Turkish Journal of Fisheries and Aquatic Sciences 14: 479-486 (2014)
www.trjfas.org
ISSN 1303-2712
DOI: 10.4194/1303-2712-v14_2_19

Monthly Differentiation in Meat Yield, Chemical and Amino Acid Composition of Wild and Cultured Brown Trout (*Salmo Trutta Forma Fario* Linneaus, 1758)

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Received 23 October 2013
Accepted 29 May 2014

Abstract

In this research, the differences between wild and cultured brown trout (*Salmo trutta forma fario* Linneaus, 1758) were determined by investigating meat yield, chemical quality and amino acid composition of wild and cultured trout in the East Black Sea region between January and December. The mean meat yield of 67.59%±0.48 in wild trout was significantly higher than that of 64.46%±0.73 in cultured trout (P<0.05). The mean crude protein, crude lipid, moisture contents and crude ash were 17.36% ± 0.037-16.66% ± 0.37, 2.71% ± 0.21-3.62%±0.224, 78.10% ± 0.239-77.43% ± 0.387, 1.16% ± 0.03-1.21% ± 0.029 in wild and cultured trout, respectively. The mean crude lipid in cultured trout was significantly higher from the wild trout (P<0.05). The mean protein amount is similar for both fish groups. Mean carbohydrate content in the wild trout was found to be 0.54±0.12 (g/100 g) and cultured trout carbohydrate was found to be 0.57±0.12 (g/100 g) (P<0.05). Maximum value at Total amino acid (TAA) was reach on cultured fish at Jun (17880 mg/100 g), wild trout was reach (18755 mg/100 g) at April. Total essential amino acid (TEAA) value was demonstrate significant variation (P<0.05). Results showed that, cultivated and wild brown trout fillets are well-balanced food source in terms of E/NE ratios in all seasons.

Keywords: Trout (*Salmo trutta*), chemical composition, meat yield, amino acid.

Doğal ve Kültür Dere Alabalıklarında (*Salmo trutta* L., 1758) Et Verimi, Kimyasal ve Amino Asit Kompozisyonunun Aylık Değişimi

Özet

Bu araştırmada, Doğu Karadeniz Bölgesi'nde doğadan avlanan ve çiftliklerde yetiştirilen Dere alabalıkları (*Salmo trutta L.1758*) arasındaki farkları belirlemek için Ocak - Aralık ayları arasında, Doğu Karadenzi Bölgesi'nden elde edilen dere alabalıklarında et verimi, et kalitesi ve amino asit kompozisyonu değerleri tespit edilmiştir. Ortalama et verimi oranları, doğal dere alabalıklarında %67.85±0.48 ile %63.73±0.73 olan kültür dere alabalıklarının et veriminden önemli derecede fazla bulunmuştur (P<0.05). Ortalama ham protein, ham yağ, nem ve ham kül değerleri doğal ve kültür dere alabalıklarında sırasıyla %17.36±0.037-%16.66±0.37, %2.71±0.21-%3.62±0.224, %78.10±0.239-%77.43±0.387, %1.16±0.03-%1.21±0.029 belirlenmiştir. Ortalama ham yağ değeri kültür balıklarında doğal balıklara göre önemli derecede yüksektir (P<0.05). Protein değerleri her iki grupta da birbirlerine benzerdir. Ortalama karbonhidrat değerleri, doğal dere alabalıklarında 0.54±0.12 (g/100 g), kültür dere alabalıklarında 0.57±0.12 (g/100 g) bulunmuştur (P<0.05). En yüksek amino asit (TAA) değerine kültür balıklarında Haziran'da, (16880 mg/100 g), doğal balıklarda ise Nisan'da (18754 mg/100 g) ulaşılmıştır. Toplam Esansiye Amino Asit değerleri her iki grupta önemli farklılık göstermiştir (P<0.05). Esansiyel (E, g amino acid/16 g N)/ Esansiyel olmayan (NE, g amino acid/16 g N) amino asit oranı; ortalama değerleri sonbaharda 0.76, kış aylarında 0.75, ilkbahar ve yazın ise 0.77 hesaplanmıştır. Sonuçlar, kahverengi alabalık filatolarının, bütün sezon boyunca E/NE amino asit oranları bakımından, değerli bir gıda kaynağı olduğunu göstermiştir.

Anahtar Kelimeler: Dere alabalığı (*Salmo trutta*), kimyasal kompozisyon, et verimi, amino asit

Introduction

Quality of any product cannot be judged solely on asset of attributes. It also depends on consumer attitudes and consumption and methods of preservation and regional preferences (Connell, 1995). afety, nutrition, flavor, texture, color and suitability of the raw material or further processing are also relevant (Haard, 1992).

The chemical composition of fish varies greatly from one species and one individual to another depending on sex, age, environment and season.

Therefore, a substantial normal variation is observed for the constituents of fish muscle (Yeannesa and Almandos, 2003).

