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Effect of Dietary Lipid Sources on the Growth and Body Fatty Acid Composition of Sea Bass *Dicentrarchus labrax* L. 1758

[1]Arzu Ozluer Hunt and [2]Nazmi Tekelioglu
[1]Faculty of Fisheries, University of Mersin, 33160 Mersin, Turkey
[2]Faculty of Fisheries, University of Cukurova, 01330 Adana, Turkey

Abstract: This study was carried out in Yumurtalik Marine Research Station, University of Cukurova in Turkey. In this study was aimed to determine the effects of different levels of soybean oil and fish oil on growth and body fatty acid composition of sea bass (*Dicentrarchus labrax*). Initial mean body weights of test subjects were 4.80±0.25 g. The fish were housed within experimental, 210 l of experimental fiberglass tanks (20 fish/tank). Fish of all groups were fed on five different levels feed a 105 day period. The fish group fed with Diet 1 (12% Fish Oil = FO) followed by Diet 5 (12% Soybean Oil = SBO) showed the highest growth performance. In this study saturated, monounsaturated and polyunsaturated fatty acid changes in all groups were significant ($p>0.05$). On the basis of these results it can be concluded that soybean oil could be used as a partial dietary substitute for fish oil within compound feeds for sea bass.

Key words: Body composition, essential fatty acid, growth, sea bass, lipid sources

INTRODUCTION

Recently the European sea bass (D. *labrax*) production level has increased in the Mediterranean coastal waters. As a result, the market demand and price for fresh sea bass have increased noticeably over the past decade due to desirable aroma and quality attributes of this fish in every where in the world. A key factor for successful commercial fish farming is having the proper balance of feeds containing suitable nutritional components. Within the intensive culture systems feeds play a major role and should contain all the essential nutrients by specific fish species. Of these nutrients, dietary lipids play one of the most important roles as a source of energy and Essential Fatty Acids (EFA) required by fish for optimum growth (Oliva-Teles, 2000). Lipids are also important carriers of EFA and vital in absorption of fat soluble vitamins. The EFA requirements of fish have been well studied and a noticeable difference in the EFA requirements between freshwater and marine fish appears to be exist: Freshwater fish species generally require linoleic acid (18:2*n*-6) or linolenic acid (18:3*n*-3) or both, whereas marine fish require Eicosapentaenoik Acid (EPA: 20:5*n*-3) and/or docosahexaenoic acid (DHA: 22:5*n*-3) (NRC, 1993; Watanabe, 1988; Barnabe, 1990; Kalogeropoulos *et al*., 1992).

The effects of lipids and EFA on the growth of sea bass using different lipid sources and environmental condition have been studied by earlier researchers (Mohr, 1987; Boonyaratpalin, 1989). In order to supply energy requirements of fish, oil sources are excellent sources of *n*-3 fish oil, soybean oil and sunflower oil are also rich in *n*-6 fatty acid series (Pigot and Tucker, 1990). Fish oil is a natural food source for marine fish and contains essential fatty acids, particularly EPA and DHA with about 11.0-14.3% EPA and 9.1-9.6% DHA (NRC, 1993). Soybean oil (not a natural food for sea bass) lacks EPA and DHA, with 18:2*n*-6 dominating about 51-64% (NRC, 1993).

Regarding to optimum dietary lipid levels, Alliot *et al*. (1979), observed the best growth rate of sea bass is 12% lipids (range tested 8-14%), Peres and Oliva-Teles (1999) found no growth differences in sea bass fed diets ranging from 12-24% lipids, while with 30% lipids a growth depression occurred. Contemporary production of sea bass is a well controlled process but knowledge of their nutritional requirements has been studied. An adequate knowledge of the nutritional requirements is, however, of maximum importance for the formulation of high quality diets that promote optimum growth rates and feed efficiencies while minimizing feed wastes, so contributing to the sustained development of this industry (Oliva-Teles, 2000). The replacement of fish oil by vegetable oil in marine fish diets has been studied in turbot (Regost *et al*., 2003) and gilthead sea bream (Kalogeropoulos *et al*., 1992; Izquierdo *et al*., 2003;

Corresponding Author: Arzu Ozluer Hunt, Faculty of Fisheries, University of Mersin, 33160 Mersin, Turkey

Izquierdo *et al*., 2005), but few focused on the European sea bass, one of the most important marine finfish species for Mediterranean aquaculture and require more study for find which level how cause fish growth and body composition (Yildiz and Sener, 2002; Izquierdo *et al*., 2003).

This report describes the response of juvenile sea bass on 5 different levels FO and SO. Each diet had the same fat levels (18%) but their soybean oil and fish oil contents were various. The diets formulations were designed regarding the vitamin and mineral requirement of marine fish. The overall goal was to find out what type or levels of oil affect growth, body composition, feed utilization, flesh composition and fatty acid composition of sea bass juveniles.

