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RESEARCH ARTICLE

Growth, Slaughter Yield and Proximate Composition of Rainbow Trout (*Oncorhynchus mykiss*) Raised Under Commercial Farming Condition in Black Sea

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Summary

Growth characteristics, slaughter yield and proximate composition of rainbow trout reared under commercial condition in Black Sea were investigated for one production season. The fish were weighted and sampled for quality assessment every month during the production period (December-May), and feed consumption was recorded daily. During the experiment, bimonthly body weight increased from 206 g to 1011 g, specific growth rate varied between 0.4 and 4.79, thermal growth coefficient varied between 0.04 and 0.35. Condition factor, visceral index and hepatosomatic index was altered by feed intake and water temperature. The degree of caecal fat score was highest during harvest month, May. Although carcass yield didn't differ significantly during farming period, fillet yield increased in the last three months. Protein content of fillet lowered from 83% to 70% by the production period. The fillet fat content increased from 10-11% to 15-16% during the experiment, and the most pronounced fat increase occurred in May. Fillets partitioned into six chunks: cranial, intermediate, caudal and their ventral, dorsal subdivisions. Results show small differences in the protein, fat and moisture content of these sections.

Keywords: *Rainbow trout, Growth, Slaughter yield, Proximate composition*

Karadeniz'de Ticari Koşullar Altında Yetiştirilen Gökkuşağı Alabalığı (*Oncorhynchus mykiss*)'nda Büyüme, Karkas Verimi ve Vücut Kompozisyonu

Özet

Karadeniz'de ticari koşullar altında yetiştirilen gökkuşağı alabalığında büyüme karakteristikleri, karkas verimi, fileto verimi, vücut kompozisyonu, bir üretim dönemi boyunca izlenmiştir. Üretim dönemi boyunca (Aralık-Mayıs) her ay örnekleme yapılarak balıklarda gerekli ölçüm ve analizler yapılmıştır. Deneme sonunda, başlangıçta 206 gram ağırlığa sahip balıkların 1011 grama ulaştığı belirlenmiştir. Spesifik büyüme oranı 0.4 ile 4.79 arasında, termal büyüme katsayısı 0.04 ile 0.35 arasında değişim göstermiştir. Kondisyon faktörü, iç organ oranı, hepatosomatik indeks değerleri su sıcaklığına ve günlük verilen yeme göre değişim göstermiştir. Çekal yağ skoru hasat ayında (Mayıs) en yüksek düzeye ulaşmıştır. Karkas verim zamana bağlı orak değişim göstermemesine karşın fileto verimi balık büyüdükçe artmıştır. Başlangıçta %83 olan fileto protein oranı hasat zamanında %70'e düşmüştür. Deneme süresince fileto yağ oranı %10-11'den %15-16'ya çıkmıştır. Kraniyal, orta, kaudal ve bunların alt parçaları dorsal ve ventral olamak üzere altı parçaya ayrılan filetoda, biyokimyasal değerler küçük farklılıklar göstermiştir.

Anahtar sözcükler: *Gökkuşağı alabalığı, Büyüme, Karkas verimi, Fileto verimi, Vücut kompozisyonu*

INTRODUCTION

Rainbow trout *(Oncorhynchus mykiss)* is one of the most important finfish species for Turkish aquaculture industry, and it has been cultured in Black Sea, Turkey since 1990s [1]. Increasing numbers of off-shore cage farm has been established in Black Sea for trout culture and trout production in the Black Sea has considerably

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increased in recent years. Rainbow trout are transferred directly from inland freshwater to the brackish Black Sea waters without any adverse effects. In this environment, trout require 5-6 months to grow from 20-200 g to the size of at least 200-1000 g [1].

