materials and Methods

2.1. Fish and Sampling

Wild *Oncorhynchus mykiss*, which escaped from fish farms to nature were caught from Körkün Brook, which is a mountain brook at 1265 meters in Pozanti, Adana, Turkey, on May 2008. Farmed *Oncorhynchus mykiss* were obtained from a local fish farm (Oz Alabalik fish breeding facility) that is built near Körkün Brook and uses waters of this brook. The oxygen content of the water was 10.5±0.23 mg/L with a pH value of 8.2±0.38 and temperature of 13±0.40 ºC. Eighteen wild and farmed fish (average weight 300 g) were used for proximate and fatty acid analyses. Triplicate samples for each fish were analyzed for body composition and fatty acid profile. During the study, commercial trout feed obtained from a private company (Abalioglu, Denizli, Turkey) was used. The nutritional values of the trout feed used in this study as follows: Crude protein (42.00%), Lipid (22.00%), Crude cellulose (3.00%), Moisture (10.00%), Crude ash (12.00%) and Total energy

(4350 kcal/kg).

2.2. Proximate Analysis

The fish samples were analyzed in triplicate for proximate composition: lipid content of trout by the BLIGH and DYER, 1959 method, moisture and the ash content of fish by AOAC[22] method, total crude protein by Kjeldhal method [23].

2.3. Fatty Acid Methyl Ester Analyses

Lipid extraction was made according to Bligh and Dyer method [24]. Fatty acids methyl esters (FAME) were prepared by transmethylation using 2M KOH in methanol and *n*-heptane according to the method as described by ICHIBARA et al., 1996 with minor modification. 10 mg of extracted oil was dissolved in 2ml *n*-heptane followed by 4ml of 2M methanolic KOH. The tube was then vortexed for 2 min at room temperature. After centrifugation at 4000 rpm for 10 min, hexane layer was taken for GC analyses.

2.4. Gas Chromatographic Condition

The fatty acid composition was analyzed by GC Clarus 500 with autosampler (Perkin Elmer, USA) equipped with a flame ionization detector and a fused silica capillary SGE column (30 m x 0.32 mm ID x 0.25 µm BP20 0.25 UM, USA). The oven temperature was 140^{o}C, held 5 min, raised to 200^{o}C at rate 4^{o}C/min and held at 220^{o}C at rate 1^{o}C/min, while the injector and the detector temperature were set at 220^{o}C and 280^{o}C, respectively. The sample size was 1 µl and the carrier gas was controlled at 16 ps. The split used was 1:50. Fatty acids were identified by comparing the retention times of FAME with the standard 37 component FAME mixture. Two replicate GC analyses were performed and the results were expressed in GC area % as a mean value and ± standard deviation.

2.5. Statistical Analysis

The mean value and standard deviation were calculated from the data obtained from the three samples for each treatment. One-sample T –Test was used to determine the significance of differences at P<0.05. All statistics were performed using SPSS 15.0 for Windows (SPSS Inc., Chicago, IL. USA).

3. Results and Discussion

3.1. Body Composition

Table 1 show the ratio of body composition of wild and farmed rainbow trout, respectively. Farmed trout consisted of 19.06% of protein and 3.51% of lipid, while the levels of the crude protein and lipid for wild trout were 22.33% and 2.53%, respectively. The crude protein value of wild trout was higher than that of farmed trout, although lipid content of wild trout is lower than farmed samples.

The amounts of the moisture and crude ash were found as 73.01% and 1.86% in wild trout, whilst farmed trout had 75.69% of moisture and 1.62% of ash. These results indicated that wild trout had higher ash and lower moisture values than that of farmed trout. The differences in the body compositions of wild and farmed rainbow trout were in significant ($p< 0.05$). The comparison of body composition of each group was given in table 1.

Table 1. Proximate composition of wild and farmed rainbow trout

Body Composition	Wild, Average (%)	Farmed, (%)
Crude Protein	22.33±0.31^{b}	19.06±0.36^{a}
Crude ash	1.86±0.06^{a}	1.62±0.09^{b}
Moisture	73.01±0.42^{a}	75.69±0.45^{b}
Lipid	2.53±0.11^{a}	3.51±0.18^{b}

Each value indicates the average ± standard deviation (n=18*3). The averages expressed using different letters in each row are significantly different ($p<0.05$). n=18*3 for each group.