MATERIALS AND METHODS

This study was conducted at the marine Research Station of the Faculty of Fisheries, University of Cukurova in Turkey. D. *labrax* fingerlings obtained from a commercial farm (Akuvatur, Tuzla, Adana, Turkey) and whose weights were 0.8±0.22 g (mean±s.e., n = 360) were housed in two, 1000l fiberglass tanks. Acclimination to seawater was done for approximately 4 weeks by arranged experiment. During this period fish received a commercial diet (Pinar, Granules No: 1.5). The feeding trials were conducted in 15 triangular fiberglass tanks (1.5 m length, 0.35 m, 0.40 m height, 210 l) stocking of 20 individual fish in each and located inside the building in three replicated. Each tank was continuously supplied with flow through seawater (40%) filtered by 1 μm with a sand filter and a series of cartridge filters (10, 5 and 1 μm) at a flow rate of approximately 2 L min^{-1} (98% h). Throughout the culture period (105 days), rearing water in each tank was permanently saturated with oxygen by supplying air continuously through air-stones from an air-blower. Daily recordings were taken at 08.00 h for abiotic parameters (temperature, dissolved oxygen and pH and salinity). Dissolved oxygen and pH were maintained above 7 mg L^{-1} and 7.5-7.8, respectively. Water parameters such as temperature, salinity, pH and dissolved oxygen were continuously monitored with YSI model 30 salinometer (Yellow Springs Instrument, Yellow Springs, OH, USA), an oxygen meter and a pH meter (pH 315i Set, WTW Measurement Systems, Germany). The average temperature was maintained at 24-27°C, as this temperature was reported as optimum for the European sea bass (Barnabe, 1990).

Fish were accustomed with a commercial sea bass feed (Pinar, No.1.5) for 3 weeks prior to starting the study. Five diets containing the same protein, carbohydrates and lipid levels were formulated using commercial raw materials. Protein, carbohydrate and lipid levels were kept fixed but the rates of fats consisting of the lipid concentration were unstable (Table 1). Diets were prepared by cooking-extrusion with semi-industrial twin-screw extruder. The processing conditions were as 2 cm diameter pellets. After prepared, all diets were measured in proximate analyses (Table 1) and fatty acid composition (Table 2).

Table 1: Percentage of raw materials and proximate analysis in the experimental diets

	Diets				
Raw materials (Percentage dry weight)	I 12% FO	II 9% FO	III 6% FO	IV 3% FO	V 0% FO
Fish meal	56	56	56	56	56
Soybean meal	10	10	10	10	10
Wheat meal	10	10	10	10	10
Corn meal	10	10	10	10	10
Fish oil	10	9	6	3	-
Soybean oil	-	3	6	9	12
Mineral mix.[a]	0.5	0.5	0.5	0.5	0.5
Vitamin mix.[b]	0.9	0.9	0.9	0.9	0.9
Endox-cemin[c]	0.025	0.025	0.025	0.025	0.025
Lignobond[d]	0.575	0.575	0.575	0.575	0.575
Proximate analysis*					
Dry matter	88.56±0.28	88.10±0.59	88.25±0.34	88.08±0.42	88.21±0.06
Crude protein	48.73±0.03	48.54±0.04	48.84±0.02	48.41±0.14	48.72±0.22
Crude fat	18.79±0.19	18.95±0.17	18.69±0.36	18.72±0.42	18.97±0.07
Ash	9.66±0.12	9.12±0.42	10.18±0.18	10.02±0.07	10.20±0.08
Gross energy (kcal kg^{-1})[e]	5421	5409	5335	5359	5366
Digestible energy (kcal kg^{-1})[f]	4411	4372	4322	4330	4339

*Values are shown mean±S.E. [a] M-1 (values are mg kg^{-1}):80.000 mg Mn, 35.000 mg Fe, 50.000 mg Zn, 5.000 mg Cu, 2.000 mg I, 400 mg Co,150 mg Se, [b]V-221(values are mg kg^{-1}): 4.800.000 IU Vit A, 800.000 IU Vit D, 12.000 mg Vit. E, 1.200 mg Vit. K,,1.200 mg thiamine, 2400 mg riboflavine, 2.000 mg Vit. B_6, 6 mg, Vit.B_{12},10.000 mg niacine, 16 mg biotine, 3.200 mg Calcium pantohenat, 400 mg folic asit, 120 mg choline chloride, 20.000 mg Vit C, [c] Endox-kemin: Antioxsidant (BHA+ Ethoxyquin+ 4% citric acid + mono+ diglycerides of edible fatty acids) 250 g Endox/ton of feed, [d]Binder e for gross energy = Carbohydrat:4.1 k cal g^{-1}, protein: 5.5 kcal g^{-1}, fat: 9.1 kcal g^{-1}, [f] for digestible energy = Carbohydrat 3.0 k cal g^{-1}, protein: 4.25 k cal g^{-1}, fat: 8.0 k cal g^{-1} (New, 1987)