It is known that rearing fish under controlled conditions can alter their growth, slaughter yield, proximate composition, and other parameters of flesh. The feed and water quality plays a significant role in both growth and proximate composition of fish [2]. It is well known that brackish water enhances growth of trout [3-5] and high growth rates have been reported in rainbow trout cultured in cage conditions in the brackish Black Sea water [6-9]. Growth of rainbow trout was defined very well in estuarine condition [10-13] and was studied by several authors [4,7,9] in Black Sea condition.

Although body composition is a good indicator of the physiological condition of a fish [14] there is limited data on body composition and flesh quality of rainbow trout in estuarine Black Sea condition. Body composition and flesh quality are also essential characteristics of farmed fish for human consumption. They influence consumer acceptance and the ability to refine fish material [15].

The aim of the present study was to investigate growth, slaughter yield and proximate composition of rainbow trout *(Oncorhynchus mykiss)* farmed in offshore cage conditions in South-Eastern Black Sea Coast, Turkey.

MATERIAL and METHODS

Experimental Fish and Fish Rearing

Experimental fish (206.38±48.3 g mean weight and 1^+ years old) were transferred into floating high density polyethylene (HDPE) cages (16 m diameter and 10 m depth) located in South-East Black Sea Coast, Rize-Turkey (41° 02' 06.36'' and 41° 02' 20.56'' North longitudes and 40° 32' 10.91'' and 40° 32' 26.20'' East latitudes) from fresh water cages (16 m diameter and 10 m depth) located in Kuzguncuk Dam Lake, Erzurum Turkey (40° 12' 04.30'' and 40° 12' 08.15'' North longitudes and 41° 03' 07.10'' and 41° 03' 12.18'' East latitudes) in November 2005. Fish were stocked into the sea cages with a stocking rate of 10 kg per cubic meter. Fish were fed *ad-libitum* two times daily with commercial extruded trout feed (45% crude protein, 18% crude fat, 10% moisture, 12% ash, 3% crude fibre) when meteorological condition was suitable.

Fish Sampling and Biometric Data Collection

Starting from December 2005 and following each month (From February 2006 to May 2006) 15 fish were randomly sampled. Before bleeding of fish, the weight and length of the whole fish was recorded and the condition coefficient ($CF = (BW\times100)/L^3$) of each fish calculated. After bleeding, fish was sexed and filleted. The sex of the fish was classified into two categories: males, females. Male fish were omitted due to insufficient male samples. The caecal fat score was immediately determined upon opening the body cavity. The pyloric caeca was scored according to the amount of fat surrounding the intestine with scores ranging between 0 (individual pyloric caeca clearly visible with no adherent fatty deposits) and 4 (all pyloric caeca completely obscured by visceral fat deposits). After gutting and removal of the kidney (but not gills), the fish were reweighed and the carcass yield (CY = carcass weight/ fish weight×100) were calculated. Sample fish were filleted by butterfly filleting method with fillet board. The pin-bone, column and fins were removed, and fillet yield was calculated (FY = fillet weight/fish weight×100). The following indices were also calculated: visceral index (VI = viscera weight/fish weight×100); hepatosomatic (HSI = liver weight/ fish weight×100); visceral fat (VFI = weight of the visceral fat/fish weight×100).

The specific growth rate, was calculated from the equation: $(SGR)= ((W_2^{1/3}-W_1^{1/3})\times t^{-1})100$, where W_2 is the final weight, W_1 is the initial weight and t is time between W_1 and W_2 in days. The thermal growth coefficient (TGC) was calculated as $(W_2^{1/3}-W_1^{1/3})\times(\Sigma T)^{-1})$ [16], where W_2 is the final weight, W_1 is the initial weight and ΣT is the sum of day degrees. The TGC was multiplied by 100 in the table to simplify the numbers.

To measure the proximate quality of fillets, fins and vertebrae were removed. Then fillet were divided into six parts: dorsal part of cranial site (Cr-D), ventral part of cranial site (Cr-V), dorsal part of intermediate site (Int-D), ventral part of intermediate site (Int-V), dorsal part of caudal site (Ca-D) and ventral part of caudal site (Ca-V) *(Fig 1)*. Each part of fillets from all fish was pooled. The pooled fillet parts were ground and homogenized in a blender and then proximate composition of the fillets was analyzed.

