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# Effects of Variations in Feed and Seasonal Changes on Body Proximate Composition of Wild and Cultured Sea Bass (*Dicentrarchus labrax* L.)

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**Abstract**

In this study, the effects of dietary composition and seasonal variation on fillet composition and some morphological indices of wild and cultured sea bass (average weight, 361 g) were investigated. Experimental fish were fed with two commercial pelleted feeds and two commercial extruded feeds in summer, winter and spring seasons of year 2004 at four marine fish farms in Aegean region in Turkey. No significant differences were found among the proximate composition of feed samples seasonally. The crude protein content (about 45%) in the commercial feeds was found similar ($P>0.05$), whereas the crude fat content (about 20%) in the extruded feeds was significantly higher ($P<0.05$) than those (about 13%) in pelleted feeds. No significant differences ($P>0.05$) were found in the condition factors (CF) of the cultured and wild sea bass, neither among different feeds nor among different seasons. The viscerosomatic index (VSI) and hepatosomatic index (HSI) values or visceral and liver lipid content of fish fed with the extruded feeds were higher ($P<0.05$) than in those fed with the pelleted feeds and wild fish. The VSI and HSI values of wild fish were similar ($P>0.05$) to the values of fish fed with lower fat diet. The visceral lipid content of cultured and wild fish significantly increased in summer, while the liver lipid content significantly increased in winter ($P<0.05$). No significant differences ($P>0.05$) were found in the ash content of the cultured and wild sea bass, neither among different feeds nor among different seasons. Crude protein levels of the fish fillet did not differ ($P>0.05$) among the fish fed with different commercial feeds or during different seasons, although the crude protein levels in the cultured fish were significantly higher ($P<0.05$) than that of the wild fish. A high positive correlation ($r = 0.84$, $P<0.01$) was found between the fillet lipid levels and the dietary lipid content. Furthermore, the lipid content of cultured fish fillet was not affected ($P>0.05$) by different seasons whereas the fillet lipid content of the wild fish during summer was slightly higher ($P<0.05$). Finally, the results of chemical analysis showed that the fillet composition of cultured and wild sea bass were good sources of protein and lipid in each of the three seasons.

*Key words*: Cultured and wild sea bass, *Dicentrarchus labrax*, dietary effect, seasonal variation, fillet quality.

## Introduction

Sea bass (*Dicentrarchus labrax*) is a fish species that has great economical importance in Turkey, and the Mediterranean mariculture industry. In Turkey the total production of the fish reached about 21.000 metric tones in 2003 (FAO, 2005). However, over production resulted in a considerable drop of the fish price of sea bass like other carnivorous fishes. Feed consumption represents the single largest expenditure in intensive culture operations. Growth and the feed requirements of fish have major importance in aquaculture. To improve productivity and profitability of aquaculture, we have to provide feeds that supply adequate levels of energy and protein to sustain efficient growth (Lupatsch *et al.*, 2003). It is well established for the majority of the cultured fish species that the efficiency of protein utilization can be improved by increasing the proportion of conventional energy sources (lipid and carbohydrate) in the diet (Peres *et al.*, 1999). While the protein sparing effect of dietary lipid is well demonstrated (Refstie *et al.*, 2001; Lanari *et al.*, 1998; Dias *et al.*, 1998), that of carbohydrate, particularly in some marine fish species, is still controversial (Peres *et al.*, 1999; Lanari *et al.*, 1999). During the last decade, there has been a marked increase in the use of extruded diets for cultured fish. These diets have superior water stability, better floating properties, and higher energy content than pelleted diets. The main effects of these diets include: an increase in fish growth, an improvement in feed conversion and an increase in hepatosomatic index (Ballestrazzi *et al.*, 1998). Furthermore, the direct dietary effect on body proximate composition of fish is well known (Lie, 2001; Jobling *et al.*, 1998). However, limited works have been carried out to the influence of the commercial feeds on body composition of cultured sea bass in Turkey (Eroldoğan *et al.*, 2004; Yıldız and Şener, 2003).