Table 2: Fatty acid composition in diet groups

Fatty acids	Diet I*	Diet II	Diet III	Diet IV	Diet V
14:0	10.63±0.35	7.95±0.48	6.38±0.11	3.70±0.25	3.33±0.28
15:0	1.26±0.01	0.86±0.03	0.75±0.01	0.37±0.02	0.26±0.01
16:0	25.63±0.43	24.04±0.97	20.77±0.37	18.25±0.86	16.05±0.53
17:0	1.24±0.01	0.97±0.01	0.92±0.03	0.58±0.01	0.40±0.01
18:0	4.27±0.01	4.26±0.09	3.78±0.07	3.74±0.07	3.26±0.05
20:0	0.57±0.01	0.55±0.01	0.39±0.03	0.28±0.02	0.25±0.05
21:0	1.40±0.09	1.00±0.03	0.77±0.01	0.70±0.01	0.40±0.01
23:0	0.28±0.01	0.25±0.01	0.15±0.07	0.11±0.02	0.09±0.01
Saturated	45.28	38.32	33.91	27.73	24.04
14:1	0.30±0.03	0.29±0.01	0.22±0.03	0.10±0.03	0.80±0.01
16:1	8.65±0.17	6.17±0.14	5.89±0.19	3.11±0.11	2.60±0.14
17:1	0.73±0.02	0.52±0.01	0.51±0.01	0.48±0.13	0.40±0.01
18:1*n*-9	17.50±0.03	19.70±0.22	21.50±0.35	22.17±0.66	23.20±0.35
20:1*n*-9	0.86±0.03	0.65±0.13	0.46±0.01	0.37±0.01	0.30±0.07
22:1*n*-9	0.86±0.03	0.43±0.01	0.35±0.08	0.09±0.01	0.08±0.01
24:1*n*-9	0.38±0.06	0.36±0.01	0.21±0.01	0.20±0.06	0.12±0.03
Monounsaturated	29.28	28.12	29.14	26.52	27.50
18:2*n*-6	4.74±0.01	12.97+0.17	20.41±0.14	29.07±0.24	36.70±0.01
18:3*n*-3a	0.94±0.02	1.74±0.03	2.32±0.05	3.30±0.03	4.00±0.01
18:3*n*-6	0.12±0.01	0.19±0.05	0.20±0.02	0.21±0.01	0.23±0.01
20:2*n*11-14c	0.16±0.01	0.21±0.01	0.25±0.05	0.29±0.04	0.33±0.04
20:4*n*-6	0.85±0.02	0.61±0.01	0.49±0.01	0.37±0.03	0.15±0.01
20:5*n*-3	6.62±0.38	5.00±0.82	4.14±0.13	3.34±0.21	2.46±0.18
22:6*n*-3	7.82±0.12	5.38±0.37	4.51±0.51	2.25±0.17	1.79±0.20
Polyunsaturated	21.25	26.10	32.32	38.83	45.66
Unidentified	4.19	7.46	4.63	6.92	2.80
n-3 PUFA	15.38	12.12	10.97	8.89	8.25
n-6 PUFA	5.71	13.77	21.10	29.65	37.08
n-3/n-6	2.69	0.88	0.52	0.30	0.22
EPA/DHA	0.85	0.93	0.92	1.48	3.11

*: Different letter in the same line indicate difference ($p<0.05$), n = 3

Fish were fed by hand three times a day (07:00, 12:00 and 18:00 h) to apparent satiation. Pellets were distributed slowly to permit all fish to eat. Unconsumed feed and feces were removed from tanks every morning prior to feeding.

All fish were individually weighted and measured every 15 days in each tank. The fish were not fed 12 h prior to measurement. The tanks were rubbed and washed during each weighting. Prior to this, fish were anaesthetized with quinaldine at a concentration of 0.008 mg 100 mL^{-1}. At the end of the experiment, all fish from each tank were individually weighted (whole body wet weigh) and their total length was measured.

At the end of the 105 days, ten fish from each tank were randomly captured, sacrificed and piled for fillet, whole body composition and body fatty acid composition. Fillets and whole bodies were ground and homogenized in a blender and stored at -20°C and thawed at 4°C for 24 h prior to the analyses. Analyses started 6 days after sampling. The samples were dried to constant weight at 103°C. Ash content was determined by burning the samples at 450°C for 5 h (AOAC, 1984). The protein content of dried fillet and whole body samples were determined using the Kjeldahl method (Matissek *et al*., 1988). Total lipid was determined according to the method chloroform/methanol; 2:1 vol/vol (Blight and Dyer, 1959). Fatty acid composition was carried out IUPAC (1979) by Tubitak Marmara Research Center, Department of Food Institute in Gebze-Turkey. Fatty acid analysis of fish fillets was carried out using the IUPAC II D10 method. The measurements were made on a Termoquest Trace gas chromatograph equipped with SP-2330 fused silica capillary column, 30 × 0.25 mm ID 0.20 μm film thickness. The fatty acid methyl mixture No. 189-19 was used for standards (Sigma Chemical Company).

Statistical analysis of the data was carried out by one-way analysis of variance using a Statgraphics version 10.0 software package. The probability level for rejection of the hypotheses was 0.05. Significant differences among means were determined by the Duncan`s multiple range test.