Analytical Methods

Proximate composition of diets and fish muscle was analyzed using standard methods [17]. Muscle was collected from the sectioned part of trout flesh as shown in *Fig. 1*. Samples, from pooled fillet parts of specimens were analyzed in triplicate, for proximate composition. Moisture was determined by drying the sample (105°C for 24 h) to a constant weight. Crude protein (Nx6.25) was measured using the Kjeldahl method after acid digestion. Crude fat was estimated by Soxhlet exhaustive extraction technique using petroleum ether (40-60°C BP) as solvent. Ash was determined by incinerating the dried sample at 550°C for 12 h. Organic matter was determined indirectly, by difference from the ash content.

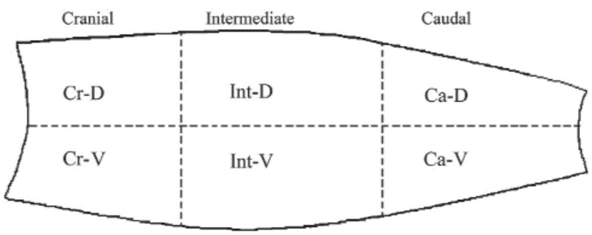

Fig 1. Partitioned fillet site for proximate composition analysis. Cr-D indicates dorsal part of cranial site, Cr-V indicates ventral part of cranial site, Int-D indicates dorsal part of intermediate site, Int-V indicates ventral part of intermediate site, Ca-D indicates dorsal part of caudal site, Ca-V indicates ventral part of caudal site of fillet

Şekil 1. Vücut kompozisyonu analizi için bölünmüş fileto parçaları. Cr-D kraniyal bölge dorsal kısmı, Cr-V kraniyal bölge ventral kısmı, Int-D orta bölge dorsal kısmı, Int-V orta bölge ventral kısmı, Ca-D kaudal bölge dorsal kısmı, Ca-V kaudal bölge ventral kısmı göstermektedir

Statistical Analysis

Proportions, as well as proximate composition were arcsine-transformed before statistical analysis. Both the transformed and the untransformed data were subject to analysis of variance (ANOVA) for biometric data, yields of fish and proximate composition. The individual comparisons of groups were obtained using Duncan's multiple range tests for biometric variables. All statistical computation was performed using the SPSS software package (Ver. 10.0 Chicago, IL, USA).

RESULTS

Higher SGR (% BW/day) is recorded in March, April and May compared to those recorded in January and February *(Table 1)*. These increases and decreases were correlated with water temperature (R^2=0.753). The thermal growth coefficient (TGC) was also used to assess growth, because TGC incorporates both fish size and temperature effects in the growth trajectory. Thermal growth coefficient (TGC) was more reliable than SGR between groups. The lowest TGC was calculated in February and the highest TGC was calculated in March.

Body weight of fish slowly increased during the first three months (December, January and February), but the differences were not significant. However for the last three months body weight increased and reached up to 1011.4 g *(Table 2)* in May 2006. The increase in total fish length was lowered in January (26.66) and February (26.77), but increased thereafter in the following months.

The condition factor decreased from a mean of 1.34 in March to 1.44 in February. The condition factor tended to increase significantly more rapidly in subsequent

Table 1. *Bimonthly recorded sea water temperature, daily mean feed intake, SGR and TGC values*

Tablo 1. *Aylık kaydedilmiş deniz suyu sıcaklığı, yemleme oranı, SGR ve TGC değerleri*

Variables	January	February	March	April	May
T (°C)	9.68	9.55	10.2	14	16.83
Feed intake (biomass day %)	0.96	0.16	1.86	2.22	1.54
SGR	1.65	0.40	3.54	4.79	3.39
TGC	0.17	0.04	0.35	0.34	0.20