Korkmaz and Kirkagac also reported the ratio of the crude protein, lipid, ash and moisture of rainbow trout as 20.33%, 4.1%, 1.22% and 74.18%, respectively[25]. In the current study, slightly lower protein level for farmed trout was found. The body compositions of rainbow trout and other species vary depending on their genotypic features and habitats. Moreover, the nutritional habits and diet influence these differences[26, 27, 28, 29].

Regarding rainbow trout, Tokur et al., reported the protein value as 22.96% and the lipid content as 2.71% [30]. Furthermore, it has been reported that the nutritional values vary according to the feeding regime, feed composition, living area, harvest season, sex, size and environmental factor [31, 20, 32].

3.2. Fatty Acid Profile

The percentages of fatty acids of wild and farmed rainbow trout are presented in Table 2. and the comparison of fatty acid classes and docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) are shown in table 2. ∑SFA, ∑MUFA, ∑PUFA, ∑n6, ∑n3, n6/n3, DHA and EPA values of wild trout were 28.04%, 24.69%, 35.07%, 8.37%, 25.75%, 0.32%, 8.97% and 6.82%, respectively. Farmed trout had 20.74%, 26.57%, 51.12%, 34.01%, 15.79%, 2.15%, 9.91 and 1.86% of ∑SFA, ∑MUFA, ∑PUFA, ∑n6, ∑n3, n6/n3, DHA and EPA values, respectively.

Table 2. Fatty acids profiles of wild rainbow trout and farmed rainbow trout.

Fatty Acids	Wild Rainbow Trout	Farmed Rainbow Trout
C10:0	0.01±0.00[a]	0.00±0.00[b]
C11:0	0.04±0.01[b]	0.01±0.00[a]
C12:0	0.21±0.04[b]	0.03±0.00[a]
C13:0	0.02±0.00[b]	0.01±0.00[a]
C14:0	2.29±0.10[b]	1.27±0.21[a]
C14:1	0.03±00[b]	0.01±00[a]
C15:0	0.31±0.03[b]	0.16±0.02[a]
C16:0	17.79±0.94[b]	13.53±0.33[a]
C16:1	7.59±0.51[b]	2.02±0.26[a]
C17:0	0.38±0.06[b]	0.21±0.02[a]
C17:1	0.32±0.17[b]	0.14±0.02[a]
C18:0	5.02±0.44[b]	4.48±0.34[a]
C18:1 n9	15.80±0.44[a]	23.14±0.51[b]
C18:2 n6	6.70±0.40[a]	32.80±0.46[b]
C18:3 n6	0.65±0.09[b]	0.14±0.08[a]
C18:3 n3	8.92±0.85[b]	3.18±0.17[a]
C18:4 n6	0.65±0.17[b]	0.13±0.02[a]
C20:0	0.14±0.00[a]	0.14±0.01[a]
C20:1	0.62±0.08[a]	0.73±0.11[b]
C20:2 cis	0.42±0.15[a]	1.21±0.15[b]
C20:3 n6	0.37±0.16[a]	0.94±0.08[b]
C20:4n6	1.04±0.28[a]	0.84±0.16[a]
C20:5 n3	6.82±0.54[b]	1.86±0.37[a]
C22:0	0.09±0.01[a]	0.24±0.01[b]
C22:1 n9	0.15±0.05[a]	0.32±0.03[b]
C22:2 cis	0.06±0.03[a]	0.12±0.02[b]
C23:0	0.10±0.03[b]	0.06±0.02[a]
C24:0	2.04±0.18[b]	0.61±0.02[a]
C22:6 n3	8.97±0.71[a]	9.91±0.66[b]
C24:1	0.12±0.03[a]	0.23±0.02[b]
∑SFA	28.04±0.54[b]	20.74±0.67[a]
∑MUFA	24.69±0.73[a]	26.57±0.65[b]
∑PUFA	35.07±0.95[a]	51.12±0.97[b]
∑n6	8.37±1,20[a]	34.01±1,40[b]
∑n3	25.75±1,54[b]	15.79±1,14[a]
n6/n3	0.32	2.15
DHA/EPA	1.31	5.32

Each value indicates the average ± standard deviation (n=18*3). The averages expressed using different letters in each row are significantly different ($p<0.05$). n=18*3 for each group.

The major fatty acids were identified as miristic acid (C14:0, 2.29%), palmitic acid (C16:0, 17.79%), palmitoleic acid (C16:1, 7.59%), stearic acid (C18:0, 5.02%), oleic acid (C18:1n9, 15.80%), linoleic acid (C18:2n6, 6.70%), linolenic acid (C18:3n3, 8.92%), ekosatrienoic acid (C20:3 n3, 1.04%), EPA (C20:5n3, 6.82%), DHA (C22:6n3, 8.97%), lignoseric acid (C24:0, 2.04%) for wild rainbow trout.