Water temperature plays an important role in governing growth of sea bream (Guinea and Fernandez, 1997) and sea bass (Person-Le Ruyet, 2004) via its effects on feeding and metabolism. In general, the proximate composition of fish body is influenced by water temperature (Person-Le Ruyet, 2004) and seasonal changes (Shiari *et al.*, 2002; Grigorakis *et al.*, 2002; Levesque *et al.*, 2002; Hamre *et al.*, 2003), but currently there are no detailed researches reported about the effect of seasonal

changes on the chemical composition and some morphological characteristics of cultured sea bass in Turkey. The aim of this study was to determine if any significant seasonal variation occurred in body quality parameters of cultured sea bass in Aegean Region from Turkey and to compare them with those of the wild fish.

## Materials and Methods

### Samples of Fish and Diet

Cultured sea bass, *Dicentrarchus labrax* (average weight, 423.2±28.0 g) and commercial feed samples were obtained from four fish farms in the Aegean coast of Turkey during the summer, winter and spring seasons in 2004. Wild sea bass (average weight, 299.0±25.7 g) were caught in the same region and seasons. Fish (initial weight of approximately 5 g) were cultured in the sea cages. Harvest stocking density of fish in the cages was 15-20 kg/m$^3$. Cultured sea bass were fed with commercial pelleted (6-8 mm) feed. The average seawater temperature was measured 15ºC (winter), 18ºC (spring) and 27ºC (summer) for cultured and wild fish. During the experiment, water salinity was about 35‰ to 38‰. The farms used different commercial feeds which were classified with letters A, B, C and D, respectively. Feeds (6-8 mm) were A pelleted (Kılıç yem, Muğla, Turkey), B extruded (EcoBio yem, İzmir, Turkey), C peletted (Çamlı yem, İzmir, Turkey) and D extruded (Trouvit feed, Skretting, Italy). Fish were fed at approximately 1% with the extruded feeds and 1.5% with the pellets of the body weight per day. The cultured sea bass fed with the same brand of feed. Feed samples and three sea bass samples were obtained from each fish farm seasonally. Similarly, three sea bass samples were caught in the farm area. Fish samples were killed and packaged with black nylon bags (packed into an insulated polystyrene box with dry ice) and then transported to the faculty laboratory. The samples were kept at –30ºC prior to the analysis.

### Proximate Analysis

The fillets, the livers and visceral organs of three fish samples for each experimental group were separately blended before the proximate analysis. All proximate analyses, that is, the moisture, crude protein, lipid, crude fiber and ash contents of commercial feeds and fish fillets were determined according to standard methods (AOAC, 1995). Crude protein was calculated as Nx6.25.

### Body Measurements

Body mass, length, and organ mass were recorded to evaluate the condition factor (CF) = ([total body weight (g)] / [total body length (cm)]$^3$ x 100), the hepatosomatic index (HSI) = ([liver weight (g)] / [total body weight (g)] x 100) and the viscerosomatic index (VSI) = ([viscera weight (g)] / [total body weight (g)] x 100) (Ricker, 1979).

### Data Analysis

All data were presented as means ± standard error. The SPSS software (version 11.5) was used for statistical analysis. Comparisons among sampling were made by one-way analysis of variance (ANOVA), at 5% confidence level using Duncan's test. Correlation coefficients were considered significant at $P<0.01$ and $P<0.05$ (Zar, 1984).

## Results and discussion

### Proximate Analysis of Experimental Feeds

The proximate compositions of commercial feeds are shown in Table 1. According to the results of analyses, there were not significant differences among the proximate composition in seasonally obtained feed samples. For this reason, the data are presented as the mean amounts. The moisture content of the commercial feeds was the highest in feed A and