Table 2. *Total length (TL), Weight (W), condition factor (CF), visceral index (VI), hepatosomatic index (HSI), gonadosomatic index (GSI), caecal fat score (CFS), fillet yield (FY) and carcass yield (CY) of cultivated rainbow trout in Eastern Black Sea (Data expressed as mean values ± S.D.)*

Tablo 2. *Karadeniz koşullarında yetiştirilen gökkuşağı alabalıklarında, toplam boy (TL), ağırlık (W), kondüsyon faktörü (CF), iç organ indeksi (VI), hepatosomatik indeks (HSI), gonadosomatik indeks (GSI), çekum yağ oranı (CFS), fileto verimi (FY) ve karkas verimi (CY) (veriler ortalama ± S. Sapma olarak verilmiştir)*

Variables	December	January	February	March	April	May
TL (cm)	24.53±1.81 ^{a}	26.66±1.54 ^{a}	26.77±2.17 ^{a}	31.79±2.28 ^{b}	35.63±3.00 ^{c}	40.22±3.98 ^{d}
W (g)	206.93±50.05 ^{a}	263.30±46.11 ^{a}	278.10±65.70 ^{a}	436.80±95.62 ^{b}	734.60±167.86 ^{c}	1011.4±257.29 ^{d}
CF	1.37±0.11 ^{a}	1.37±0.10 ^{a}	1.44±0.11 ^{ab}	1.34±0.10 ^{a}	1.59±0.11 ^{c}	1.53±0.25 ^{bc}
VI (%)	13.38±1.55 ^{a}	14.20±2.88 ^{a}	14.29±1.55 ^{a}	13.61±1.43 ^{a}	18.55±4.61 ^{b}	16.88±2.05 ^{b}
HSI (%)	1.026±0.12 ^{a}	1.288±0.16 ^{b}	1.509±0.28 ^{c}	1.492±0.34 ^{bc}	1.830±0.24 ^{d}	1.439±0.20 ^{bc}
GSI (%)	0.085±0.032 ^{ab}	0.056±0.023 ^{a}	0.064±0.035 ^{ab}	0.142±0.097 ^{c}	0.086±0.032 ^{ab}	0.113±0.054 ^{b}
CFS	2.8±1.08 ^{ab}	3.1±0.57 b	2.7±1.57 ^{ab}	1.8±1.68 ^{a}	3.0±1.15 ^{b}	3.5±0.85 ^{b}
FY (%)	67.34±3.03 ^{ab}	66.06±3.03 ^{a}	68.38±2.37 ^{abc}	69.94±1.85 ^{bc}	69.89±4.10 ^{bc}	70.96±2.55 ^{c}
CY (%)	75.41±2.39 ^{b}	72.33±3.11 ^{a}	74.90±1.80 ^{b}	75.85±1.65 ^{b}	74.05±4.08 ^{ab}	75.48±2.37 ^{b}

Values expressed in the same row with different letter indicate differences are statistically significant (P<0.05) months, April and May 2006. The highest condition factor was recorded as 1.59 and 1.53 in May and April, respectively. Similarly, a higher visceral index (VI) was found in April (18.55%) and May (16.88%). HSI was also high in April due to high feeding rate. The highest GSI (0.142%) was calculated in March samplings. The lowest caecal fat score was recorded as 1.8 in March and the highest was recorded as 3.5 in May.

Concerning fillet yield, FY was raised gradually from beginning of experiment to last month May. Fish had showed a fillet yield of 67.34% in December, and 70.96% in May that is harvest stage. On the other hand carcass yield was lowered on January (72.33%), but it was detected invariable in other sampling months.

Mean crude protein content in the whole fillet *(Fig. 2)* decreased from February 2006 (86.72±3.02%) to May 2006 (70.22±3.43%) ($P<0.05$). General trend, crude protein was lowered in all parts of fillet after February. The higher mean crude protein rate was detected as 90.26±3.43% in the dorsal part of caudal site of trout on February, and the lowest crude protein rate was detected in 60.96±1.72% during experiment. Ventral part of cranial and intermediate sections performed lower rate crude protein than dorsal parts.

