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Seasonal Changes in Proximate Composition of Some Fish Species from the Black Sea

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Abstract

Nutritional composition of four marine fish species (horse mackerel, garfish, golden mullet, and shad), constitute to 25% of the total marine fish production in Turkey, was examined monthly during the catching season (October through March). Among fish species studied; horse mackerel, garfish, and golden mullet revealed increases in protein up to 35% until December and then a dramatic decrease in January up to 30%. Fat content was also found increasing until December in horse mackerel and garfish, and a sudden decrease was observed in January. Protein content varied between 13.0-19.8% among the species studied on fresh weight basis. The lowest protein content was found to be in horse mackerel, 14.8% and the highest in garfish, 16.9%. The results showed that shad gives the highest energy upon consumption due to high fat content, throughout four months from December to March. Fat content of garfish and golden mullet was found to be low compared to other species studied. Consequently, energy values of these two species were low, 479 and 460 kj/100 g, respectively.

Keywords: Proximate composition, shad, garfish, horse mackerel, golden mullet.

Karadeniz'deki Bazı Balık Türlerinin Biyokimyasal Kompozisyonundaki Mevsimsel Değişimler

Özet

Bu çalışmada, Türkiye'deki toplam deniz balıkçılığı üretiminin yaklaşık %25'ini oluşturan dört balık türünün (istavrit, zargana, altınbaş kefal ve tirsi) besin kompozisyonu avlanma sezonunda (ekim ve mart ayları arasında) altı ay boyunca aylık olarak incelenmiştir. Çalışılan balık türleri arasında; istavrit, zargana ve altınbaş kefalin protein miktarı Aralık ayına kadar %35'e kadar artmış ancak daha sonra ocak ayında %30'a kadar ciddi bir düşüş göstermiştir. İstavrit ve zarganının yağ miktarı da aralık ayına kadar artmış ancak ocak ayında ciddi bir düşüş göstermiştir. Çalışılan türlerin protein miktarı aylara göre taze balık ağırlığının %13 ve %19,8'i arasında değişmiştir. En düşük ve en yüksek ortalama protein miktarı sırasıyla %14,8 ile istavritte ve %16,9 ile zarganada tespit edilmiştir. Elde edilen sonuçlar, aralık ayından mart ayına kadar dört ay boyunca, yüksek yağ miktarı nedeniyle tirsinin en yüksek enerjiyi vereceğini göstermektedir. Zargana ve altınbaş kefalin yağ miktarının çalışılan diğer türlere göre daha düşük olduğu belirlenmiştir. Buna bağlı olarak, bu iki türün enerji miktarının düşük ve sırasıyla 479 ve 460 kj/100 g olduğu hesaplanmıştır.

Anahtar Kelimeler: Biyokimyasal kompozisyon, tirsi, zargana, istavrit, altınbaş kefal.

Introduction

Protein, fat and water content of fish is important to consumers, scientists and manufacturers from many aspects including nutritional value, seasonal variations and considerations regarding processing (Murray and Burt, 2001). Fish is one of the main food constituents in our diet as it includes essential fatty acids, amino acids and some of the principal vitamins and minerals in sufficient amounts for healthy living (Borgstrom, 1961). Furthermore, some nutritional components of fish have functional effects on human health. For example, fish oil is one of the most important natural sources of polyunsaturated fatty acids including eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which have been proven to have useful effects on human health (Saoud *et al*., 2008; Rafflenbeul, 2001). In addition, fish oil is a rich source of vitamins including vitamin A, D, E, and K, which are soluble in oil and must be taken on a regular basis because of their key roles in human health and metabolism (Kinsella, 1987).

Principal composition of fish is 16-21% protein, 0.2-25% fat, 1.2-1.5% mineral, 0-0.5% carbohydrate and 66-81% water (Love, 1970). The composition, however, varies greatly from species to species and also from individual to individual depending on age, sex, environment and season (Huss, 1988; 1995). Furthermore, the variations in proximate composition of fish are closely related to the feed intake. During periods of heavy feeding, the protein content of muscle tissue increases slightly at first and then the fat content might show a marked and rapid increase. On the other hand, fish may have starvation periods for natural or physiological reasons (spawning or migration) or because of external factors such as shortage of food. In that case, fat content gradually decreases and then a decline in protein may also be seen (Huss, 1988; 1995). Therefore, it is important to know proximate composition of fish and variations throughout the year. In this study, proximate composition of selected fish species were examined only for 6 months from October to March, as this period of time is legal fishing season in Turkey for these species studied and they are generally available at the local market.

