Effect of two different protein/fat ratios of the diet on meagre (*Argyrosomus regius*) traits

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ABSTRACT

The aim of this study was to evaluate the effect of two diets with different protein/fat ratios (P/F) (diet A: P/F 2.26; diet B: P/F 3.36) on the chemical composition, fatty acid profile and some somatic indexes of meagre (*Argyrosomus regius*). The trial was carried out on two groups of meagre raised in two different sea cages during 15 months. At the end of the production cycle biometric measures as well as chemical-nutritional analysis of the fillets were conducted on 25 fishes per group. Diet A, with a lower P/F, furnished animals with higher percentages of mesenteric fat (0.48 *vs* 0.41%; P<0.01) and of fillet yield (51.21 *vs* 48.12; P<0.01). Moreover, the fillets obtained with the diet A showed higher percentage of fat (3.60 *vs* 2.41%; P< 0.01), lower moisture (74.10 *vs* 75.42%; P<0.01), lower losses of water under pressure (16.73 *vs* 20.20%; P<0.01) and after 48 h of refrigeration (3.08 *vs* 4.23%; P<0.01). The fatty acids profile of fillets was affected by the diet. Diet A resulted in a higher level of saturated fatty acids (26.44 *vs* 23.17% of total lipid; P<0.01) and a lower percentage of polyunsaturated fatty acids (31.56 *vs* 36.08%; P<0.01) in the fillet, mainly due to the lower content of linoleic acid (13.63 *vs* 19.77%; P<0.01). The atherogenic (AI) and thrombogenic (TI) indexes, which resulted very low in the fish of Group B (AI=0.48 *vs* 0.60, P<0.01; TI=0.33 vs 0.37, P<0.01), together with the low lipid content of meat in both groups, confirmed the very high nutritional quality of meagre fillets.

Key words: Meagre, Somatic indexes, Chemical composition, Fatty acid profile.

RIASSUNTO

INFLUENZA DEL RAPPORTO PROTEINE/GRASSI DELLA DIETA SULLE CARATTERISTICHE QUALITATIVE DELL'OMBRINA BOCCADORO (*ARGYROSOMUS REGIUS*)

Scopo dello studio è stato quello di valutare l'influenza di due diversi rapporti proteine/grassi (P/G) della dieta su alcuni indici somatici, sulla composizione chimica e sul profilo acidico dei lipidi della porzione *edule dell'Ombrina boccadoro (*Argyrosomus regius*). La prova è stata effettuata su due gruppi di ombrine allevate in due diverse gabbie a mare per un periodo di 15 mesi. I due gruppi hanno ricevuto per tutto il periodo di allevamento due diete caratterizzate da un diverso rapporto proteine/lipidi: A (P/G=2,26) e B (P/G=3,36). Al termine del ciclo di allevamento su 25 soggetti per gruppo sono stati condotti i rilievi biometrici e sono state valutate le caratteristiche chimico-nutrizionali delle carni. La dieta A, caratterizzata da un più basso rapporto P/G, ha fornito soggetti con maggiore incidenza di grasso mesenterico (0,48* vs *0,41%; P<0,01) e resa in filetto (51,21* vs *48,12; P<0,01). La suddetta dieta ha fatto registrare anche filetti che, oltre ad avere più elevato contenuto di lipidi (3,60 vs 2,41%; P<0,01) e più basso tenore di umidità (74,10* vs *75,42%; P<0,01), hanno presentato minori perdite di acqua alla compressione (16,73* vs *20,20%; P<0,01) e allo sgocciolamento (3,08* vs *4,23%; P<0,01). Anche la composizione acidica del grasso intramuscolare è stata influenzata dal trattamento alimentare. La dieta A ha fornito un profilo acidico caratterizzato da una maggiore presenza di acidi grassi saturi (26,44* vs *23,17% dei lipidi totali; P<0,01) e da una minore percentuale di acidi grassi polinsaturi (31,56* vs *36,08%; P<0,01), principalmente per un minor contenuto di acido linoleico (13,63* vs *19,77%; P<0,01). Gli indici di aterogenicità (AI) e di trombogenicità (TI), particolarmente bassi nei soggetti del gruppo B (AI=0,48* vs *0,60, P<0,01; TI=0,33* vs *0,37, P<0,01), unitamente al basso contenuto lipidico delle carni in entrambi i gruppi, rappresentano una evidente conferma delle ottime qualità dietetico-nutrizionali dei filetti di questa specie.*