**Table 1.** Proximate composition of the commercial feeds (Results represent means ±standard error, n=6)

| | Feed groups * | | | |
|---|---|---|---|---|
| | A (Pelleted) | B (Extruded) | C (Pelleted) | D (Extruded) |
| Chemical composition (%) | | | | |
| Moisture | 9.8±0.67$^a$ | 8.7±0.34$^{ab}$ | 8.7±0.46$^{ab}$ | 7.9±0.40$^b$ |
| Crude protein | 44.9±0.71$^a$ | 44.6±0.26$^a$ | 45.4±0.18$^a$ | 45.1±0.31$^a$ |
| Ether extract | 14.0±0.36$^b$ | 20.4±0.41$^a$ | 12.6±0.26$^c$ | 20.6±0.24$^a$ |
| Ash | 8.7±0.17$^b$ | 11.7±0.33$^a$ | 10.8±0.45$^a$ | 8.5±0.32$^b$ |
| Crude fiber | 3.2±0.45$^a$ | 2.7±0.36$^a$ | 2.6±0.34$^a$ | 2.5±0.22$^a$ |
| Nitrogen free extract | 19.3±0.55$^a$ | 11.8±1.10$^c$ | 19.4±0.50$^a$ | 15.5±0.69$^b$ |

*: Feeds A, B, C and D were used by different fish farms, respectively. These feeds were Kılıç yem, EcoBio yem, Çamlı yem and Trouvit feeds, respectively.

Results in each row with different superscript letters were significantly different ($P<0.05$). Means were tested by ANOVA and ranked by Duncan's multiple range test.

the lowest in feed D (P<0.05). The crude fat of the extruded feeds (feed B and D) were significantly higher (P<0.05) than the A and C pelleted feeds, while the nitrogen free extract were significantly lower (P<0.05). The crude protein and crude fiber of all feeds were found similar (P>0.05). Feeds B and C represented significantly higher (P<0.05) level of ash content than feeds A and D.

The dietary protein requirements of fish are generally higher than those of land animals (Wilson, 2002). However, protein is the most expensive component in diets for aquatic species. Formulated feeds for intensively reared carnivorous fish generally contain 40-50% crude protein (Wilson, 2002; NRC, 1993). Carnivorous species such as sea bass use fats more efficiently than carbohydrates as an energy source (Lovell, 1991).

The protein requirement for maximum growth of juvenile sea bass has been estimated to be around 50% (Wilson, 2002; Ballestrazzi *et al.*, 1994; Barnabe, 1990; Hidalgo and Alliot, 1988), and the optimum lipid level in the diets of sea bass is around 9-15% (Barnabe, 1990). Perez *et al.* (1997) also reported that the best growth for sea bass fingerlings was related to a diet containing 45% CP, and the percentage of carbohydrate in sea bass diets should not exceed 30%, and that lipid content can vary between 12 and 14%. Lanari *et al.* (1999) found that the growth parameters for sea bass (about initial weight, 91 and final weight, 340 g) improved when the dietary fat level was increased from 15 to 19%, while the increase from 21.5 to 28.5% in NFE content had no effect. In contrast, Peres and Oliva-Teles (1999) reported that the increase of dietary lipid level from 12 to 24% did not improve growth performance, feed efficiency and protein sparing, in sea bass juveniles. Similarly, Ballestrazzi and Lanari (1996) stated that growth performance and protein efficiency ratio of growing sea bass were not affected by dietary lipid source or lipid level from 13 to 21%. Beginning from the 1980s to 1990s, diets containing 12-14% crude fat have been commonly used for sea bass (Hidalgo and Alliot, 1988; Metailler *et al.*, 1980). Following the expansion in the use of the extrusion technique in feed production, the positive effects of extruded diets on growth performance were observed in salmonids fed diets characterized by high fat content; similar feeds have been formulated for sea bass and currently used in commercial farms (Lanari *et al.*, 1999). Ballestrazzi *et al.* (1998) reported that the moisture content of the extruded diet was lower than the pelleted diet, while the crude fat and crude fiber were higher. The proximate composition in the commercial pelleted and extruded feeds of our study agrees with the results reported by the researchers cited above.