Fish species selected for this study are horse mackerel (*Trachurus trachurus* L., 1758), shad (*Alosa fallax* Lacepede, 1803), garfish (*Belone belone,* L., 1758) and golden mullet (*Mugil auratus* Risso, 1810) (Ivanov and Beverton, 1985). These species are important because of their production adding up to around 25% of the total marine fish production in Turkey and their common consumption in the region (Anonymous, 2002). Despite the importance of these species, seasonal variation in their proximate composition is not well known. This study is designed to examine monthly changes in proximate composition of these four fish species caught in the eastern Black Sea, to determine their nutritional value and variations during the fishing season.

Materials and Methods

Sample Preparation

Fish species examined in this study were obtained monthly (4-5 individuals of shad and golden mullet, 12-15 individuals of horse mackerel and garfish) from October to March during six months from a local marketplace in Trabzon, Turkey. Golden mullets were about 30 cm in length and 350 g in weight while shads were about the same in length and 400 g in weight. Garfish samples were about 35 cm in length and 90 g in weight while horse mackerels were about 15 cm in length and 50 g in weight. Upon arrival of fish to marketplace, they were immediately transported to the laboratory in cold chain, washed with cold tap water, eviscerated and filleted manually using a sharp knife, and then minced and homogenized using a blender (Waring Laboratory, Torrington, CT, USA) for 2 min at high speed (22000 rpm) under ambient conditions. Fish samples were stored at 0°C for maximum 24 hours until performing proximate composition analyses. All analyses were duplicated by sampling from the homogenates.

Proximate Composition Analyses

After preparation of edible parts of fish as described, proximate composition analyses were performed according to AOCS (Anonymous, 1992) procedures. Water content was determined by drying samples at 105±2°C until a constant weight was obtained. Dried samples were used for determination of crude fat, protein and mineral contents. Crude fat was measured by solvent extraction method in a soxhlet system where n-hexane was used as solvent. Crude protein content was calculated by using nitrogen content obtained by Kjeldahl method. A conversion factor of 6.25 was used for calculation of protein content (Anonymous, 1992). Total mineral content was determined by incinerating samples at 550±10°C for 3 hours where magnesium acetate solvent was used as an incineration aid (Watson, 1994). Carbohydrate content and energy value were calculated by subtracting the total of protein, fat, water and mineral from the whole and by multiplying fat, protein and carbohydrate with appropriate coefficients (Holland *et al*., 1993; Guner *et al*., 1998). All chemicals used were in analytical grade and obtained from Merck (Darmstadt, Germany), Sigma-Aldrich (St. Louis, MO, USA) and Mallinckrodt Baker (formerly known as J.T. Baker, Phillipsburg, NJ, USA).

Statistical Analyses

The results obtained were analyzed statistically by performing ANOVA and Tukey's tests where there were significant differences. All statistical analyses were performed using MINITAB (State College, PA, USA) statistics software. Significance level was set to an alpha level of 0.05 (Sokal and Rolf, 1974). Statistical significance is indicated with appropriate letters on the data tables.

Results and Discussion

Monthly variations in nutritional composition of horse mackerel are shown in Table 1. Changes in water and fat indicate that while there was a decline in water content, fat content evidently increased due to heavy feeding during this period, which is in good agreement with previously reported results by Huss (1988; 1995). There was a significant increase in protein content for all species except shad in December. According to the report published by Salihoğlu and Mutlu (2000), plankton concentration in Black Sea is at the highest level during November and December, which could explain the increment in both fat and protein contents, observed for horse mackerel and garfish in December. After December, protein content of horse mackerel decreased again to an almost stable level for the following three months, which might be associated with egg development as horse mackerel usually spawns early spring. In addition, Salihoğlu and Mutlu (2000) report that they observed a sharp decline in plankton amount in January for a number of years in Black Sea, which is in agreement with a dramatic decrease observed in fat content of horse mackerel and garfish in January. The results indicated that the protein content of horse mackerel was around 13% although it is higher in November and December. The average protein content for six months was found to be 14.78% in horse mackerel, which was lower than that reported by Celik (2008), Bandarra *et al*. (2001) and Osako *et al*. (2002). These researchers have found higher protein amounts in horse mackerel and their results were 18.66-20.13%, 18.3-19.9% and 17.5-21.6%, respectively. The difference might be because of species-specific characteristics, for instance, horse mackerel studied in this study was not the exact same species studied by Osaka *et al*. (2002). The difference in fat and protein content might be because of different catching locations as environmental conditions might cause dramatic variations among the same species living in different locations. Although the results obtained in this study are in agreement with fluctuations reported by Bandarra *et al*. (2001), in this study considerably higher fat and lower protein contents were observed in horse mackerel. Other components including water and mineral are in good agreement with those reported previously by these researchers.