RESULTS AND DISCUSSION

During the experiment time, survivals in 5 groups were 100%. Final body weight and specific growth rate (SGR) of sea bass fingerlings increased in Diet I from the first observation day until the 105th observation days.

The mean body weight of the diet groups were 4.80±0.25 g at initial whereas it varied between 6.10-7.96 g on the 15th observation period and 9.39-11.14 g on 30th period. There were significant differences in both

Table 3: Growth performances and feed utilization efficiency of juvenile sea bass fed the experimental diets

	Diet I	Diet II	Diet III	Diet IV	Diet V
Initial body weight (g)	4.80±0.25^{a}	4.80±0.25^{a}	4.80±0.25^{a}	4.80±0.25^{a}	4.80±0.25^{a}
Final body weight (g)	29.01±0.53^{a}	24.77±0.46^{b}	26.31±0.32^{c}	25.32±0.64^{bc}	24.77±0.19^{c}
Initial length (cm)	7.41±0.19^{a}	7.41±0.19^{a}	7.41±0.19^{a}	7.41±0.19^{a}	7.41±0.19^{a}
Final length (cm)	12.77±0.28^{ab}	12.53±0.19^{ab}	12.40±0.06^{a}	12.45±0.17^{a}	13.06±0.08^{b}
Weight gain (g kg^{-1} ABW day)	24.21	19.97	21.51	20.52	22.97
Specific growth rate[1] (SGR)	1.71	1.56	1.62	1.58	1.67
Feed intake (g kg^{-1} ABW day)	31.95	27.95	30.73	27.43	30.18
Food Conversion Ratio[2] (FCR)	1.32^{a}	1.40^{c}	1.43^{d}	1.34^{b}	1.31^{a}
Protein Efficiency Ratio[3] (PER)	1.55^{a}	1.46^{c}	1.43^{d}	1.51^{b}	1.55^{a}

*Figures in the same line with different superscript letters are different ($p<0.05$), Mean±S.E, [1] SGR: ((ln(final body weight)- ln(initial body weight))/ (time in days))×100, [2] FCR: Amount of (dry) feed intake/ wet weight gain, [3] PER: Wet weight gain/ crude protein intake

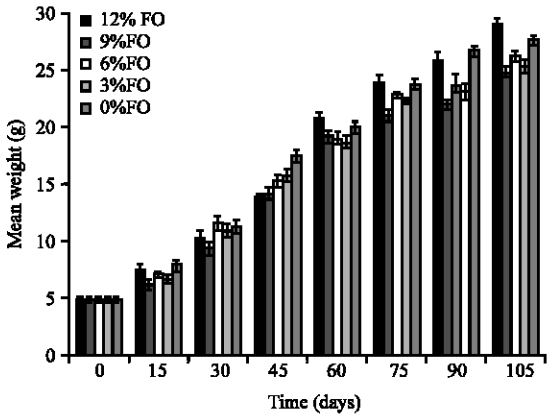

Fig. 1: Mean weight changes at day intervals of the fish fed different 5 diets. Each bar represents a mean±S.E (n = 20) differed from each other ($p<0.05$)

observation periods ($p<0.05$). On day 45, these weight amounts varied 13.88-17.57 g; on day 60, 19.09-20.75 g; on day 75, 21.10-23.89 g; on day 90, 22.0-26.75 g and last observation day (105 day), 25.32-29.01 g. Diet I (12% fish oil additive group) achieved more growth compared to other oil supplemented diet groups ($p<0.05$). Later, Diet V attained the best growth weight (Fig. 1).

Growth performance, Food Conversion Ratio (FCR) and Protein Efficiency Ratio (PER) of sea bass fed the experimental diets reported in Table 3. The final body weight of the fish fed on/with the 12% fish oil supplemented diet (I) was differed ($p<0.05$) and higher than the weight of those fed on/with the other diets.

However, no significant differences in weight gain were observed between the Diet V (no fish oil supplementation) and Diet III (6% fish oil+6% soybean oil). Feed intake (g kg^{-1} ABW/day) was differed with the Diet I and Diet V from with the other three diets. Feed Conversion Ratio (FCR) of fish fed the Diet I and V was lower and differed ($p<0.05$) than with other diets (Diet II, III and IV). PER of the 12% fish oil diet (I) and 12% soybean oil diet (V) were higher than that of the 9% fish oil+3% soybean oil (II), 6% fish oil+ 6%soybean oil (III), 3% fish oil+9% soybean oil (IV). The highest SGR (1.71% day^{-1}) were observed in sea bass juveniles reared on the Diet I. FCR of sea bass reared on the Diet I and V differed ($p<0.05$) from other three diets. PER and FCR were similar at the Diet I and Diet V. SGR one of the growth values obtained from the current trial ranged from 1.56-1.71% day^{-1} at the end 105 days when fish weighted around 30 g. Although within certain limits increasing dietary lipid levels improve diet utilization (Johnsen *et al*., 1993), in some studies showed that, the increase in dietary lipid level from 12-24% did not significantly affect growth rate or food efficient ratio (Morales and Oliva-Teles, 1995; Peres and Oliva-Teles, 1999).