Parole chiave: *Ombrina boccadoro, Indici somatici, Composizione chimica, Profilo acidico grassi.*

Introduction

In recent years, despite the constant increase in world aquaculture production, Italy has shown a decrease in water species production that involves almost all the raised species (ISMEA, 2005). Among the factors penalizing Italian fish production we should highlight a decrease in demand and the presence on the market of foreign products, which are very competitively priced. This is true for European sea bass (*Dicentrarchus labrax)* as well as gilthead sea bream (*Sparus aurata*), whose price is now very low compared with that of some years ago. Consequently, the specialists of the sector have perceived the necessity to introduce new valuable species, such as two-banded sea bream (*Diplodus vulgaris)*, sharpsnout sea bream (*Diplodus puntazzo)*, common dentex (*Dentex dentex)*, shi drum (*Umbrina cirrosa)*, turbot (*Psetta maxima)* and sole (*Solea solea)*.

Meagre (*Argyrosomus regius*) is a potential new species for Mediterranean marine aquaculture owing to its fast growth and to the chemical composition of its fillet (Poli *et al*., 2003). However, it is evident that, to improve its raising, further studies are needed to increase knowledge on the real potential of the species and the characteristics of the meat as affected by different diets.

This study aims to evaluate the main chemical-nutritional characteristics, such as proximate and fatty acids composition of the fillets and the biometrical characteristics of meagre bred in a cage system in a Sardinian bay and fed two commercial diets with different protein/fat ratio.

Material and methods

The trial was carried out on two groups of meagre bred for 15 months (September 2003 – December 2004) in a cage system placed in a Sardinian bay (Italy) and fed two commercial diets with a different protein/fat ratio (diet A=2.26; diet B=3.36). The meagre were placed into the cages at an average weight of 12.8 grams. Throughout the experimental period the water temperature ranged from a minimum of 8.5°C during winter to a maximum of 26.5°C during summer and the salinity from 31‰ to 38‰. The final stocking density was 9.8 kg/m^3.

Feeding rate ranged from 0.5% to 2% of biomass in function of the water temperature.

The diets were analysed for crude protein (CP), ether extract (EE), crude fibre (CF) and ash according to AOAC method (2000). The gross energy was determined by an adiabatic bomb calorimeter (Parr 1241). The fatty acid profile of the two diets was determined with the method utilised for the fillet as described below. The results of the macronutrient composition and fatty acid profile analysis are shown in Table 1.

After 15 months of breeding, when the fish reached an average weight of 869.1 and 811.8 g, respectively for groups A and B, twenty five fishes per group, as homogenous as possible in terms of body weight, in order to reduce the variability between the groups, were used for linear measurements, complete dissection of the body and to weigh the most important body components such as fillets, head, gills and fins. The morphometric indexes were calculated from the linear measures and weights as follows: condition factor (CF=100 x total weight/total lenght^3), cranial index (CI=length head/total length), agility index (AI=trunk and peduncle length/maximum height), relative profile (RP=maximum height/length total), dressing index (DI=100 x carcass weight/total weight), hepatosomatic index (HSI=100 x liver weight/total weight), viscerasomatic index (VSI=100 x viscera weight/total weight), mesenteric fat index (MFI=100 x mesenteric fat weight/total weight) and fillet yeld (FY = 100 x fillets weight/total weight).