During starvation periods, the fish uses the energy depots in the form of lipids and also may utilize protein, thus depletion of these reserves results in a general diminution of biological condition (Huss, 1995). This condition will influence the quality of the different fish products and it will condition the yield and process efficiency. Therefore, the knowledge of proximate composition of fishery species has fundamental importance in the application of different technological processes (Stansby, 1967; Connell, 1995). Proximate composition is also important as an aspect of quality of raw material, sensory attributes and storage stability (Sikorski, 1994), and gives an idea of sexual stage (Huss, 1995; Connell, 1995).

Carbohydrates comprise a significant part of the fish and glycogen is an important energy reserve during muscle metabolism too. An increase in glycogen reserves is probably a major determinant in the improved swimming performance and fatigue resistance observed in exercise-conditioned fish (Johnston, 1982).

The relationship between the nutritive value of feeds and culture fish had demonstrated that the content of essential amino acids (EAA) is important factor in their dietary value (Metailler *et al.,* 1981). Many marine animals have a limited ability to synthesize several EAA from precursor molecules (Watanabe *et al.,* 1988). The fish growth optimization is closely linked to the supply of dietary protein with appropriate quality and quantity. Growth and food conversion efficiencies can be maximized by manipulating the composition of the dietary AAs, as AA imbalances in the diet can cause increased AA oxidation and decreased food conversion efficiencies. Thus, AA balanced diet is the principal goal of fish feed research (Limin *et al.,* 2006).

Brown trouts are living in rivers which flow into the North Sea and the Baltic Sea belong to the subspecies *Salmo trutta fario*, those living in rivers that flow into the Black Sea. The brown trout is an economically important species, particularly because it’s favored by anglers (Cihar, 1991). Brown trout is one of the most preferred wild freshwater fish species in east Black Sea Region (Turkey) due to its nutritional value, palatable aroma and as well as being popular in sport fishing (Kaya and Erdem, 2009).

While numerous studies have reported differences amino acids analysis between wild and farmed fish for various fish species, little information is available on monthly changes in the nutritional value and amino acids composition of wild and farmed brown trout. The aim of this study was to determine monthly variations of the energy value, carbohydrate and amino acids composition of wild and farmed brown trout (Hata *et al.,* 1988; Ozyurt and Polat, 2006; Kaya and Erdem, 2009).

Materials and Methods

Wild brown trout was caught monthly for a year (expect for May*in May the river was not suitable to obtain samples because of bad weather conditions), using electric fishing gear (300_500 V) and a casting net in the Pazar Rivers of Rize, Turkey, in the east Black Sea region. Ten Wild fish weights were between 17.97-89.60 g, and fillets weights averaged 46.42 g each. Cultured brown trout were obtained from “ The Dört Mevsim” fish farm in Güneysu-Rize. Ten Cultured brown trout weights were between 90.25-162.31 g, and fillets weights averaged 125.74 g each. Average length at wild fish was 16.28 cm and cultured fish was 22.77 cm. Ten numbers of wild and farmed fish were sampled and used for analysis in each sampling month. The fish samples were kept on ice in isothermic fish boxes, until they arrived to the laboratory and immediately frozen and stored at -35C until used for analyses for about three months.

Morphological Data and Meat Yield

Fish were measured length and weighed. After rigor mortis resolved (12 h), fish were filleted. The fish were not skinned in this study. Meat yields were calculated according to Erkoyuncu *et al.* (1994).

$$\text{Meat yield (\%)} = \frac{Wy}{Wt} \times 100$$

Wy: Edible fish weight (g)
Wt: Totally fish weight (g)

Proximate Composition

Crude lipid content was performed by acid digestion prior to petroleum ether extraction (b.p. 40–60°C) in a Soxtec system (AOAC, 2005). Moisture and ash contents were determined as described by AOAC (1995), and protein content was determined by the Kjeldahl method (AOAC, 1995). These analyses were performed in triplicate.

Amino Acid Analyses

Amino acid analyses were carried out using the hydrolysis method (Anonymous 1998). The samples were hydrolysed with 6 N HCl in sealed vacuum tubes at 110°C for 24 h. The HCl was removed from the hydrolysed samples using a rotary evaporator. The samples were analysed using a Varian CP-3800 GC (Varian, Holland). The amino acid analyses were conducted in triplicate.

Carbonhydrate and Energy Value

Carbonhydrate and energy were calculated according to Merrill and Watt (1973). Carbohydrate (g/100g)= 100 – [crude lipid+(100-dry matter)+crude protein+crude ash] Energy values Kcal/100g=(Crude proteinX5.65)+(crude lipidX9.50)+(CarbonhyrateX3.90).

(1 g protein produces 5.65 kcal energy).

Statistical Analysis

The statistical analysis was performed using Minitab Release 13.20 (Minitab Inc., State College, PA, USA). Differences in seasonal changes between wild and farmed brown trout were analyzed by one-way analysis of variance and Tukey's test. In all statistical tests, P<0.05 was considered statistically different.