In the present study, lipid level maintained at 18% in all experimental diets. Fish oil is a preferred lipid source and best growth performances of sea bream found with 15-16% lipids in the diet a study showed that, the highest SGR was obtained 1.67% day^{-1} for diet containing 15% lipid and 51% protein (Santinha *et al*., 1999). In the present study, the highest growth rate was found with Diet I and the second highest rate was found Diet V, including 12% soybean oil. Similar results were obtained from a study carried on sea bream which fed on soybean oil (Kalogeropolous *et al*., 1992). In this study, fish fed with different level of soybean oil was reported to obtain higher growth rate. Similar responses were previously observed in different studies and plus adding enough fish oil compromised slow growth rate (Nematipour and Gatliw-Delbert, 1993; Perez *et al*., 1997; Peres and Oliva-Teles, 1999). The best FCR and PER values obtained from Diet I and V. PER values did not effected negativity with soybean supplementation for diet V. At the same protein level (48%), for 12% soybean oil with 12% fish oil supplemented diet any negative response against growth was not observed. It was reported that 12% soybean oil additions were different from 12% cod-liver oil for PER ratio in the gilthead sea bream (Kalogeropolous *et al*., 1992). Another study which was altered lipid and protein level in sea bass diets observed SGR between 1.62- 2.05% day^{-1} (Perez *et al*., 1997). In the present study,

Table 4: Fillet and whole body composition of D. labrax fingerlings fed on different fat sources for 105 days

Diets		Crude protein (%)	Crude lipid (%)	Dry matter (%)	Ash (%)
Fillet	I	19.55±0.01^{a}	4.37±0.16^{a}	26.43±0.28^{a}	2.36±0.10^{a}
	II	19.53±.0.04^{a}	5.08±0.06^{b}	27.17±0.97^{a}	2.41±0.04^{a}
	III	19.55±0.05^{a}	5.25±0.21^{b}	27.42±0.59^{a}	2.47±0.02^{a}
	IV	19.59±0.10^{a}	4.86±0.21^{ab}	26.86±1.97^{a}	2.26±0.04^{a}
	V	19.22±0.02^{b}	5.37±0.16^{b}	27.15±0.14^{a}	2.41±0.13^{a}
Whole body	I	20.36±0.01^{a}	10.68±0.46^{a}	36.12±0.30^{a}	4.52±0.02^{a}
	II	20.21±0.04^{b}	12.24±0.15^{b}	37.48±0.34^{a}	4.47±.0.10^{a}
	III	20.18±0.02^{b}	11.14±0.12^{ca}	36.10±0.15^{a}	4.22±0.03^{a}
	IV	20.19±0.02^{b}	11.67±0.25^{bc}	36.71±0.04^{a}	4.29±0.10^{a}
	V	20.42±0.03^{a}	11.37±0.12^{ac}	36.80±0.16^{a}	4.45±0.02^{a}

Values are mean±S.E. (n = 3, each *n* consists of measurement of fish 7 fish), *Values in the column superscript are different (p<0.05)

Table 5: Fatty acid composition of diet groups in the fillet (%)