The major fatty acids of farmed rainbow trout were also found as miristic acid (C14:0, 1.27%), palmitic acid (C16:0, 13.53%), palmitoleic acid (C16:1, 2.02%), stearic acid (C18:0, 4.48%), oleic acid (C18:1n9, 23.4%), linoleic acid (C18:2n6, 32.80%), linolenic acid (C18:3n3, 3.18%), ekosatrienoic acid (C20:3 n3, 1.04%), ekosadienoic acid (C20:2 cis,1.21%), EPA (C20:5n3, 1.86%), DHA (C22:6n3 , 9.91%).

Blanchet et al., 2005 reported ∑SFA, ∑MUFA, ∑PUFA, EPA and DHA values for wild rainbow trout as 24.4%, 17.0%, 58.6%, 8.1% and 32.2%, respectively. However, the values of ∑SFA, ∑MUFA, ∑PUFA, EPA and DHA for farmed rainbow trout were 26.9%, 32.5%, 40.6%, 7.3% and 18.7%, respectively [33].

In our research, 37 fatty acids detected with our standard chromatogram; however, it was determined that our wild group has much more fatty acids, some of which couldn't be identified. Similarly Polat and Özogul showed that they also detected some unidentified fatty acids ranging from 16.87%-20.07% in their study[34].

In the present study, the amount of n-3 in wild rainbow trout is higher than farmed sample, which is in agreement of the results of previous studies [33, 35]. The fatty acid profile of fish considerably may effect on the nutritional values of fish [29, 28, 36].

Haliloglu et al. reported that rainbow trout ∑MUFA was 30.81%, the EPA (C20:5n3) value was 3.07% and the DHA (C22:6n3) value was 19.17% [36]. In his study, Beyter, 2008 fed rainbow trout with three different feeds and found that the eicosapentaenoic acid (C20:5n3-EPA) values were 3.13%, 2.60%, and 2.20% respectively, while the docosahexaenoic acid values were (C22:6n3-DHA) 20.32%, 8.69% and 10.83% and the ∑MUFA values ranged between 33.00% and 36.90% [37]. We found a lower range of ∑MUFA values (24.69% - 26.57%) than these two studies, but wild rainbow trout EPA (6.82%) values was found higher than this two studies.

Wild rainbow trout had EPA four times (fold-erase) higher than farmed fish, whereas almost no differences in DHA contents were determined in both fish. EPA is the most important essential fatty acid of n3 series in the human diet because it is precursor of eicosanoids. On the other hand, it was reported that DHA decreases the concentration of low density lipoprotein, cholesterol in plasma [38].

The fatty acid composition of fish reflects the fatty acid composition of their natural foods [39, 40, 41]. Diet, location and season are the major factors affecting the fatty acid composition [42], while seasonal changes in water temperature and nutrients are the major factors affecting composition of fish muscle.

4. Conclusions

In conclusion, the wild rainbow trout caught from Körkün Brook had higher nutritional value compared to farmed fish. This is first report for Körkün Brook. The present study provides the basic information for the next researches about trout species all over the world. Despite everything, more detailed studies about the nutritional value of these fish should be carried to know the variations

between the wild and farmed fish in this habitat.

REFERENCES

[1] Holub D. J. and Holub B. J. 2004. Omega-3 fatty acids from fish oils and cardiovascular disease. *Molecular and Celllular Biochemistry*, 263,216-225.

[2] Aslan S. S., Güven K. C., Gezgin T., Alpaslan M. and Tekinay A. 2007. Comparison of fatty acid contents of wild and cultured rainbow trout *Onchorhynchus mykiss* in Turkey. *Fisheries Science*, *73*(5):1195-1198.

[3] Conner W. E. 2000. Importance of n-3 fatty acids in health and disease. *The American Journal of Clinical Nutrition,* 17(1), 171S–175S.

[4] JHCI UK. 2004. Eating long chain omega-3 polyunsaturated fatty acids, as part of a healthy lifestyle, has been shown to help maintain heart health. British report. Available from: www.jhci.org.uk/approv/omega.htm.

[5] Kinsella J. E., Broughton K. S. and Whelan J. W. 1990. Dietary unsaturated fatty acids: interactions and possible needs in relation to eicosanoid synthesis. *Journal of Nutritional Biochemistry* , 1, 123–141.