Results and Discussion

Length, Weight and Yield

In this study, at wild brown trout average total length (cm), wight (g) and fillet yield were found 16.28±1.27 cm, 46.42±6.13 g and 67.85±0.48%, respectively. Cultured brown trout was found total length 22.77±0.36 cm, wight 125.65±6.26 g and fillet yield 63.73±0.73%. There are significantly important changes at length (cm), wight (g) and fillet yield between wild and cultured brown trout (P<0.05). Average total length at wild trout was 16.28±1.27 cm and wight at wild trout was 46.42±6.13 g. In cultured trout average length and wight was found 22.77±0.36 cm and 125.65±6.26 cm, respectively.

Meat yield changes between 65.53%±1.16-70.10%±0.06 at wild fish and it changes between 59.54%±1.75-69.32%±0.52 cultured fish. Average fillet yields were found at wild and cultured trout 67.85% ±0.48 and 63.73%±0.73, respectively (P<0.05) (Table 1).

Deniz and Uzunhasanoglu (1991) announced that *S. trutta labrax*'ın fillet yields, which captured in Rize region were found 70.66%, and total wight was 53.68 g. In another research, filet yield was calculated at *Oncorhynchus mykiss* 64.8%±1.97 and at *Salvelinus fontinalis* 62.28%±2.81, respectively (Çelikkale *et al.*, 1998).

Chemical Composition

Fish quality is conducted amount protein, lipid, mineral matter, energy value and water. These matters are predominant in fish metabolism (Jobling, 1994). However, carbohydrates also comprise a significant part of the fish and glycogen is an important energy reserve during muscle metabolism (Johnston, 1982).

The compositional characteristics in terms of crude protein, crude lipid, moisture (dry matter), crude ash was determination of the different raw trout lots and the corresponding cultured and wild trout. Chemical composition in fish groups were shown significantly differences at mounts of the year (P<0.05). These monthly variations in crude protein, crude fat, dry matter, crude ash of both brown trout were most likely due to changes associated with feeding and spawning season in the trout (Table 2).

The protein content of wild brown trout was highest at 18.69%±0.589 in the June, but decreased to 14.70%±0.050 in the February. At cultured trout protein amount was highest at 18.38% ±0.221in the August, but decreased to 14.55%±0.276 in the November. Crude lipid amount of wild trout was, also, highest in the June at 3.57%±0.185, but lowest in the January at 1.85%±0.133. At cultured trout crude lipid amount was highest at 4.69%±0.035 in the June, but decreased to 2.22%±0.116 in the September. Dry matter and crude ash values were relatively stable in the year at both fish groups.

In the wild trout average protein content was 17.39%±0.274 and cultured trout protein amount was 16.66%±0.337. Wild trout protein was significantly higher than in farmed trout (P<0.05). At a study, Einen *et al.* (1998) have research at Atlantic salmon

Tablo 1. Total length, weight and meat yield of wild and cultured Brown trout at seasonal changes

Mount	Total length (cm)		Wight (g)		Fillet yield (%)	
	Wild*	Cultured	Wild*	Cultured	Wild *	Cultured
Jan	$13.17±0.63^{a}$	$21.81±0.26^{a}$	$19.94±4.33^{a}$	$109.96±2.89^{ab}$	$67.70±1.26^{a}$	$64.90±0.77^{a}$
Feb	$13.96±0.82^{a}$	$21.45±0.48^{a}$	$32.15±5.88^{b}$	$96.71±8.32^{a}$	$69.05±0.57^{a}$	$64.67±0.62^{f}$
Mar	$18.08±0.90^{c}$	$21.03±0.31^{a}$	$70.60±11.40^{d}$	$107.86±5.78^{a}$	$68.61±70.00^{a}$	$64.13±0.68^{c}$
Apr	$13.53±0.34^{a}$	$23.18±0.40^{b}$	$32.24±2.07^{b}$	$118.44±9.39^{b}$	$67.45±0.74^{ab}$	$66.18±0.84^{h}$
May	**	$20.63±0.61^{a}$	**	$90.25±5.09^{a}$	**	$69.32±0.52^{j}$
Jun	$19.39±1.14^{d}$	$23.54±0.53^{bc}$	$89.60±15.4^{e}$	$134.21±9.52^{cd}$	$68.61±0.96^{c}$	$69.21±0.70^{ı}$
July	$16.65±0.31^{c}$	$21.41±0.24^{a}$	$51.10±3.08^{c}$	$104.21±4.34^{a}$	$70.10±0.06^{c}$	$65.56±0.27^{d}$
Agu	$17.68±0.76^{c}$	$22.94±0.18^{b}$	$65.10±3.08^{c}$	$126.26±3.59^{c}$	$65.53*±1.16^{c}$	$68.04±0.67^{g}$
Sep	$18.17±0.50^{c}$	$24.03±0.27^{c}$	$66.31±5.43^{c}$	$146.90±5.03^{d}$	$67.40±0.95^{bc}$	$60.41±1.34^{b}$
Oct	$13.76±0.59^{a}$	$24.68±0.31^{c}$	$27.92±3.93^{b}$	$162.31±6.64^{e}$	$65.93±0.56^{ab}$	$59.62±2.54^{e}$
Nov	$12.71±0.96^{a}$	$24.14±0.42^{c}$	$17.97±0.85^{a}$	$151.60±5.42^{d}$	$66.45±0.59^{a}$	$59.54±1.75^{e}$
Dec	$14.93±0.89^{b}$	$24.45±0.35^{c}$	$37.72±6.69^{b}$	$159.11±9.06^{de}$	$66.68±0.93^{ab}$	$61.94±1.43^{b}$
Avr	15.64±1.27	22.77±0.36	46.42±6.13	125.74±6.26	67.59±0.48	64.46±0.73

SD: Mean±st. deviation
* (→): Overall means bearing different superscripts between rows differ significantly (P<0.05).
[a, b, c, d, e] (↓): Interaction means bearing different superscripts between columns differ significantly-Season effect (P<0.05).
** Due to bad weather conditions in May, sampling was not done.