Variations in proximate composition of shad are summarized in Table 2. The results obtained are in partial agreement with that previously reported by Guner *et al*. (1998). Guner *et al*. (1998) reported that fat content of shad is 15.91% which is lower than what was found in our study. The protein content of shad is reported to be 22.42% by Guner *et al*. (1998), which is higher than the average obtained in this study. This might be because of the inability to compare the average values of six months with the values obtained from a single sample obtained in different times of the catching season. In fact, the fat content of shad was found to be quite high in December, January, February, and March, compared to the previously reported results, which increased the average. This could be due to heavy feeding as a sign of preparation of spawning as shad normally spawns around June. It is found that shad has the highest fat among the species studied. While the fat content of shad was 19.70% on average and higher than that of other three species, its water content was lower as expected and as a result, the energy value of shad was higher compared to that of other three species studied.

The proximate composition of garfish was almost steady during the study period except January (Table 3). Significant declines in both protein and fat contents were observed in garfish which is in good agreement with the increase in the water content of garfish in January. The decline in fat and protein

Table 1. Monthly changes in proximate composition of horse mackerel [1, 2]

	Water(%)	Fat(%)	Protein(%)	Mineral(%)	Carbohydrate(%)	Energy (kJ/100 g)
October	75.01±0.16^{a}	8.42±0.12^{a}	13.78±0.17^{a}	2.19±0.14^{a}	0.61±0.31^{ab}	556±2.3^{a}
November	72.03±0.07^{b}	9.64±0.20^{b}	15.93±0.06^{b}	2.19±0.12^{a}	0.22±0.18^{b}	631±3.4^{b}
December	65.56±0.17^{c}	13.26±0.20^{c}	18.60±0.07^{c}	2.09±0.14^{ab}	0.50±0.24^{ab}	815±4.8^{c}
January	75.25±0.14^{a}	10.06±0.12^{b}	13.01±0.16^{d}	1.36±0.35^{c}	0.32±0.16^{ab}	599±1.1^{d}
February	73.99±0.15^{d}	9.55±0.13^{b}	13.45±0.22^{ad}	1.92±0.10^{ac}	1.09±0.13^{a}	600±3.1^{d}
March	73.14±0.10^{e}	12.15±0.10^{d}	13.91±0.22^{ad}	1.04±0.06^{bc}	0.14±0.04^{b}	676±0.7^{e}
Average	72.50	10.51	14.78	1.80	0.48	646
Std. Dev.	3.60	1.82	2.12	0.48	0.35	91.77

[1]Values are shown as mean ± standard error of duplicates.
[2]Within the column values with different letters are significantly different ($P<0.05$).

Table 2. Monthly changes in proximate composition of shad[1, 2]

	Water(%)	Fat(%)	Protein(%)	Mineral(%)	Carbohydrate(%)	Energy (kJ/100 g)
October	67.71±0.22^{a}	9.34±0.29^{a}	19.80±0.06^{a}	2.79±0.17^{a}	0.36±0.16^{ab}	688±12.5^{a}
November	68.13±0.16^{a}	8.80±0.19^{a}	19.25±0.11^{b}	2.77±0.16^{b}	1.05±0.07^{a}	670±3.8^{a}
December	59.28±0.10^{b}	23.23±0.09^{b}	15.81±0.08^{c}	1.54±0.12^{ac}	0.17±0.21^{ab}	1131±1.3^{b}
January	57.81±0.22^{c}	25.45±0.11^{c}	15.00±0.06^{d}	1.58±0.10^{c}	0.16±0.36^{ab}	1199±7.4^{c}
February	58.23±0.29^{c}	26.16±0.19^{cd}	14.43±0.06^{e}	1.06±0.10^{c}	0.13±0.13^{b}	1215±10.4^{c}
March	57.98±0.06^{c}	25.24±0.16^{d}	14.30±0.05^{e}	2.15±0.27^{d}	0.33±0.44^{ab}	1182±0.3^{c}
Average	61.52	19.70	16.43	1.98	0.37	1014
Std. Dev.	4.98	8.30	2.46	0.71	0.35	261.21

[1]Values are shown as mean ± standard error of duplicates.
[2]Within the column values with different letters are significantly different ($P<0.05$).

might be because of a potential starvation due to the sharp decrease in the amount of plankton in January reported by Salihoğlu and Mutlu (2000). Declines in the amount of the planktons might indirectly have an effect on the proximate composition of garfish as garfish mostly consumes plankton-eating species; i.e., anchovy. In addition, egg development might be the reason of decline in fat and protein content of garfish in January as garfish begins to spawn around February. Carbohydrate and mineral content of garfish were almost constant during the study. Interestingly, garfish had the highest protein but the lowest fat compared to that of the other species studied, which resulted in a relatively low energy value for garfish.