[6] Mozaffarian D., Bryson C. L., Lemaitre R. N., Burke G. L. and Siscovick D. S. 2005. Fish intake and risk of incident heart failure. *Journal of the American College of Cardiology,* 45(12), 2015–2021.

[7] Simopoulos A. P. 1991. Omega-3 fatty acids in health and disease and in growth and development, a review. *American Journal of Clinical Nutrition*, *54*:438–463.

[8] Ward O. P. and Singh A. 2005. Omega-3/6 fatty acids: alternative sources of production. *Process Biochemistry, 40*:3627–3652.

[9] Crawford M. A. 1993. The role of essential fatty acids in neural development: implications for perinatal nutrition. *American Journal of Clinical Nutrition*, 57, 703S–710S.

[10] Daviglus M. L., Stamler J., Orencia A. J., Dyer A. R., Liu K., Greenland P., Walsh M. K, Morris D. and Shekelle R. B. 1997. Fish consumption and the 30-year risk of fatal myocardial infarction. The new England journal of medicine. 10;336(15):1046-53.

[11] Goodnight, S. H. Jr., Harris W. S., Connor W. E., and Allingworth R. D. (1982). Polyunsaturated fatty acids, hyperlipidemia and thrombosis. *Artheriosclerosis,* 2, 87–113.

[12] Kinsella J. E. 1988. Food lipids and fatty acids: importance in food quality, nutrition and health. *Food Technology*, 42(10), 124.

[13] Exler J., Kinsella J. E. and Watt B. K. 1975. Lipids and fatty acids of important finfish:New data for nutrient tables. *Journal of the American Oil Chemist's Society*, 52, 154–159.

[14] Gorgun S. and Akpınar M. A. 2007. Liver and muscle fatty acid composition of mature and immature rainbow trout (Oncorhynchus mykiss) fed two different diets. *Biologia*, Bratislava, 62(3), 351–355.

[15] Rueda F. M., Lopez J. A., Martinez F. J., Zamora S., Divanach P. and Kentouri M. 1997. Fatty acids in muscle of wild and farmed red porgy, Pagrus pagrus. *Aquaculture Nutrition,* 3, 161–165.

[16] Shearer K.D. 1994. Factors affecting the proximate composition of cultured fishes with emphasis on salmonids. Aquaculture, 119, 63–88.

[17] Gill H. S. and Weatherley A. H. 1984. Protein, lipid and caloric content of bluntnose minnow, pimephales notatus, rafinosque, during growth at different temperatures, *Journal of Fish Biology*, 25: 491-500.

[18] Yilmaz O. 1995. Alteration of total lipid and fatty acid composition as affected by season of *Capoeta capoeta umbla* (Heckel, 1843) lives in Elazığ Hazar Lake. *PhD thesis*. Fırat University, Elazığ, Turkey.

[19] Haard N.F. 1992. Control of chemical composition and food quality attributes of cultured fish. *Food Research International*, 25, 289–307.

[20] Rasmussen R.S. 2001. Quality of farmed salmonids with emphasis on proximate composition, yield and sensory characteristics. Aquaculture Research (32), 10, 767-786.

[21] Jankowska B., Zakes Z., Zmijewski T. and Szczepkowski M. 2003. A comparison of selected quality features of the tissue and slaughter yield of wild and cultivated pikeperch Sander lucioperca (L.). *European Food Research and Technology*, 217,401–405.

[22] AOAC**.** 1990. Official Methods of Analysis of the Association of the Official Analysis

[23] AOAC. 1984. Official Methods of Analysis of the Association of the Official Analysis Chemists. Association of Official Analytical Chemists, (14th ed.), Washington, DC.

[24] Bligh E. C. and Dyer W. J. 1959. A rapid method of total lipid extraction and purification. Canadian Journal of Biochemistry and Physiology, Chemists. Association of Official Analytical Chemists, 15th edn. In: P. Cunniff (Ed.), *Official Methods of Analysis of AOAC International* (pp. 913–917).Washington, DC:Gaithersburg.

[25] Korkmaz A.Ş. and Kirkağaç M. 2008. Fillet Yield, Body Composition and Energy Content of Rainbow Trout *(Oncorhynchus mykiss)* Reared In Sea Net-Cages and Fresh Water Concrete Ponds. , *Ankara Üniversitesi Ziraat Fakültesi Tarım Bilimleri Dergisi*, 14 (4) 409-413.

[26] Kiris G. A. and Dikel S. 2002. Comparison of growth performance and carcass composition of rainbow trout (Oncorhynchus mykiss Walbaum, 1792) reared in fiberglass tanks and cages placed in a concrete pond. Ege University, Journal of Fisheries and Aquatic Sciences. 19, (3-4): 371–380.