Mean crude fat of whole fillet (WF) was decreased for three months, from December (11.81%) to February (9.19%). After February mean crude fat was increased up to highest level on May (16.64%). Ventral part of cranial site and intermediate site had a higher level of crude fat than both dorsal part of those parts and caudal site *(Fig 2)*.

Mean crude ash content lowered in whole fillet month by month. Crude ash content of whole fillet was calculated sequentially 1.4%, 1.29%, 1.33%, 1.29%, 1.27%, 1.30% from December to May *(Fig. 2)*. Higher crude ash content was detected for the dorsal part of

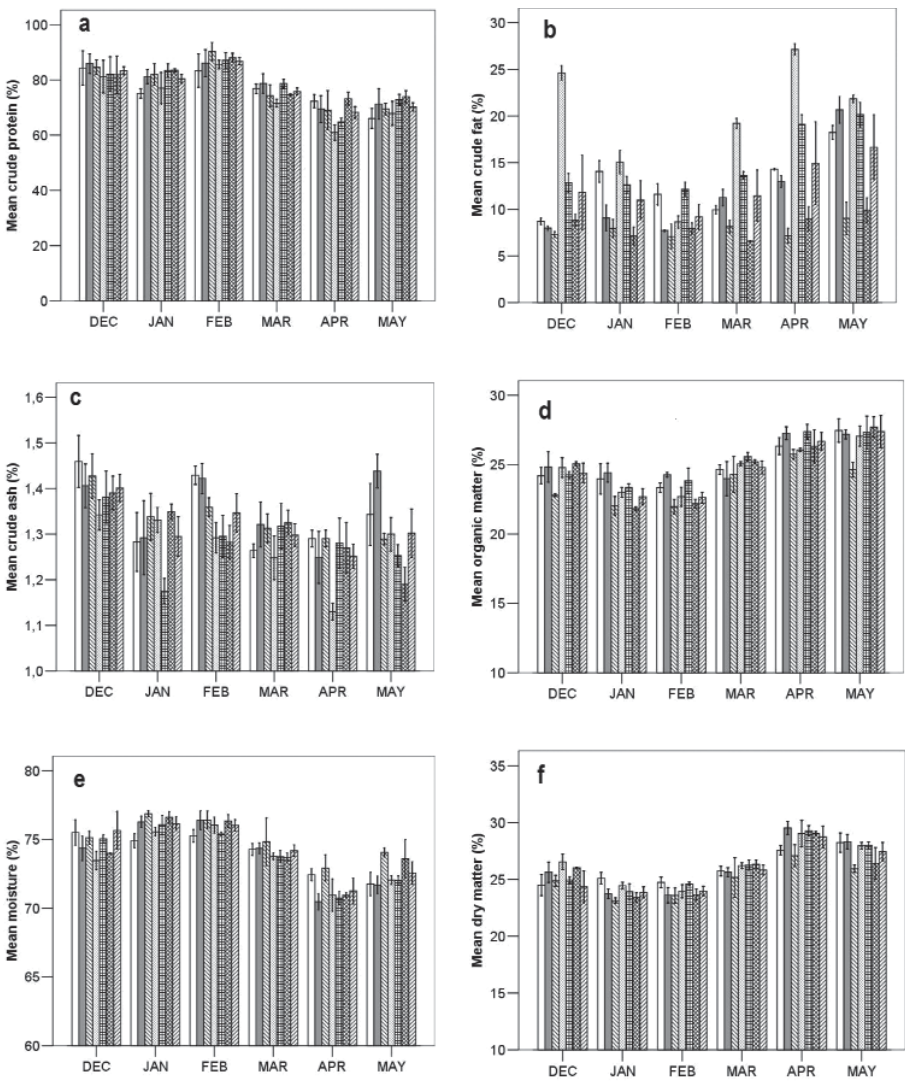

Fig 2. Mean crude protein (a), mean crude fat (b), mean crude ash (c), mean organic matter (d), mean moisture (e) and mean dry matter (f) content of partitioned fillet site and whole fillet in Black Sea reared rainbow trout. ( ) indicates dorsal part of cranial site, ( ) dorsal part of intermediate site, ( ) dorsal part of caudal site, ( ) ventral part of cranial site, ( ) ventral part of intermediate site, ( ) ventral part of caudal site and ( ) whole fillet. Error bars represent mean ±S.E.

Şekil 2. Karadeniz'de ticari şartlar altında yetiştirilen gökkuşağı alabalığı filetosunda kısımlara göre ortalama ham protein (a), ortalama ham yağ (b), ortalama ham kül (c), ortalama organik madde (d), ortalama nem (e) ve ortalama kuru madde (f) oranları. ( ) kraniyal bölge dorsal kısmı, ( ) orta bölge dorsal kısmı ( ) kaudal bölge dorsal kısmı, ( ) kraniyal bölge ventral kısmı, ( ) orta bölge ventral kısmı, ( ) kaudal bölge ventral kısmı ve ( ) tüm filetoyu göstermektedir. Hata çubukları ortalama±S.H'yı göstermektedir sections than ventral sites. Unlike crude ash, organic matter content of whole fillet was slowly reduced from December to February and thereafter it was increased from February to May *(Fig. 2)*.

Water content in the whole fillet was found as 75.65%, 76.14%, 76.02% and 75.65% in December, January, February and March, respectively. However, a decrease was recorded in April (71.25%) and May (72.56%) *(Fig. 2)*. Unlike moisture, dry matter content of whole fillet was slowly decreased from December to February and then, increased from February to May *(Fig. 2)*. This increase after February was significant (P<0.05) between months.