Fatty acids	Diet I*	Diet II	Diet III	Diet IV	Diet V
14:0	6.64±0.21^{a}	5.49±0.45^{b}	4.75±0.48^{b}	3.26±0.18^{c}	2.41±0.32^{c}
15:0	0.84±0.06^{a}	0.65±0.02^{b}	0.52±0.01^{c}	0.37±0.05^{d}	0.25±0.03^{e}
16:0	21.45±0.84^{a}	20.60±0.93^{a}	17.75±0.23^{b}	16.40±0.41^{b}	16.05±0.20^{b}
17:0	1.04±0.02^{a}	0.88±0.02^{b}	0.73±0.04^{c}	0.54±0.04^{d}	0.44±0.03^{d}
18:0	3.73±0.10^{a}	3.89±0.10^{a}	3.50±0.41^{a}	3.88±0.22^{a}	3.90±0.15^{a}
20:0	0.41±0.03^{a}	0.34±0.04^{ab}	0.32±0.03^{b}	0.28±0.01^{b}	0.18±0.01^{c}
21:0	1.25±0.02^{a}	0.95±0.03^{b}	0.90±0.05^{b}	0.58±0.06^{d}	0.47±0.03^{c}
23:0	0.35±0.02^{a}	0.29±0.01^{b}	0.27±0.01^{b}	0.21±0.01^{c}	0.16±0.01^{d}
Saturated	35.71	33.09	28.74	25.52	23.86
14:1	0.24±0.03^{a}	0.19±0.01^{b}	0.16±0.01^{b}	0.08±0.01^{c}	0.05±0.01^{c}
16:1	6.88±0.25^{a}	5.96±0.29^{b}	4.88±0.30^{c}	3.35±0.08^{d}	2.55±0.23^{e}
17:1	1.05±0.03^{a}	0.84±0.02^{b}	0.77±0.02^{c}	0.57±0.03^{d}	0.41±0.03^{e}
18:1*n*-9	18.93±0.23^{a}	20.86±0.84^{b}	21.24±0.30^{b}	22.38±0.60^{bc}	23.71±0.48^{c}
20:1*n*-9	1.88±0.07^{a}	1.33±0.03^{b}	1.28±0.17^{b}	1.24±0.06^{b}	1.02±0.07^{b}
22:1*n*-9	1.18±0.05^{a}	0.80±0.05^{b}	0.70±0.03^{b}	0.50±0.04^{c}	0.41±0.03^{c}
24:1*n*-9	0.50±0.02^{a}	0.45±0.03^{a}	0.26±0.02^{b}	0.25±0.02^{b}	0.21±0.01^{b}
Monounsaturated	30.66	30.43	29.29	28.37	28.36
18:2*n*-6	5.25±0.20^{a}	10.70±0.60^{b}	17.30+0.80^{c}	24.38±1.28^{d}	29.58±1.40^{e}
18:3*n*-3a	0.80±0.10^{a}	1.23±0.09^{b}	2.07±0.12^{c}	3.22±0.03^{d}	3.52±0.02^{e}
18:3*n*-6	0.18±0.01^{a}	0.20±0.01^{a}	0.24±0.01^{b}	0.24±0.01^{b}	0.26±0.01^{b}
20:2*n*11-14c	0.35±0.02^{a}	0.45±0.01^{b}	0.54±0.02^{b}	0.70±0.01^{c}	0.87±0.05^{d}
20:4*n*-6	0.70±0.04^{a}	0.60±0.03^{a}	0.48±0.02^{b}	0.42±0.03^{b}	0.32±0.01^{c}
20:5*n*-3	7.10±0.35^{a}	6.00±0.23^{b}	5.50±0.06^{b}	4.07±0.08^{c}	3.50±0.05^{c}
22:6*n*-3	11.37±0.62^{a}	9.73±0.44^{b}	8.44±0.26^{c}	6.04±0.37^{d}	4.54±0.15^{e}
Polyunsaturated	25.75	28.91	34.57	39.07	42.59
Unidentified	7.88	7.57	7.40	7.04	5.19
n-3 PUFA	19.27	16.96	16.01	13.33	11.56
n-6 PUFA	6.13	11.50	18.02	25.04	30.16
n-3/*n*-6	3.14	1.47	0.89	0.53	0.38
EPA/DHA	0.62	0.62	0.65	0.67	0.77

*: Different letter in the same line indicate difference (p<0.05). n = 3

even in the Diet V, lacking any oil supplementation there is some amount fish oil stemmed from fish meal. From some studies, it may be argued that sea bass and sea bream do not seem to use high dietary lipid levels as efficiency as salmonids. However, plant oils can be used up to certain levels to replace fish oil and considered as good alternative lipid sources (Alexis, 1997; Montero *et al*., 2005).

The results of proximate analysis of initial samples of fillet and whole body samples sea bass reared on different fat sources supplemented diets are given Table 4.

Concerning fillet composition, at the end of the growth trial, the protein content found in the fish fed on Diets I, II, II and IV was higher than and differed from that found in the fish fed on Diet V. Lipid content was lower in fish fed Diet I than fed on Diets II, III and V. Dry matter and ash content of the fish reared in different fat sources did not vary from each other in fillet or whole body composition (p>0.05).

The protein content in the whole body of sea bass was differed from fish fed on the diets I and V than the other three diets. However, lipid content of fish fed with Diet I, III and V was lower than those fed with in Diet II. Dry matter ranged between 36.10-37.48% in whole body content and the amount of dry matter was observed to higher than fillet dry matter composition. During the last few years, sea bass has been frequently sold as frozen products and/or in fillet frozen forms in Europe. In view of this, it is thought to be important to understand the effects of fish feed (especially feed components) on fillet composition and flesh quality (Oliva-Teles, 2000). The proximate composition, whole body and muscle

Table 6: Fatty acid composition of diet groups in the whole body (%)