**Body Measurements and Fillet Composition**

The results of condition factor, viscerosomatic index and hepatosomatic index of cultured and wild sea bass were shown in Table 2 and body composition in Table 3. No significant differences (P>0.05) were found in the condition factors (CF) of the cultured and wild sea bass neither among different feeds nor in seasons except for group A. The condition factor of

**Table 2.** Condition factor, viscerosomatic index and hepatosomatic index of cultured and wild sea bass at different seasons (Results represent means ±standard error, n=3)

| Seasons and fish groups* | Total length (cm) | Live weight (g) | Condition factor | Viscerosomatic index | Hepatosomatic index |
|---|---|---|---|---|---|
| Summer | | | | | |
| Wild | 26.7±0.75$^{e}$ | 224.3±7.75$^{h}$ | 1.2±0.06$^{ab}$ | 12.7±0.66$^{bcd}$ | 1.5±0.10$^{e}$ |
| A | 35.5±1.00$^{b}$ | 433.4±0.97$^{d}$ | 1.0±0.07$^{b}$ | 13.2±0.14$^{abc}$ | 1.6±0.08$^{cde}$ |
| B | 42.5±0.50$^{a}$ | 908.0±9.95$^{a}$ | 1.2±0.03$^{ab}$ | 16.4±0.76$^{ab}$ | 1.7±0.04$^{cde}$ |
| C | 29.2±0.75$^{cde}$ | 275.2±8.05$^{g}$ | 1.1±0.05$^{ab}$ | 13.8±0.05$^{abc}$ | 1.6±0.11$^{cde}$ |
| D | 32.8±0.71$^{bcd}$ | 370.2±7.55$^{f}$ | 1.1±0.09$^{ab}$ | 11.5±1.10$^{cd}$ | 1.7±0.02$^{cde}$ |
| Winter | | | | | |
| Wild | 28.6±0.18$^{de}$ | 271.8±5.34$^{g}$ | 1.2±0.03$^{ab}$ | 10.9±0.44$^{d}$ | 2.0±0.43$^{cde}$ |
| A | 33.0±0.29$^{bc}$ | 431.0±6.41$^{d}$ | 1.2±0.03$^{ab}$ | 16.1±0.27$^{abc}$ | 2.7±0.11$^{b}$ |
| B | 34.8±2.00$^{b}$ | 531.2±7.01$^{b}$ | 1.3±0.20$^{ab}$ | 17.7±0.76$^{a}$ | 3.5±0.45$^{a}$ |
| C | 30.7±2.75$^{cde}$ | 369.7±10.3$^{f}$ | 1.3±0.31$^{ab}$ | 12.5±2.88$^{bcd}$ | 2.2±0.59$^{bc}$ |
| D | 29.3±0.05$^{cde}$ | 294.9±11.8$^{g}$ | 1.2±0.05$^{ab}$ | 14.6±0.50$^{abc}$ | 3.8±0.53$^{a}$ |
| Spring | | | | | |
| Wild | 31.4±1.22$^{bcd}$ | 399.9±10.2$^{ef}$ | 1.3±0.12$^{ab}$ | 11.4±0.65$^{bcd}$ | 1.9±0.32$^{cde}$ |
| A | 27.1±0.29$^{e}$ | 297.6±2.04$^{g}$ | 1.5±0.05$^{a}$ | 15.0±1.20$^{abc}$ | 2.0±0.33$^{bcde}$ |
| B | 32.7±0.63$^{bcd}$ | 411.2±6.92$^{de}$ | 1.2±0.00$^{ab}$ | 14.6±1.10$^{abc}$ | 2.2±0.04$^{bcd}$ |
| C | 33.0±0.46$^{bc}$ | 474.1±7.92$^{c}$ | 1.3±0.05$^{ab}$ | 10.9±0.77$^{d}$ | 2.0±0.15$^{cde}$ |
| D | 29.1±0.24$^{cde}$ | 282.9±10.3$^{g}$ | 1.1±0.01$^{ab}$ | 13.6±0.81$^{abc}$ | 2.1±0.26$^{bcde}$ |

*: Fish A, B, C and D were cultured by different fish farms, respectively. These fish were fed feeds A, B, C and D, respectively.
Results in each column with different superscript letters were significantly different (P<0.05). Means were tested by ANOVA and ranked by Duncan's multiple range test.