On sections of the left fillets (25x25x5 mm) the water holding capacity was evaluated measuring the weight losses by 4 different methods: 1) after refrigeration (drip losses) at 4°C for 48h in a container with grate as indicated by Lundstrom and Malmfors (1985); 2) cooking on a hot plate (CHP) at 300°C until the core temperature of 70°C is reached (Wheeler *et al.*, 1990); 3) cocking in a bain-marie (CBM) in a polyethylene bag at 70°C for 15 minutes (Gault, 1985); 4) after compression for 10 min according to Grau and Hamm (1957).

After grinding and freeze-drying, the muscle proximate composition was determined. The moisture, protein and ash contents were determined according to AOAC (2000). The total lipids of fish muscles were extracted according to the Folch method (1957). The fatty acid composition of the fillets was determined by gas chromatographic separation on the fatty acid methyl esters (FAMEs), using a 30 m x 0.32 mm capillary column (Omegawax, Supelco Inc., Bellefonte, USA), hydrogen as carrier gas and flame ionisation detection (ThermoQuest TRACE GC). The FAMEs were identified by comparison of the retention times of known standards. The individual fatty acid concentrations were expressed as percentages of the total content (g of each fatty acid per 100 g of total fatty acids). Thirteen different fatty acids were determined in duplicate and grouped into saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), PUFA n-3 and PUFA n-6. The fat quality indexes were calculated according to Ulbricht and Southgate (1991) as follows:

Atherogenic index
(AI)=[C12:0+(4xC14:0)+C16:0]/(PUFAn-3+PUFAn-6+MUFA).

Since lauric acid (C12:0) was not detected in the samples, it was not taken into account for the calculations.

Thrombogenic index
(TI)=[C14:0+C16:0+C18:0]/[(0.5xC18:1) +(0.5 x sum of other MUFA) + (0.5xPUFAn-6) + (3xPUFAn-3) + (PUFAn-3/PUFAn-6)].

All the data were processed by ANOVA using a general linear model procedure of SAS (2000), according to the following model:

$Y_{ij} = \mu + S_i + \varepsilon_{ij}$

where Y is the single observation; μ is the general mean; S is the diet effect (i=diet A, diet B) and ε is the error.

Table 1. Proximate composition (g/kg) and fatty acid composition (% of total fatty acids) of the two commercial diets.

Diet	A	B
Moisture	90.1	110.2
Crude protein	468.0	470.1
Ether extract	207.0	140.2
Ash	85.2	109.6
Gross energy (MJ/kg)	21.5	19.4
CP/EE ratio	2.26	3.36
Fatty acids:		
C14:0	6.48	5.70
C16:0	19.06	18.32
C18:0	2.44	2.85
SFA	27.98	26.87
C16:1 n-7	7.82	7.05
C18:1 n-9	14.90	15.10
C22:1 n-11	5.05	5.12
MUFA	27.77	27.27
C18:2 n-6	6.44	7.98
C18:3 n-3	1.10	1.24
C18:4 n-3	3.22	3.18
C20:4 n-6	0.36	0.30
C20:5 n-3	7.72	7.55
C22:5 n-3	0.40	0.50
C22:6 n-3	10.93	9.62
PUFA	30.17	30.37
Other	14.18	15.49
n-3	23.37	22.09
n-6	6.80	8.28
n-3/n-6	3.44	2.67
AI	1.25	0.71
TI	0.31	0.31

SFA=saturated fatty acids; MUFA=monounsaturated fatty acids; PUFA=polyunsaturated fatty acids; AI=Atherogenic index; TI=Thrombogenic index.

Results and discussion

The biometric traits were not affected by the diet (Table 2), which instead affected some morphometric indexes (Table 3). The mesenteric fat (0.48 *vs* 0.41%) and FY (51.21 *vs* 48.12%) resulted significantly higher (P<0.01) in diet A, characterized by a lower protein/fat ratio. The low contents of mesenteric fat in both the groups and the low incidence of viscera made it possible to obtain high dressing indexes. These results are in agreement with the data recorded by Poli *et al*. (2003) in meagre of about 1 kg of body weight. Although the dressing indexes were higher than the values normally recorded in sea bass and gilthead sea bream (Poli *et al*., 1999; Poli *et al*., 2001) the fillet yield was similar to that of these species (48.6%). This is due to the high incidence of the head (average 25.3%), according to the data (26.8%) recorded by Poli *et al.* (2003). The other parameters reported in Table 3 were similar to the data reported by Poli *et al*. (2003) and confirmed that meagre is a fish with a low corpulence and a high agility index.