DISCUSSION

Weight gain varied significantly between sampling months. This was related to water temperature and feeding regime that was arranged according to water temperature. Temperature was changed between 9-16°C. Growth of fish is dependent to changes in water temperature, diet, fish size, and seasonal period of the year and is usually measured in terms of weight or length of the fish [18]. Specific growth rate (SGR) is an index used to compare actual mass gain to predicted mass gain of salmonids in aquaculture [19]. The calculation of SGR assumes that the cube root of mass increases linearly over time and that the effect of temperature on growth is linear between 5 and 15°C. But in this study, SGR was changed between 0.4 and 4.79 during farming activities. In previous studies, SGR rate of rainbow trout was reported between 1.02-1.11 [6], 3.36 [4], 1.35-1.79 [20] or between 0.79-3.26 [7] in Black Sea condition. Our results were in close agreement with those of the previous reports by those authors. Thermal growth coefficient (TGC) was used to assess growth, because TGC incorporates both fish size and temperature effects in the growth trajectory. TGC was calculated between 0.04 and 0.35 and strong linear correlation was detected with SGR (R^2=0.84)

Slaughter parameters of fish such as VI were significantly different (P<0.05) in the last two months of the experiment than the initial four months of trial. Unlike CFS, HSI was recorded significant higher (P<0.05) for the last four month period compared to those recorded during the initial two months. Carcass yield was almost constant during the course of the experiment, except January data, which was significantly lower (P<0.05) than the other months. Fillet yield was highest in May. This was linked directly to the higher VI index of the rainbow trout from this group. Similarly, Mathis et al.[21] reported that the VI index was one of the parameters that were correlated with filleting yield in perch. Condition factor followed the same trend, increasing by months except March. This was linked to higher water temperature and higher feed consumption.