Variations in proximate composition of golden mullet are summarized in Table 4. As observed in the species studied, golden mullet also showed a decline in protein content in January because of a possible starvation due to the sharp decrease in the amount of plankton. Golden mullet consumes plankton-eating fish species. With respect to the fat content of golden mullet, a gradual decrease from October to December and then an increase from January to March was observed, which might be due to spawning as golden mullet normally spawns from July until November. Except a significant decrease in fat in December and in protein in January, the nutritional composition of golden mullet was almost steady during the study period. As the fat content of golden mullet is relatively low compared to that of the other species studied, its average energy value was the lowest, which suggests it might be suitable for low energy diets.

Considering all the results obtained, the water content of the species was low while their fat content were high in December. The protein content of horse mackerel, shad, garfish and golden mullet varied between 13.01-18.60%, 14.30-19.80%, 13.99-18.45% and 13.31-17.20%, respectively. When the average values are compared, the lowest amount of protein was in horse mackerel with 14.78% and the highest content of protein was in garfish with 16.89%. With respect to the content of water and fat, both the lowest water and the highest fat were in shad with the values of 61.52% and 19.70%, respectively. Similarly, the highest content of water and the lowest content of fat were in golden mullet with the values of 76.67% and 4.78%, respectively. Average energy values were 647 kJ for horse mackerel, 1014 kJ for shad, 479 kJ for garfish and 460 kJ for golden mullet per 100 g edible parts of fish samples.

Conclusions

The results suggest that the proximate composition of fish species greatly varies during the catching season. This might be due to physiological reasons and changes in environmental conditions, i.e., spawning, migration, and starvation or heavy feeding. Species-specific physiological characteristics might greatly affect the proximate composition. This study provides valuable information on variations in proximate composition of fish species studied in order to take necessary precautions in processing from a manufacturer point of view and to distinguish their

Table 3. Monthly changes in proximate composition of garfish[1, 2]

	Water (%)	Fat (%)	Protein (%)	Mineral (%)	Carbohydrate (%)	Energy (kJ/100 g)
October	75.18±0.10^{a}	4.95±0.00^{a}	17.47±0.18^{a}	2.17±0.07^{a}	0.23±0.15^{a}	484±0.6^{a}
November	73.01±0.03^{b}	5.90±0.05^{b}	18.45±0.05^{b}	2.21±0.04^{a}	0.43±0.11^{a}	539±1.1^{b}
December	74.00±0.04^{c}	5.70±0.03^{c}	18.20±0.09^{b}	1.96±0.01^{b}	0.14±0.14^{a}	523±0.1^{c}
January	81.24±0.26^{d}	3.21±0.04^{d}	13.99±0.01^{c}	1.02±0.03^{c}	0.54±0.25^{a}	365±5.5^{d}
February	76.79±0.12^{e}	4.55±0.05^{e}	17.08±0.04^{d}	1.06±0.05^{c}	0.53±0.27^{a}	467±1.7^{e}
March	75.68±0.04^{a}	5.91±0.05^{b}	16.15±0.03^{e}	1.93±0.04^{b}	0.34±0.02^{a}	498±0.8^{f}
Average	75.98	5.04	16.89	1.73	0.37	479
Std. Dev.	2.89	1.05	1.64	0.54	0.16	61.74

[1]Values are shown as mean ± standard error of duplicates.
[2]Within the column values with different letters are significantly different ($P<0.05$).

Table 4. Monthly changes in proximate composition of golden mullet [1, 2]

	Water (%)	Fat (%)	Protein (%)	Mineral (%)	Carbohydrate (%)	Energy (kJ/100 g)
October	75.77±0.17^{a}	4.81±0.18^{a}	16.77±0.14^{ab}	1.96±0.07^{ab}	0.69±0.07^{a}	474±5.3^{a}
November	76.69±0.34^{b}	4.65±0.23^{a}	16.55±0.09^{ab}	1.88±0.13^{ab}	0.23±0.11^{a}	457±8.4^{a}
December	77.55±0.29^{c}	2.62±0.20^{b}	17.20±0.24^{b}	2.23±0.12^{a}	0.41±0.36^{a}	396±2.3^{b}
January	80.11±0.02^{d}	4.19±0.22^{a}	13.31±0.20^{c}	1.87±0.14^{ab}	0.52±0.58^{a}	390±2.3^{c}
February	75.57±0.01^{a}	5.06±0.08^{a}	16.86±0.14^{ab}	1.91±0.13^{ab}	0.60±0.06^{a}	484±0.1^{a}
March	74.30±0.09^{e}	7.33±0.35^{c}	16.47±0.19^{a}	1.57±0.13^{b}	0.33±0.20^{a}	557±6.5^{d}
Average	76.67	4.78	16.19	1.90	0.46	460
Std. Dev.	2.01	1.52	1.44	0.21	0.17	61.94

[1]Values are shown as mean ± standard error of duplicates.
[2]Within the column values with different letters are significantly different ($P<0.05$).

nutritional value and make a choice based on that information from a consumer point of view.

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