The different protein/fat ratio affected the compression and drip losses (Table 4) which were significantly (P<0.01) higher for meagre of group B (20.20 *vs* 16.73% and 4.23 vs 3.08%, respectively, for compression and drip losses). Unfortunately, the lack of data available in literature makes the evaluation of the results very difficult. Also, the fillet proximate composition was different between the diets (Table 4). Diet A, with a high fat percentage, furnished fillet with higher fat (3.60 *vs* 2.41%; P<0.01) and lower moisture (74.10 *vs* 75.42 %; P<0.01). However, for group A, the incidence of the fillet fat was very low as well, confirming that the name

Table 2. Effects of the diet on meagre biometric traits.

Diet		A	B	MSE
N.		25	25	–
Total weight	g	821.5	831.5	7293
Length (cm):				
Total		42.21	42.43	5.28
Standard		38.23	38.39	4.35
Head		9.98	9.93	0.086
Trunk		28.24	28.46	3.91
Maximum height	cm	8.19	8.10	0.29
Maximum thickness	"	5.17	5.03	0.34
Maximum girth	"	20.10	20.16	3.69
Gill Cover girth	"	19.77	19.69	4.14
Eyes girth	"	16.75	16.95	4.81

MSE=mean square error.

Table 3. Effects of the diet on meagre morphometric indexes.

Diet		A	B	MSE
N.		25	25	-
Gut	%BW	4.43	4.57	0.36
Head	"	24.92	25.71	19.28
Mesenteric fat	"	0.48[a]	0.41[b]	0.007
FY	"	51.21[a]	48.12[b]	2.14
HSI	"	1.54	1.56	0.09
Dressing index		93.4	93.3	1.31
Condition factor		1.22	1.14	0.26
Agility index		3.37	3.42	0.33
Cranial index		0.24	0.23	0.0001
Relative profile		0.19	0.19	0.0003

FY=Fillet Yeld; HSI=Hepatosomatic index; MSE=mean square error. A, B: P<0.01.

meagre of this species is perfectly appropriate. The raised meagre showed fat contents (about 3%) of fillets not very different from those of the wild caught fish and, from this point of view, is very different from the other species (in particular sea bass, gilthead sea bream and trout), in which higher percentages of fat (from 2 to 5 times) occur (Orban *et al.*, 1996; Lanari *et al.*, 1999; Orban *et al.*, 1999; Poli *et al.*, 2001; Ballestrazzi *et al.*, 2006). The low incidence of fat in the fillet of group A, fed a diet at 20.7% of fat, suggests that the use of diets with a progressive increase in fat levels is possible without wors-

Table 4. Effects of the diet on the meagre fillet, proximate composition and water holding capacity.

Diet		A	B	MSE
N.		25	25	-
Moisture	%	74.10[b]	75.42[a]	1.16
Protein	"	21.09	20.89	0.58
Lipid	"	3.60[a]	2.41[b]	0.69
Ash	"	1.24	1.31	0.099
CBM	"	26.12	26.53	1.39
CMP	"	24.11	24.50	6.09
Pressure losses	"	16.73[b]	20.20[a]	7.56
Drip losses	"	3.08[b]	4.23[a]	0.56

CBM=cooking in bain marie losses; CHP: cooking in hot plate losses; MSE=mean square error.
A,B: P<0.01.

Table 5. Effects of the diet on fatty acid composition of meagre fillets (% of total fatty acids) and on atherogenic and thrombogenic indexes.