**Table 3.** Fillet composition (percentage wet weight), the lipid percentage in the visceral and liver of cultured and wild sea bass at different seasons (Results represent means ±standard error, n=3)

| Seasons and fish groups* | Proximate composition of fillet | | | | Lipid contents of visceral and liver | |
|---|---|---|---|---|---|---|
| | Moisture | Crude protein | Crude lipid | Ash | Visceral lipid | Liver lipid |
| Summer | | | | | | |
| Wild | 74.1±0.27$^{abc}$ | 18.1±0.32$^{d}$ | 5.1±0.08$^{cd}$ | 1.4±0.00$^{ab}$ | 40.0±0.97$^{f}$ | 23.0±0.30$^{g}$ |
| A | 73.6±0.29$^{bc}$ | 19.5±0.39$^{bc}$ | 5.5±0.15$^{cd}$ | 1.5±0.29$^{ab}$ | 52.5±1.13$^{c}$ | 37.8±0.84$^{d}$ |
| B | 72.2±0.06$^{de}$ | 19.1±0.21$^{c}$ | 7.6±0.18$^{a}$ | 1.3±0.03$^{ab}$ | 77.8±1.16$^{a}$ | 39.4±1.22$^{c}$ |
| C | 74.0±0.11$^{ab}$ | 19.4±0.40$^{c}$ | 5.1±0.20$^{cd}$ | 1.4±0.06$^{ab}$ | 36.4±0.90$^{g}$ | 24.5±0.52$^{f}$ |
| D | 72.5±0.15$^{de}$ | 19.2±0.08$^{c}$ | 6.6±0.24$^{b}$ | 1.2±0.01$^{b}$ | 65.9±0.22$^{b}$ | 39.6±0.19$^{c}$ |
| Winter | | | | | | |
| Wild | 74.5±0.38$^{ab}$ | 18.6±0.42$^{cd}$ | 4.9±0.11$^{d}$ | 1.4±0.02$^{ab}$ | 29.9±0.10$^{h}$ | 27.9±0.20$^{e}$ |
| A | 70.3±0.56$^{g}$ | 20.6±0.31$^{a}$ | 5.6±0.17$^{c}$ | 1.6±0.03$^{a}$ | 23.7±0.16$^{j}$ | 40.8±0.10$^{c}$ |
| B | 70.8±0.11$^{fg}$ | 20.2±0.27$^{ab}$ | 7.4±0.18$^{a}$ | 1.3±0.08$^{ab}$ | 40.0±0.08$^{f}$ | 43.7±0.21$^{b}$ |
| C | 74.9±0.35$^{a}$ | 20.7±0.17$^{a}$ | 3.2±0.07$^{f}$ | 1.4±0.03$^{ab}$ | 15.8±0.09$^{k}$ | 28.6±0.26$^{e}$ |
| D | 71.5±0.63$^{ef}$ | 20.3±0.20$^{ab}$ | 6.3±0.08$^{b}$ | 1.6±0.24$^{a}$ | 48.7±0.18$^{d}$ | 48.2±0.24$^{a}$ |
| Spring | | | | | | |
| Wild | 74.8±0.08$^{a}$ | 19.2±0.17$^{c}$ | 4.0±0.09$^{e}$ | 1.3±0.01$^{ab}$ | 30.5±0.30$^{h}$ | 4.1±0.12$^{l}$ |
| A | 72.4±0.44$^{de}$ | 20.3±0.10$^{ab}$ | 5.5±0.06$^{c}$ | 1.4±0.09$^{ab}$ | 44.3±0.29$^{e}$ | 20.1±0.20$^{h}$ |
| B | 72.2±0.25$^{de}$ | 20.1±0.27$^{ab}$ | 6.1±0.23$^{b}$ | 1.3±0.03$^{ab}$ | 38.9±0.42$^{f}$ | 39.5±0.49$^{c}$ |
| C | 73.0±0.22$^{cd}$ | 20.9±0.40$^{a}$ | 3.9±0.17$^{e}$ | 1.4±0.03$^{ab}$ | 26.4±0.43$^{i}$ | 22.6±0.45$^{g}$ |
| D | 72.2±0.45$^{de}$ | 20.8±0.33$^{a}$ | 6.2±0.11$^{b}$ | 1.3±0.01$^{ab}$ | 36.7±0.40$^{g}$ | 45.0±0.30$^{b}$ |