Within sampling periods, crude protein content of whole fillet was lower in periods with higher water temperature (April and May). The dorsal part (Int-D, Ca-D) had higher protein content than the ventral parts in general *(Fig. 2)*. There are reports on variation in body constituents of fish reared at different temperatures [22]. In the present study with rainbow trout, higher protein content was found in lower water temperature (except January). However, no effect of temperature or ration was noted on body protein content in *Oncorhynchus nerka* [23] and *Salmo trutta* [24]. Cr-V and Int-V were significantly different from other partitioned fillet sites for crude fat except last sampling months *(Fig. 2)*. In general fat content of ventral parts were detected higher than dorsal parts. Andrews and Stickney [25] observed that in channel catfish, an increase in temperature led to increased lipid content. In rainbow trout fillets the lipid content tends to increase following the cranio-caudal direction, whereas this trend seems to be less pronounced in the dorso-ventral direction [26]. Fat content of whole fillet and portioned fillet parts are straightly related with condition factor. Crude ash and organic matter content of whole fillet related inversely. Organic matter content of fillet increased until harvest month, May. Lower organic matter content was detected in dorsal part of caudal site.

Water content of whole fillet was reduced month by month until fish harvest. Teskeredzic and Pfeifer [27] reported that the fish reared in brackish water condition has lower water content, higher fat deposit than reared in fresh water condition. Crude fat content and moisture of fillet related inversely. Similarly, some scientist reported these two components are inversely related in fish flesh [2,28].

Results of these studies showed that remarkable differences in proximate composition emerged between the dorsal and ventral fillet portions of farmed rainbow trout under commercial condition, even though these differences were not of equal importance for all of the components considered.

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REFERENCES

1. Canyurt MA, Akhan S: Development and situation of trout culture in Turkey. *Research for Rural Development 2009, Annual 15th International Scientific Conference Proceeding,* Jelgava, 90-94, 2009.

2. Jankowska B, Zakes Z, Zmijewski T, Szczepkowski M, Kowalska A: Slaughter yield, proximate composition, and flesh colour of cultivated and wild perch (*Perca fluviatilis* L.). *Czech J Anim Sci,* 52 (8): 260-267, 2007.

3. Tsintsadze ZA: Adaptational capabilities of various size-age groups of rainbow trout in relation to gradual changes of salinity. *J Ichthyol,* 31, 31-38, 1991.

4. Yiğit M, Aral O: A comparison of the growth differences of rainbow trout (*Oncorhynchus mykiss* W., 1792) in freshwater and seawater (The Black Sea). *Turk J Vet Anim Sci,* 23, 53-59, 1999.

5. Altinok I, Grizzle JM: Effects of brackish water on growth, feed conversion and energy absorption efficiency by juvenile euryhaline and freshwater stenohaline fishes. *J Fish Biol,* 59, 1142-1152, 2001.

6. Akbulut B, Temel Ş, Aksungur N, Aksungur M: Effect of initial size on growth rate of rainbow trout, *Oncorhynchus mykiss,* reared in cages on the Turkish Black Sea Coast. *Turk J Fish Aquat Sci,* 2, 133-136, 2002.

7. Sahin T, Okumus I, Celikkale MS: Evaluation of rainbow trout *(Oncorhynchus mykiss)* mariculture on the Turkish Black Sea Coast. *Isr J Aquacult-Bamid,* 51 (1): 17-25, 1999.

8. Aral O, Büyükhatipoğlu Ş, Erdem M, Ağırağaç C: The Effect of two different feeds on the growths of rainbow trout (*Oncorhynchus mykiss* W. 1792) in net cages in the Black Sea. *Turk J Vet Anim Sci,* 20, 121-126, 1996.

9. Büyükhatipoğlu Ş, Erdem M, Aral O, Tarakçı Y, Ağırağaç C: The Effects of different stocking densities on growth of rainbow trout (*Oncorhynchus mykiss* W. 1792) in net cages in the Black Sea. *Turk J Vet Anim Sci,* 20, 137-142, 1996.