[27] Uysal I., Cakli Ş. and Celik U. 2002. Biochemical compositions of the Abant Trout (*Salmo trutta abanticus T.,* 1954) a nd Rainbow Trout (Oncorhynchus mykiss W., 1792) were fed with extruded pellet diet in culture conditions. *Ege University Journal of Fisheries and Aquatic Sciences*, *19*(3-4):447 – 454.

[28] Sener E. and Yildiz M. 2003. Effect of the Different Oil on Growth Performance and Body Composition of Rainbow Trout (*Oncorhynchus mykiss W., 1792*) Juveniles. *Turkish Journal of Fisheries and Aquatic Sciences* 3: 111-116.

[29] Yildiz M., Sener E. and Timur M**.** 2006. The effects of seasons

and different feeds on fatty acid composition in fillets of farmed gilthead sea bream (*Sparus aurata* L.) and European Sea Bass (*Dicentrarchus labrax* L.) in Turkey. *Turkish Journal of Veterinary and Animal Sciences*, *30*:133-141.

[30] Tokur B., Çakli Ş. and Polat A. 2006. The quality changes of trout (*Oncorhynchus mykiss* W., 1792) with a vegetable topping during frozen storage (-18°C). E.U. Journal of Fisheries and Aquatic Sciences, 23:345–350.

[31] Weatherup R. N. and Mccracken K.J. 1999. Changes in rainbow trout, *Onchorhynchus mykiss* (Walbaum), body composition with weight. Aquaculture Research, 30:305-307.

[32] Özden Ö. and Erkan N. 2008. Comparison of biochemical composition of three aqua cultured fishes (*Dicentrarchus labrax*, *Sparus aurata*, *Dentex dentex*). International Journal of Food Sciences and Nutrition, 59:545- 557.

[33] Blanchet C., Lucasa M., Julienc P., Morind R., Gingrasa S. and Dewaillya E. 2005. Fatty acid composition of wild and farmed atlantic salmon (*Salmo salar*) and Rainbow Trout (*Oncorhynchus mykiss*). *Lipids, 40*:529–531.

[34] Polat S. and Ozogul Y. 2009. Fatty acid, mineral and proximate composition of some seaweeds from the northeastern mediterranean coast, Ital. J. Food Sci. n. 3, vol. 21 – 2009, Page: 321.

[35] Celik M., Gokce M. A., Basusta N., Kucukgulmez A., Tasbozan O., and Tabakoglu S. S. 2008. Nutritional quality of rainbow trout (*Oncorhynchus mykiss*) caught from the Ataturk dam lake in Turkey. *Journal of Muscle Foods, 19*:50–61.

[36] Haliloglu H. İ., Aras N.M. and Yetim H. 2001. Comparison of Muscle Fatty Acids of Three Trout Species (Salvelinus alpinus, Salmo trutta fario, Oncorhynchus mykiss) Raised under the Same Conditions. *Turkish Journal of Veterinary and Animal Sciences*. 26 (2002) 1097-1102.

[37] Beyter N. 2008. Effects of different commercial feeds on the rainbow trout's (Oncorhynchus mykiss) growth, meat composition and fatty acids profile. Ph. D. Thesis, Ankara University Graduated School of Natural and Applied Sciences Department of Food Engineering.

[38] Özogul Y. and Özogul F. 2007. Fatty acid profiles of commercially important fish species from the Mediterranean, Aegean and Black Seas, Food Chemistry (100) 1634–1638.

[39] Grigorakis K., Alexis M. N., Taylor K. D. A. and Hole M. 2002. Comparison of wild and cultured gilthead sea bream (Sparus aurata): Composition, appearance and seasonal variations. International Journal of Food Science and Technology, 37, 477–484.

[40] Henderson R. J. and Tocher D. R. 1987. The lipid composition and biochemistry of freshwater fish. In R. T. Holman, W. W. Christie, and H. Sprecher (Eds.). Progress in Lipid Research (Vol. 26, pp. 281–437). New York: Pergamon Press.

[41] Van Vliet T. and Katan M. B. 1990. Lower ratio of n3 to n6 fatty acids in cultured than in wild fish. American Journal of Clinical Nutrition, 51, 1–2.

[42] Gruger E. H. Jr. 1967. Fatty acid composition. In M. E. Stansby (Ed.), Fish oils (pp. 3p). Westport, CT: AVI Publishing Co