*: Fish A, B, C and D were cultured by different fish farms, respectively. These fish were fed feeds A, B, C and D, respectively.
Results in each column with different superscript letters were significantly different (P<0.05). Means were tested by ANOVA and ranked by Duncan's multiple range test.

group A was highest in spring season and lowest in summer season. Similar results for cultured sea bass from Aegean Sea were reported by Yıldız and Şener (2003). Eroldoğan *et al.* (2004) also stated that CF of sea bass (body weight about 11.5 g) reared in fresh water or seawater and fed from 2.0% body weight day$^{-1}$ to 4.0% and not differ significantly from each other.

Lipids seem to be mainly deposited in the viscera. In this study, viscerosomatic index (VSI) is represented between 10.9 to 17.7% of body weight (Table 2) and lipids are represented between 15.8 to 77.8% of viscera fresh-weight (Table 3). No significant (P>0.05) effect of seasons on the VSI values of the cultured and wild sea bass was noticed. However, the highest VSI value was found in the fish fed with the higher fat diet (feed B, extruded) compared to those fed with the lower fat diet (feed C, pelleted) and the wild fish (P<0.05). The VSI values of wild fish were similar to fish fed with lower fat diet. Visceral lipid content of the cultured sea bass fed with the extruded feeds (feeds B and D) was generally higher (P<0.05) than those fed with the pelleted feeds (feeds A and C) and wild sea bass. Furthermore, the highest contents of visceral lipid in the cultured and wild fish were found in summer and the lowest in winter (P<0.05). Regression analysis of water temperature and visceral lipid content of the sea bass indicated a significant (r = 0.55, P<0.05) positive correlation. This indicates that fish had consumed more feed by the increase in temperature during summer. There was also a positive correlation (r = 0.62, P<0.05) between visceral lipid contents and dietary lipid content. Similar results show that the percentage of the VSI and visceral lipid in the sea bass steadily increased with dietary fat content (Peres and Oliva-Teles, 1999; Perez *et al.*, 1997). However, Metailler *et al.* (1980) observed that restricting feed intake was effective in reducing visceral lipid content in sea bass fingerlings. The VSI and visceral lipid results of our work on sea bass are generally in agreement with these conclusions. On the other hand, Ballestrazzi and Lanari (1996) and Dias *et al.* (1998) stated that the VSI and visceral lipids was unaffected by the diets which contain different fat levels.

In the present study, the hepatosomatic index (HSI) varied from 1.5 to 3.8% and liver lipid content ranged from 4.1 to 48.2% of liver wet weight (P<0.05). HSI values and liver lipid content were significantly higher (P<0.05) in fish fed with the extruded diets (feeds B and D) than in those fed the pelleted diets (feeds A and C). A significant positive correlation (r = 0.80, P<0.01) was found between the liver lipid content and the diets. The HSI values of wild fish were similar to fish fed with lower fat diet. Previous studies have also reported that an increase in dietary fat levels generally results an increased HSI values and liver lipid deposition (Peres and Oliva-Teles, 1999; Dias *et al.*, 1998; Perez *et al.*, 1997; Ballestrazzi and Lanari, 1996; Yıldız and Şener, 2003). In this study, the HSI and liver lipid content of wild sea bass were significantly lower (P<0.05) than the cultured sea bass. The HSI values of cultured fish were higher than those of wild fish which have also been reported for gilthead sea bream by Grigorakis *et al.* (2002). In our study, the HSI values and liver lipid

content of cultured and wild sea bass were found significantly higher (P<0.05) in winter than other seasons. A strong negative relationship was found in the correlation analysis between HSI and the water temperature (r = –0.88, P<0.01). It is well known that a rise in temperature increases standard metabolism, given the general effect of temperature on biochemical reactions of fish (Guinea and Fernandez, 1997). Similar results were obtained for trout by Hilton (1982), for yellow perch by Levesque *et al.* (2002) and for sea bream by Grigorakis *et al.* (2002) who observed an increase of HSI in winter samples of fish and explained as a metabolic malfunction of the liver during low temperature periods.