Table 2. Proximate composition of wild and cultured Brown trout at monthly changes

	Crude Protein (%)		Crude Fat (%)*		Dry Matter (%)		Crude Ash (%)	
Mount	Wild	Culture	Wild	Culture	Wild	Culture	Wild	Culture
Jan	16.31±0.13^{ab}	16.03±0.23^{ab}	1.85±0.13^{ab}	4.27±0.02^{bfg}	22.24±0.27^{acd}	22.64±0.14^{abd}	1.33±0.03^{ah}	1.39±0.04^{ac}
Feb	14.70±0.05^{aa}	15.79±0.33^{bbc}	1.26±0.05^{aa}	3.40±0.27^{bbcd}	18.94±0.06^{aa}	23.52±0.17^{bbcd}	1.12±0.04^{aa}	1.36±0.17^{ac}
Mar	17.02±0.35^{abc}	17.52±0.07^{ad}	3.37±0.12^{ae}	4.21±0.48^{bfg}	21.94±0.21^{ac}	23.49±0.27^{bbcd}	1.11±0.04^{aa}	1.30±0.08^{acb}
Apr	16.76±0.55^{abcd}	17.06±0.25^{ad}	3.25±0.11^{ae}	4.03±0.31^{afg}	22.26±0.14^{acd}	23.99±0.22^{bd}	1.08±0.05^{aab}	1.29±0.08^{bcb}
May	-	17.05±0.05^{d}	-	4.57±0.18^{e}	-	23.89±0.06de	-	1.14±0.02^{ab}
Jun	18.69±0.59^{ae}	17.24±0.06^{bde}	3.57±0.19^{af}	4.69±0.04^{bf}	23.85±0.80^{ad}	23.36±0.51^{adef}	1.16±0.07^{abc}	1.15±0.06^{aab}
July	18.61±0.04^{ae}	16.87±0.15^{bbcd}	2.87±0.03^{ad}	3.37±0.01^{bde}	21.67±0.12^{ac}	22.44±0.35^{bbc}	1.12±0.02^{abc}	1.17±0.01^{ab}
Agu	18.62±0.16^{ae}	18.38±0.22^{af}	2.83±0.05^{ad}	3.96±0.06^{bdef}	21.51±0.21^{ac}	24.14±0.31^{bdef}	1.14±0.01^{ade}	1.18±0.03^{ab}
Sep	18.46±0.43^{ade}	16.71±0.23^{bbcd}	2.21±0.03^{ac}	2.22±0.12^{aab}	21.99±0.01^{ac}	20.29±0.16^{babc}	1.16±0.12^{ae}	1.19±0.09^{ab}
Oct	17.79±0.39^{abcd}	17.87±0.41^{aef}	3.08±0.13^{adef}	2.67±0.09^{ab}	22.24±0.09^{acd}	21.55±0.08^{abcd}	1.32±0.15^{ah}	1.11±0.02^{aa}
Nov	17.06±0.03^{abcd}	14.55±0.28^{ba}	3.11±0.09^{adef}	2.85±0.16^{abc}	21.48±0.17^{abc}	20.89±0.37^{abc}	1.18±0.15^{aef}	1.05±0.09^{aa}
Dec	16.92±0.13^{abcd}	14.79±0.05^{ba}	2.40±0.13^{ac}	3.18±0.05^{bc}	20.59±0.09^{aab}	21.64±0.80^{bcd}	1.08±0.06^{aa}	1.21±0.02^{ab}
Avr.	17.36±0.37^{A}	16.66±0.37^{A}	2.71±0.21^{A}	3.62±2.24^{B}	21.70±0.36^{A}	22.65±0.41^{A}	1.16±0.03^{Ab}	1.21±0.0^{A}

SD: Mean±st. deviation

Capital letters show differences of the wild/cultivated comparison, while low-case letters related to differences as a result of the catching/harvest month (P<0.05).

* Crude Fat value published in International Journal of Food Sciences and Nutrition. 60 (5), 413-423, (Kaya and Erdem, 2009).

and crude protein value was found 21.1±1.19 g/100 g. Jonsson and Jonsson (1998) was calculated at anadrom wild Brown trout (*Salmo trutta fario*) crude protein ratio 19.2% in Southern Norway. A similar finding was reported by Saito and Nakatsugawa (1994) in cultured amago (*Oncorhynchus masou ishikawae*) captured in June or October, but no differences were found in March. In another study, protein was found cultured brown trout (Fuyama *et al.,* 1991). As farmed fish generally contain more lipid than their wild fish, there is a potential need for lower the lipid content of farmed fish; however, it should be mentioned that the desired product lipid content is dependent on final processing requirements (Kim and Kaushik, 1992; Martinez, *et al.,* 1992; Rønsholdt, 1995).