Fatty acids	Diet I*	Diet II	Diet III	Diet IV	Diet V
14:0	8.61±0.60^{a}	6.08±0.54^{b}	6.03±1.02^{b}	3.74±0.30^{c}	2.93±0.20^{c}
15:0	1.01±0.05^{a}	0.74±0.03^{b}	0.71±0.06^{b}	0.43±0.03^{c}	0.27+0.01^{d}
16:0	22.42±0.33^{a}	21.00±0.61^{a}	20.75±1.10^{a}	17.72±0.86^{b}	17.71±0.17^{b}
17:0	0.45±0.04^{a}	0.28±0.06^{b}	0.15±0.03^{c}	0.08±0.01^{c}	0.06±0.01^{c}
18:0	4.02±0.35^{a}	3.98±0.10^{a}	4.11±0.30^{a}	4.55±0.08^{a}	4.70±0.20^{a}
20:0	0.45±0.02^{a}	0.39±0.05^{a}	0.35±0.02^{a}	0.17±0.06^{b}	0.16±0.02^{b}
21:0	1.22±0.01^{a}	0.85±0.04^{b}	0.82±0.01^{b}	0.57±0.01^{c}	0.33±0.02^{d}
23:0	0.30±0.01^{a}	0.27±0.01^{b}	0.20±0.01^{c}	0.18±0.01^{c}	0.11+0.01^{d}
Saturated	38.48	33.59	33.12	27.44	26.27
14:1	0.26±0.02^{a}	0.16±0.02^{b}	0.14±0.02^{b}	0.09±.0.01^{c}	0.06±0.01^{c}
16:1	7.71±0.23^{a}	6.22±0.11^{b}	5.53±0.32^{c}	3.82±0.12^{d}	2.84±0.03^{e}
17:1	0.54±0.01^{a}	0.46±0.03^{b}	0.37±1.33^{c}	0.27±0.01^{d}	0.15±0.02^{e}
18:1*n*-9	17.99±0.30^{a}	19.85±0.10^{ab}	20.10±0.26^{ab}	20.70±0.18^{b}	23.60±1.44^{c}
20:1*n*-9	1.86±0.23^{a}	1.58±0.12^{a}	1.53±0.35^{a}	1.64±0.06^{a}	1.40±0.02^{a}
22:1*n*-9	1.30±0.06^{a}	0.91±0.01^{b}	0.87±0.02^{bc}	0.77±0.01^{c}	0.62±0.30^{d}
24:1*n*-9	0.38±0.01^{a}	0.32±0.02^{b}	0.30±0.01^{b}	0.30±0.02^{b}	0.25±0.01^{c}
Monounsaturated	30.04	29.50	28.84	27.59	28.92
18:2*n*-6	5.15±0.11^{a}	11.54±0.39^{b}	18.75±0.49^{c}	24.39±0.61^{d}	29.20±0.82^{e}
18:3*n*-3a	0.93±0.02^{a}	1.42±0.01^{b}	2.02±0.04^{c}	2.46±0.09^{d}	2.66±0.11^{e}
18:3*n*-6	0.25±0.03^{a}	0.24±0.03^{a}	0.23±0.02^{a}	0.22±0.03^{a}	0.24±0.01^{a}
20:2*n*11-14c	0.32±0.01^{a}	0.51±0.05^{b}	0.62±0.02^{c}	0.87±0.02^{d}	0.92±0.02^{d}
20:4*n*-6	0.55±0.03^{a}	0.50±0.01^{a}	0.38±0.03^{b}	0.30±0.02^{c}	0.19±0.01^{d}
20:5*n*-3	5.71±0.15^{a}	5.04±0.13^{b}	3.90±0.22^{c}	3.33±0.11^{d}	2.20±0.08^{e}
22:6*n*-3	9.08±0.60^{a}	7.30±0.20^{b}	5.40±0.80^{c}	3.78±0.19^{d}	1.91±0.15^{e}
Polyunsaturated	21.99	26.55	31.30	35.35	37.32
Unidentified	9.49	10.36	6.74	9.62	7.49
n-3 PUFA	15.72	13.76	11.32	9.57	6.77
n-6 PUFA	5.95	12.28	19.36	24.91	29.63
n-3/*n*-6	2.64	1.12	0.58	0.38	0.23
EPA/DHA	0.63	0.69	0.72	0.88	1.15

*: Different letter in the same line indicate difference ($p<0.05$). n = 3

composition of fillet are affected by lipid and protein sources. Concerning different lipid sources, lipid and protein content of fillet were differed in the current study, although no clear trend in dry matter and ash content was observed at the end of the experimental period. This situation has already been demonstrated with sea bass, in which case, an increase in lipid level of diets from 12-30% caused a rise in the lipid content and decreased in the protein content of the whole body (Peres and Oliva-Teles, 1999).

The fatty acid profiles of the total lipids in the fillet and in the whole fish after treatment with the different diets are shown Table 5 and 6.

After the feeding trial, the composition of fatty acids, both in the muscle and the whole fish, was altered according to the diets. The main saturated fatty acids in sea bass, palmitic acid (16:0), which was about 21.45 and 22.42% in muscle and the whole fish, respectively; decreasing in diets I-V depends on soybean oil added diets. Similar results for sea bass reported in the literature (Krajnovic-Ozretic *et al*., 1994; Alasalvar *et al*., 2002). Other saturated fatty acids (14:0, 15:0, 17:0, 18:0, 20:0, 21:0 and 23:0) in the filet and whole fish decreased depends on increasing soybean oil and statistically different all diet groups ($p<0.05$). One study show that the total amount of saturated fatty acids in the sea bream fillet was altered 29.1-33.6% depends on increasing fish oil in diets like this study. In addition to same results are seen total saturated fatty acids. Various studies have shown that the composition of body lipids in fish is strongly influenced by dietary lipids, although in some cases the body fat shows a tendency to conserve certain characteristics that are peculiar to the species (Viagas and Guzman, 1998).