The results of proximate analysis in the fillets of the cultured and wild sea bass are shown in Table 3. The sea bass fed with extruded feeds had high levels of lipid and low levels of moisture compared with sea bass fed with pelleted feeds and wild sea bass (P<0.05), probably due to high fat level in the extruded feed (average 20.5%). A high positive correlation (r = 0.84, P<0.01) was found between the fillet lipid levels and the diets. This agrees with Peres and Oilva-Teles (1999) who observed, in sea bass juveniles, that the increase in dietary lipid level from 12 to 24% increased the whole body lipid deposition. The fillet lipid content of group A and group D were not affected by different seasons. But, the fillet lipid content was the lowest of group B (6.1±0.23%) in spring and group C (3.2±0.07) in winter seasons. This might indicate that the feeding regimes of farmers being used for sea bass are different. Person-Le Ruyet *et al.* (2004) reported that body lipid level was highest at the range of 13-16 ºC ranges for juvenile sea bass fed with the same diet at six constant water temperatures (13, 16, 19, 22, 25 and 29 ºC, respectively) and explained that it was a result of a low metabolic rate in sea bass at low water temperature. In the present study, the fillet lipid content of the wild fish during summer season was slightly higher and the reason for this situation may be the increase in nutrient sources with the increase in temperature of the seawater. Similar results also reported that for Norwegian herring (*Clupea harengus* L.) by Hamre *et al.* (2003).

Crude protein levels of the fish fillet did not differ (P>0.05) among fish fed with extruded or pelleted feeds, although the crude protein levels in the cultured fish were significantly higher (P<0.05) than those of wild fish. Similarly, no significant (P>0.05) effects of seasons on crude protein level in the fillets of fish were noticed. Grigorakis *et al.* (2002) also found that the protein levels in the cultured sea bream were similar, not indicating any significant seasonal variation. These results are in accordance with the conclusions of our study. In contrast, the same work reported that wild fish showed higher muscle protein levels (about 20% protein vs. an 18% in cultured fish) probably because of their significant lower lipid content. In the present study, no significant differences (P>0.05) were found in the fillet ash level of the cultured and wild sea bass, neither between different feeds nor between different seasons. This agrees with Ballestrazzi *et al.* (1998) who reported that the body ash level of sea bass was not affected by different diets. Grigorakis *et al.* (2002) also stated that no significant differences were observed in ash content, between wild and cultured sea bream. Person-Le Ruyet *et al.* (2004) reported that there were no differences body protein and ash levels of juvenile sea bass fed same diet at six constant temperatures (13, 16, 19, 22, 25 and 29ºC, respectively) during winter and summer seasons. Similar results were obtained for sea bass by Eroldoğan *et al.* (2004) who observed no interactive effect between culture condition and feeding rate was found for protein and ash content of fillet composition.

## Conclusions

This study demonstrated that there were effects of the commercial feeds and seasonal changes on the fillet composition, liver lipid deposition, visceral lipid content and some morphological indices of the sea bass at marine farms in Aegean Region, Turkey. The commercial feeds did not show significant differences between proximate compositions in different seasons (summer, winter and spring). The chemical composition of these feeds was found adequate for sea bass. Furthermore, crude fat content in the extruded feeds was higher than that in the pelleted feeds and the high crude fat content in the extruded feeds is more in agreement with the recent researches. The higher fat content in the extruded feeds increased the lipid deposition in the fillet, liver and visceral. Lipid deposition in wild sea bass indicates seasonal variation with a minimum deposition during spring and a maximum deposition during summer. Overall, the fillet lipid content of wild fish was found similar to that of the fish fed with pelleted feeds. There was an interaction among seasons and liver and visceral lipid content. Both parameters are important in the determination of metabolism and in the determination of sea bass during seasons. The liver lipid content was the highest during winter although visceral lipid content was the highest during summer. This indicates that fish had consumed more feed by the increase in temperature, and explained as a metabolic malfunction of the liver during low temperature periods. Finally, the results of chemical analysis indicate that the fillet of cultured and wild sea bass in Turkey was good source of protein and lipid in each of the three seasons.

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