In the wild brown trout crude lipid content was slightly higher (P<0.05) than in farmed trout. Average lipid content in the wild trout is 2.80±0.165% and cultured trout lipid amount is 3.62±0.228%. It's reported that was the greatly increased lipid content in cultivated channel catfish and Coho salmon compared with wild samples. Each of these species had, on average, more than twice as much fat as their wild fish (Nettleton and Exler, 1992).

Average dry matter content in the wild trout was found 21.70%±0.36 and cultured trout dry matter was found 22.65%±0.41. In the farmed brown trout dry matter content was slightly higher (P<0.05) than in wild trout. Minimum and maximum dry matter values in wild and cultured brown trout were found in the February (18.94%±0.06), Jun (23.85%±0.80) and September (20.89%±0.37), August (24.14%±0.31), respectively. While dry matter was minimum, crude protein and crude fat were maximum. Dry matter values are similar to those studies reported by Nettleton and Exler (1992) for trout species fillets.

Dry ash contents were similar wild trout to cultured trout. Mean crude ash values at wild and cultured trout were found 1.16±0.03% and 1.21±0.03%, respectively. These values are similar to those reported by Köse *et al.* (2001), Hata *et al.,* (1988) for crude ash of trout.

Amino Acid Composition

The amino acid compositions of cultured and wild Brown trout during twelve months are shown in Table 3. The basic amino acids for brown trout aspartic acid, glutamic acid and lysine were higher than the other amino acids in brown trout fillets. The level of tryptophan was not determined. Similarly reported that the main amino acids in fish muscle were these amino acids (Ozyurt and Polat, 2006). The changes in amino acid contents in fish muscle were affected by spawning period and feeding season of fish, and some part of protein was used by fish for spawning, resulting in an increase the level of protein in fish eggs (Pigott, and Tucker, 1990). According the Wesselinova (2000); the amounts and types of amino acids in fish were pertaining to catching period and catching location. Although the ratio of essential to nonessential amino acids (EAA/NEAA ratio) in dietary protein has important effects on protein utilization by fish (Green, *et al*, 2002).

In the present study, total amino acid (TAA) amount was found significantly important to mounts and fish species (P<0.05). Maximum value at TAA was reach on cultured fish at Jun (16880 mg/100 g), wild trout was reach (18754 mg/100 g) at April. Total essential amino acid (TEAA) value was demonstrate significant variation (P<0.05). Significant differences (P<0.05) in the total amino acids (TAA) analysis existed in six EAA (valine, methionine, isoleucine, leucine, phenylalanine and histidine) and five non-essential NEAA (aspartic acid, glutamic acid, alanine, glycine and proline) (P<0.05).

The results obtained from this study showed that brown trout fillets have well-balanced and high-quality protein source in the respect of EAA/NEAA ratio in all mounts. The ratio of essential (E, mg/100 g)/nonessential (NE, mg/100 g) amino acids was observed to be 0.76 in autumn, 0.75 in winter and 0.77 in spring and summer (Özyurt and Polat, 2006). Contents of MAAs were low to almost undetectable during the ice-cover season, whereas they increased as the ice started to melt, and reached highest concentrations during the ice-free season (Tartarotti

Table 3. Amino acid composition of cultured (C) and wild (W) Brown trout captured in different mount (mg/100 g) (N=10)