Oleic acid (18:1*n*-9) was identified as the primary monounsaturated fatty acid in both fillet and whole body and was differed ($p<0.05$) from fish oil supplementary diets. 18:1*n*-9 was revealed highest rate in animal oil; secondly plant oil and then sea food oil (Wanakowat and Boonyaratpalin, 1993). Correspondingly, 18:1*n*-9 was depending on decreasing fish oil amount in diets were 18.23-23.73% in fillet and 17.99-23.60% whole body. Similar result was shown in sea bream fed soybean oil added diets as 18.3% in whole body (El-Kardawy and Salama, 1997).

The composition of polyunsaturated fatty acids of the fish was strongly influenced by the fatty acids in the diets. The modification both in the fillet and the whole fish occurred mainly with acids 18:2*n*-6, 18:3*n*-3, 20:4*n*-6, 20:5*n*-6 and 22:6*n*-3. The amount of linoleic acid was altered between 5.25 and 29.58% in fillet; 5.15 and 29.20% in whole body and differed from all diet groups ($p<0.05$).

This fatty acid is present in plant oils, 48-58% in soybean oil (Alexis, 1997), used in the feed of cultured fish and is accumulated largely unchanged in the lipids of marine fish due to their reduced capacity for chain elongation and desuration (Kalogeropoulos *et al*., 1993; Alasalvar *et al*., 2002). So, higher amount of linoleic acid is related to use in feed soybean oil in diets and in this study was shown same results in 12% soybean oil added diet. Fish fed the diets containing more than 3% soybean oil indicate lower levels of 20:4*n*-6 (arashidonic acid) significant differences between other three diets (Diet 1 and Diet II).

Among the *n*-3 series, fish fed with diet I both muscle and whole body were good sources of 20:5n-3 and 22:6*n*-3 showed differed from in all diet groups ($p<0.05$). Those fatty acids that were highly unsaturated and had along chain length were preferentially deposited in the fillets in opposite relation to what occurred with the fatty acids with the smaller chain lengths. Short chain length fatty acids were deposited preferentially in the whole body, including visceral and cavitary fat. Amount of DHA and EPA was decreased both muscle and whole body depends on soybean oil supplementation in diets. EPA and DHA were shown even V (soybean oil added) diet in muscle and whole body because of fish meal.

Fish meal was supplied some fat for diets and shown in small amount depends on decreased fish oil. Lipids of wild fish are often higher in desirable *n*-3 fatty acids than farmed fish (Alasalvar *et al*., 2002). The differences between cultured and wild fish suggest the beneficial effects of seafood consumption may not be realized if fish are cultured with diets high in *n*-6 PUFA resulting in lower *n*-3 PUFA and lower *n*-3/*n*-6 ratios. In this study muscle fatty acids reflect dietary fatty acids, muscle concentrations of EPA may be a useful indicator of fish fed higher amount fish oils that have a higher proportion of EPA. Similar effect was shown *n*-3/*n*-6 ratio and differed ($p<0.05$) from in all diet groups. A significant increase of *n*-3 fatty acids can be achieved in sea bass muscle and whole body by feeding diets more fish oil added diets. Percentage of *n*-3 PUFA in cultured marine fish lipids is often lower than that in their wild counterparts because of artificial feeds usually include high proportion of lipids rich in SFA and MUFA but are deficient in *n*-3 HUFA. However, good choice of dietary lipid would tolerate the fatty acid composition of cultured fish to be modified to deal with the beneficial health aspects and consumer's demand. Additionally, the cost efficiency of feed formulations is a main factor.

The present results clearly showed that even in Diet V (12% soybean oil added), not having any fish oil addition, similar effect with normal level pelleted feed does whole body protein and fillet protein except for lipids. In correlation with this study was a shown lipid concentration in liver different in all diets (Hunt and Tekelioglu, 2004). Addition of soybean oil adds any level increase the protein level end of the trial. For sea bass, considering the effect of the soybean oil on bass body components and on fish growth might be used some only if supplied protein source as fishmeal. Fish can only supply *n*-3 fatty acids from fish oil for their diets (Alexis, 1997; Tucker *et al*., 1997; Orban *et al*., 2002). On the basis of encouraging results obtained during this feeding trial, it is clear that, depends on soybean oil level in diets, addition of fish oil diet growth better than other diets but protein content in fillet composition has shown same effect. It can suggest considerable potential for use in aqua feeds as a source of dietary energy depends on level in diets. However, although this plant lipid may be more available and/or cheaper than fish oil in some countries, considerable further research is required concerning its long term use in aqua feeds and concerning its possible effect on market size fish quality.

CONCLUSION

Fatty acid composition of both muscle and whole body of sea bass appear to respond to dietary treatment. However, there was no adverse effect of supplementary practical diets for sea bass with soybean oil as compared with fish oil. This study indicate that this kind of plant oil might use for fish feed and didn't bring any adverse effect for flesh quality.

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