10. McKay LR, Gjerde B: The Effect of salinity on growth of rainbow trout. *Aquaculture,* 49, 325-331, 1985.

11. Siitonen L: Factors affecting growth in rainbow trout *(Salmo gairdneri)* stocks. *Aquaculture,* 57, 185-191, 1986.

12. Jürss K, Bittorf TH, Vökler TH, Wacke R: Effects of temperature, food, deprivation and salinity on growth, RNA/DNA ratio and certain enzyme activities in rainbow trout (*Salmo gairdneri* Richardson). *Comp Biochem Physiol B,* 87, 241-253, 1987.

13. Teskeredzic E, Teskeredzic Z, Tomec M, Modrusan ZA: Comparison of the growth performance of rainbow trout *(Salmo gairdnerii)* in tresh and brackish water in Yugoslavia. *Aquaculture,* 77, 1-10, 1989.

14. Cui Y, Wootton RJ: Effects of ration, temperature and body size on the body composition, energy content and condition of minnow (*Phoxinus phoxinus* L.). *J Fish Biol,* 32, 749-764, 1988.

15. Kause A, Ritola O, Paananen T, Mäntysaari E, Eskelinen U: Coupling body weight and its composition: A quantitative genetic analysis in rainbow trout. *Aquaculture,* 211, 65-79, 2002.

16. Cho CY, Bureau DP: Development of bioenergetic models and the Fish-PrFEQ software to estimate production, feeding ration and waste output in aquaculture. *Aquat Living Resour,* 11, 199-210, 1998.

17. AOAC: Offical methods of analysis. 15th ed. Association of Offical Analytical Chemists, Washington DC, 1990.

18. Johnston G: Arctic Char Aquaculture. Blackwell Publishing, Oxford, 2002.

19. Iwama GK: Growth of salmonids. **In,** Pennell W, Barton BA (Eds): Principles of Salmonid Culture. pp. 467-516. Elsevier, Amsterdam, 1996.

20. Yıldırım Ö, Ergün S, Yaman S, Türker A: 2009. Effects of two seaweeds (*Ulva lactuca* and *Enteromorpha linza*) as a feed additive in diets on growth performance, feed utilization, and body composition of rainbow trout *(Oncorhynchus mykiss). Kafkas Univ Vet Fak Derg,* 15 (3): 455-460, 2009.

21. Mathis N, Feidt C, Brun-Bellut J: Influence of protein/ energy ratio on carcass quality during the growing period of Eurasian perch *(Perca fluviatilis). Aquaculture,* 217, 453-464, 2003.

22. Shearer KD: Factors affecting the proximate composition of cultured fishes with emphasis on salmonids. *Aquaculture,* 119, 63-88, 1994.

23. Brett JR, Shelbourn JE, Shoop CT: Growth rate and body composition of fingerling sockeye salmon, *Oncorhynchus nerka,* in relation to temperature and ration size. *J Fish Res Board Can,* 26, 2363-2394, 1969.

24. Elliott JM: The growth rate of brown trout (*Salmo trutta* L.) fed on maximum rations. *J Anim Ecol,* 44, 805-821, 1975.

25. Andrews JW, Stickney RR: Interactions of feeding rates and environmental temperature on growth, food conversion and body composition of channel catfish. *Trans Am Fish Soc,* 101, 94-99, 1972.

26. Fjellanger K, Obach A, Rosenlund G: Proximate analysis of fish with special emphasis on fat. **In,** Kestin SC, Warriss PD (Eds): Farmed Fish Quality. pp. 307-317, Blackwell Science, Oxford, UK, 2001.

27. Teskeredzic Z, Pfeifer K: The meat quality of rainbow trout, *Salmo gairdneri* cultured in the Brackish Water. *Ichthiologia,* 18 (1): 15-22, 1986.

28. Katikou P, Hughes SI, Robb DHF: Lipid distribution within Atlantic salmon *(Salmo salar)* fillets. *Aquaculture,* 202, 89-99, 2001.