Amino acids		J	FAB	MAR	AP	JUN	JLY	AUG	SEP	OCT	NOV	DEC
Aspartic acid	C	1981±0.33^{bc}	1977±1.86^{b}	1285±3.18^{a}	1979±0.41^{bc}	2497±2.04^{c}	2170±0.41^{bc}	1959±0.82^{bc}	1895±1.63^{bc}	1883±2.04^{bc}	174[illegible]	1705±2.60^{b}
	W	1261±1.20^{a}	1637±4.64^{b}	1970±3.60^{c}	2448±2.96^{d}	2019±2.84^{c}	2035±2.84^{c}	2446±3.36^{d}	2057±3.28^{c}	2230±5.81^{cd}	1717±2.91^{bc}	1536±3.28^{b}
Threonine^{A}	C	849.3±0.33^{b}	872.3±1.45^{b}	492.0±2.52^{a}	1049±7.93^{c}	1177±1.67^{d}	1065±8.66^{b}	839.7±0.67^{c*}	1042±6.98^{c}	986.7±4.37 ^{bc}	915.0±1.73^{b}	885.7±1.76^{b}
	W	533.6±6.33^{a}	735.7±0.33^{b}	951.7±4.41^{c}	1183±0.58^{d}	1027±1.33^{bc}	906.3±1.45^{c}	848.7±4.98^{c}	948.7±4.97^{d}	965.7±2.40^{bc}	811.3±3.48^{c}	701.7±1.76^{b}
Serine	C	686.5±1.22^{c}	690.7±0.66^{c}	352.0±1.15 ^{a}	782.0±4.89^{d}	892.5±4.49^{e}	786.0±0.81^{d*}	591.0±5.71^{b}	822.5±3.67^{d}	796.3±1.85^{d}	746.6±1.20^{c}	707.6±3.38^{c}
	W	133.7±5.86^{a}	186.2±1.0^{b}	214.1±3.38^{bc}	331.3±3.84^{e}	272.2±3.84^{d}	238.7±8.76^{c}	199.6±6.88^{b}	206.3±2.31^{b}	210.6±0.61^{bc}	194.7±4.58^{b}	153.8±4.37^{a}
Glutamic acid	C	2413±2.18^{d}	2167±4.08^{c}	1636±0.88^{a}	1621±5.71^{a}	2366±3.67^{d}	2140±0.40^{c}	1776±3.67^{b}	2095±4.08^{c}	2281±1.63^{d}	2288±1.20^{d}	2314±2.60^{d}
	W	1495±2.96^{a}	1892±1.39^{c}	2417±1.45^{e}	2539±4.30^{e}	2004±7.27^{c}	2153±7.79^{d}	1854±1.52^{bc}	1713±2.32^{b}	2052±1.20^{cd}	1874±5.75^{bc}	1609±1.54^{b}
Glycine	C	735.7±0.33^{b}	819.0±4.08^{c}	547.3±2.18^{a}	1062±1.45^{cd}	1171±0.57^{d}	1124±2.40^{d}	868.3±1.63^{b}	1134±0.81^{d}	894.0±2.85^{c}	825.6±2.02^{c*}	777.7±1.63^{c}
	W	544.3±2.33^{a}	607.7±0.85^{ab}	774.3±9.56^{b}	1197±4.05^{e}	932.0±4.04^{c}	975.3±5.54^{c}	906.3±3.28^{c}	1004±4.33^{d}	1073±7.83^{d}	813.3±0.88^{bc}	691.7±3.71^{b}
Alanine	C	639.0±0.81^{a}	630.0±0.81^{a}	952.5±1.55^{b}	1327±0.0^{c}	1461±1.63^{d}	1402±245^{d}	1102±1.85^{c}	1433±0.81^{d}	1137±0.81^{c}	951.5±1.52^{b}	782.5±2.60^{ab}
	W	421.3±2.96^{a}	543.3±1.66^{ab}	650.7±5.78^{b}	1471±4.48^{d}	1248±5.85^{cd}	1237±3.93^{cd}	1168±2.33^{cd}	1245±3.67^{cd}	1329±1.76^{d}	992.7±1.85^{c}	649.3±2.18^{b}
Valine^{A}	C	918.0±1.63^{b}	1046±3.26^{bc}	672.5±2.04^{a}	1047±0.81^{bc}	1260±0.0^{d}	1186±0.40^{c}	990±4.08^{b}	1282±0.41^{d}	1003±2.45^{b}	1057±0.88^{bc}	988.0±0.81^{b}
	W	699.7±3.28^{a}	809.3±1.76^{a}	1051±3.67^{b}	1291±1.52^{d}	1004±1.73^{b}	980.3±6.33^{b}	1011±2.85^{b}	1035±0.88^{b}	1203±3.26^{c}	974.7±2.40^{b}	759.3±1.76^{a}
Methionine^{A}	C	563.5±2.86^{e}	558.3±3.28^{d*}	453.0±2.45^{c}	379.5±3.67^{bc}	347.0±0.81^{b*}	349.0±0.0^{b}	324.5±2.86^{b}	368.0±1.63^{b*}	295.7±1.76^{a}	354.0±2.08^{b}	465.6±1.85^{c}
	W	412.7±7.79^{c}	562.3±3.38^{b}	658.0±6.01^{e}	496.7±8.98^{ab}	383.0±6.08^{b}	290.5±6.12^{a}	401.3±5.89^{bc}	380.0±3.60^{b}	402.3±1.20^{bc}	452.0±1.73^{c}	385.3±2.02^{b}
Isoleucine^{A}	C	963.0±0.0^{bc}	1045±2.65^{c}	625.0±2.65^{a}	960.5±0.42^{bc}	1085±1.76^{c}	1046±2.65^{c}	877.0±1.63^{b}	1265±4.99^{d}	853.0±3.51^{b}	827.3±1.85^{b}	904.6±2.03^{b}
	W	670.7±4.05^{a}	828.7±4.09^{b}	1011±7.76^{c}	1210±5.71^{d}	891.5±0.41^{cd}	918.7±2.38^{b}	934.0±3.26^{bc}	997.0±1.63^{c}	1190±1.20^{d}	1011±2.08^{c}	886.7±0.88^{b}
Leucine^{A}	C	1548±1.63^{b}	1438±1.63^{b}	999.0±2.08^{a}	1837±0.81^{c}	1949±0.82^{cd}	2009±4.49^{d}	1618±1.22^{b}	2056±2.85^{d}	1606±3.67^{b}	1591±1.20^{b}	1557±2.03^{b}
	W	1015±4.24^{a}	1228±4.04^{ab}	1511±3.46^{bc}	2057±2.08^{d}	1726±3.84^{c}	1716±2.88^{c}	1685±2.33^{c}	1800±3.05^{c}	1956±1.63^{d}	1637±1.52^{c}	1353±1.22^{b}
Tyrosine	C	905.3±1.85^{d}	789.0±4.08^{c*}	468.0±2.64^{a}	662.5±2.04^{b}	820.5±2.04^{c}	673.0±2.88^{b*}	696.0±3.26^{b*}	849.0±2.45^{c}	657.5±2.04^{b}	745.0±2.30^{bc}	818.6±1.85^{c}
	W	605.7±4.04^{a}	776.7±2.72^{b}	911.3±2.30^{c}	709.3±3.05^{ab}	661.5±0.71^{ab}	654.0±5.29^{a}	689.7±5.19^{ab}	723.0±5.19^{ab}	834.7±2.01^{bc}	805.0±3.00^{bc}	759.7±5.01^{b}
Phenyl-alanin^{A}	C	918.3±0.33^{b}	1030±0.42^{c}	658.7±6.38^{a}	1050±0.81^{c}	1166±0.40^{c}	1120±2.44^{c}	919.5±2.85^{b}	1177±0.42^{c*}	921.0±4.08^{b}	996.3±2.72^{b}	957.7±2.60^{b}
	W	681.0±5.77^{a}	781.0±1.00^{b}	966.0±3.51^{c}	1154±2.12^{d}	962.5±2.12^{c}	1040±0.71^{c}	988.5±2.83^{c}	1168±2.89^{d}	1137±2.00^{d}	916.5±3.00^{c}	763.0±5.03^{b}
Histidine	C	614.5±2.04^{c}	632.5±1.22^{c}	390.0±1.63^{a}	468.0±5.71^{b*}	713.0±0.0^{d*}	788.0±0.81^{e}	758.0±0.81^{e}	602.5±0.42^{c*}	657.0±1.63^{c}	689.5±0.42^{d}	630.0±1.63^{c}
	W	427.3±6.65^{a}	415.3±5.01^{a}	562.0±6.55^{b}	447.5±3.05^{a}	715.0±0.00^{d}	652.0±4.00^{c}	643.2±0.68^{c}	612.8±3.29^{bc}	586.9±1.21^{bc}	543.8±2.26^{b}	487.9±0.81^{ab}
Lysine^{A}	C	2299±0.0^{e}	1974±2.90^{d}	1555±4.08^{c}	1098±0.40^{b}	975.5±3.67^{b}	922.0±3.26^{b}	586.5±0.40^{a}	724.5±1.22^{ab}	888.5±1.22^{b}	1758±1.00^{c}	2119±2.40^{d}
	W	1479±7.63^{bc}	1704±5.50^{c}	2373±9.45^{d}	1220±5.03^{b}	882.0±2.82^{ab}	655.7±4.04^{a}	814.0±2.00^{ab}	837.0±2.83^{ab}	1045±5.00^{ab}	1212±2.08^{b}	1398±3.21^{bc}
TAA	C	16034±1.11	15669±2.31	11086±2.53	15322±2.50	17880±1.68	16780±2.29	13905±2.28	16746±4.62	14860±2.42	15490±1.47	15613±2.13
	W	10380±4.65	12707±2.67	16021±5.06	18755±3.71	14727±3.06	14642±4.43	14589±3.38	14727±6.32	16215±5.30	13955±2.68	12134±2.63
TEAA	C	8059±1.75	7964±1.11	5455±3.17	7421±2.12	7960±1.30	7697±3.13	6525±1.96	7915±2.64	6554±3.01	7497±1.64	7878±1.93
	W	5492±6.53	6649±2.87	8522±5.47	8612±3.58	6876±2.62	6507±3.42	6683±3.44	7166±2.84	7899±2.38	7015±2.33	6247±2.27
TNEAA	C	7975±1.25	7705±2.40	5631±2.25	7901±2.89	9921±2.06	9083±1.45	7750±2.54	8831±1.98	8306±1.84	7991±1.24	7735±2.33
	W	4888±3.71	6058±2.47	7499±4.92	9143±3.68	7852±3.51	7945±5.45	7907±3.32	7561±3.48	8316±2.92	6941±3.03	5887±2.96
E/NE	C	1.010	1.034	0.969	0.939	0.801	0.847	0.841	0.896	0.789	0.938	1.018
	W	1.123	1.098	1.136	0.942	0.875	0.819	0.845	0.948	0.950	1.011	1.061

[A]Essential amino acid for humans, *. TAA, Total amino acid; TEAA, Total essential amino acid; TNEAA, Total nonessential amino acid; (Tryptophan was not determined)

Table 4. Carbohydrate and energy value of wild and cultured brown trout at monthly changes

Mount	Carbohydrate (g/100 g)		Energy (Kcal/100 g)	
	Wild	Culture	Wild	Culture
Jan	0.97 ± 0.02^{Ad}	0.95 ± 0.29^{Ad}	114 ± 1.24^{Ab}	136 ± 2.15^{Bc}
Feb	0.89 ± 0.08^{Ad}	2.97 ± 0.13^{Bg}	99 ± 1.68^{Aa}	133 ± 1.28^{Bc}
Mar	0.44 ± 0.03^{Ac}	0.46 ± 0.09^{Ac}	130 ± 2.05^{Ac}	141 ± 1.56^{Bcd}
Apr	1.17 ± 0.12^{Ae}	1.63 ± 0.05^{Be}	130 ± 3.26^{Ac}	140 ± 1.89^{Bcd}
May	-	1.13 ± 0.06^{d}	-	143 ± 1.46^{d}
Jun	0.43 ± 0.26^{Ac}	0.28 ± 0.02^{Bb}	140 ± 0.98^{Ad}	132 ± 2.21^{Ac}
July	0.91 ± 0.03^{Ad}	1.00 ± 0.28^{Ad}	130 ± 2.15^{Ac}	131 ± 0.15^{Ac}
Agu	0.91 ± 0.05^{Ad}	0.63 ± 0.21^{Bc}	136 ± 1.64^{Acd}	142 ± 0.08^{Acd}
Sep	0.16 ± 0.02^{Ab}	0.23 ± 0.03^{Ab}	126 ± 2.15^{Abc}	116 ± 0.32^{Ba}
Oct	0.05 ± 0.07^{Aa}	0.10 ± 0.05^{Aa}	133 ± 2.21^{Acd}	126 ± 1.29^{Ab}
Nov	0.13 ± 0.22^{Ab}	2.44 ± 0.18^{Bf}	127 ± 0.56^{Abc}	119 ± 1.65^{Ba}
Dec	0.19 ± 0.25^{Ab}	2.46 ± 0.21^{Bf}	120 ± 1.84^{Ab}	124 ± 2.79^{Ab}
Avr.	0.57 ± 0.12^{A}	1.19 ± 0.12^{A}	126 ± 3.44^{A}	132 ± 2.85^{A}

SD: Mean±st. deviation
^{A,B} (→) : Overall means bearing different superscripts between rows and between columns (A,B,C,D,E,F,G) differ significantly ($P<0.05$)
$^{a, b, c, d, e}$ (↓): Interaction means bearing different superscripts differ significantly ($P<0.05$).

and Sommaruga, 2006). The ratio of E/NE was determined as 0.71 for cod (*Gadus morhua*) by Jhaveri *et al.* (1984), 0.77 for sea bream (*Pagrus major*), 0.77 for mackerel (*Scomber japonicus*), 0.71 for mullet (*Mugil cephalus*), 0.69 for sardine (*Sardina melonosticta*), 0.74 for herring (*Clupea pallasi*), 0.75 chum salmon (*Oncorhynchus keta*) and 0.77 and Pacific flounder (*Paralichthys olivaceus*) by Iwasaki and Harada (1985).

Carbohydrate and Energy Value

Table 4 shows the compositional characteristics in terms of carbohydrate and energy content of the different raw trout lots and the corresponding cultured and wild trout. Energy value and carbohydrate amount in fish groups were shown significantly differences at mounts of the year ($P<0.05$). These monthly variations in crude protein, crude fat, moisture (dry matter), crude ash, carbohydrate and energy content of both brown trout were most likely due to changes associated with feeding and spawning season in the trout.

Mean carbohydrate content in the wild trout was found 0.54±0.12 (g/100 g) and cultured trout carbohydrate was found 0.57±0.12 (g/100 g) ($P<0.05$). The carbohydrate content of wild brown trout was highest at 1.17±0.12 (g/100 g) in April, and minimum value 0.05±0.07 (g/100 g) in the October. At cultured trout carbohydrate amount was highest at 2.97±0.13 (g/100 g) in the February, but decreased to 0.10±0.05 (g/100 g) in the October.

Minimum and maximum energy values in wild and cultured brown trout were found 140±0.98 Kkal/100 g in the Jun, 99±1.68 Kkal/100 g in the February and 116±0.32 Kkal/100 g September, 143±1.46 Kkal/100 g May, respectively. The energy content of the wild and cultured brown trout in October was similar to that of resident and anadromous brown trout spawners (Jonsson and Jonsson, 1997; Berg *et al*., 1998).

Conclusion

Lipid content and chemical composition were high seasonal in wild and cultured Brown trout. Cultured trout protein and lipid amounts were higher than wild trout. Dry matter and crude ash values were relatively stable in the year at both fish groups. There are significantly important changes at length, wight and fillet yield between wild and cultured brown trout. The most uniform quality of brown trout groups were observed during the summer, apparent in its good quality and higher nutritional value, compared with the spawning season and winter wild and cultured brown trout of lesser nutritional value.

Acknowledgements

This study was supported by departments of “Scientific Research Project Commission” University of Ondokuzmayıs (project number: 2000/088).

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