Diet	A	B	MSE
C14:0	3.68[a]	3.34[b]	0.51
C16:0	18.99[a]	15.89[b]	0.56
C18:0	3.78	3.95	0.69
SFA	26.44[a]	23.17[b]	0.54
C16:1	4.68[a]	4.24[b]	0.29
C18:1	14.18[b]	15.24[a]	0.95
C22:1	5.93	5.43	0.95
MUFA	24.79	24.91	7.29
C18:2	13.63[b]	19.77[a]	2.57
C18:3	1.66[b]	2.20[a]	0.09
C18:4	1.12	1.03	0.10
C20:4	0.69[a]	0.57[b]	0.02
C20:5	4.15	4.03	0.84
C22:5	0.22	0.23	0.09
C22:6	10.10[a]	8.25[b]	1.03
PUFA	31.56[b]	36.08[a]	6.35
Other	17.20	15.84	8.12
N3	17.35[a]	15.74[b]	2.23
N6	14.32[b]	20.34[a]	6.47
N3/n6	1.21[a]	0.77[b]	0.08
AI	0.60[a]	0.48[b]	0.05
TI	0.37[a]	0.33[b]	0.03

SFA=saturated fatty acids; MUFA=monounsaturated fatty acids; PUFA=polyunsaturated fatty acids; AI=Atherogenic index; TI=Thrombogenic index; MSE=mean square error; A,B: P<0.01.

ening of the body composition in this species. Confirming what has already been stated, the protein content was similar for both groups (21.09 and 20.89%, respectively for groups A and B). The fillet proximate composition recorded in this trial was similar to that reported by Poli *et al*. (2003) for meagre with both lower and higher weight and to the data recorded by Segato *et al*. (2005) for an analogous species (Umbrina cirrosa).

Table 5 shows the fatty acid profile of the meagre fillets in the two groups. Palmitic acid (16:0) and oleic acid (18:1) were the predominant saturated and monounsaturated fatty acids in both fish groups while, among polyunsaturated fatty acids, 18:2, 20:5 and 22:6 were prevalent. Meagre fed diet B showed a lower amount of saturated fatty acids (SFA 23.17 *vs* 26.44%; P<0.01) due to a lower content of palmitic acid (15.89 *vs*

18.99%; P<0.01) compared to group A.

The total saturated fatty acids were in agreement with the data reported by Poli *et al*. (2003) in meagre of different weight as found also by other authors on different fish species (Orban *et al*., 2000; Rondan *et al*., 2004; Giani *et al*., 2005).

Some significant differences between the MUFA were found. In particular group A showed a significantly higher content of 16:1 (4.68 *vs* 4.24%, P<0.01) and lower concentration of 18:1 (14.18 *vs* 15.24%, P<0.01).

As regards polyunsaturated fatty acids, the fish fed diet B showed a significantly higher concentration of C18:2 (19.77 *vs* 13.63%, P<0.01) and C18:3 (2.20 *vs* 1.66%, P<0.01) and a lower concentration of C20:4 (0.57 *vs* 0.69%, P<0.01) and C22:6 (8.25 *vs* 10.10%, P<0.01). C18:2 n-6 values, resulted high in both groups if compared to the content of the diets. This could be attributed to the accumulation of this fatty acid as reported by Montero *et al.* (2005). This could be particularly true in our trial where the fish were fed the same diets for 15 months. The fish fed diet B were also characterized by a lower concentration of n-3 PUFA (15.74 *vs* 17.35%, P<0.01) and a higher concentration of n-6 PUFA (20.34 *vs* 14.32%, P<0.01).

The atherogenic and thrombogenic indexes show significant differences between the diets (AI=0.60 and 0.48, P<0.01; TI=0.37 and 0.33, P<0.01, respectively, for groups A and B). The lipid quality indexes were similar to those reported by Poli *et al*. (2003) for the meagre and by Rondan *et al.* (2004) and Ballestrazzi *et al.* (2006) for other fish species and to those of other foodstuffs which are advisable for human consumption (Peres-Llamas *et al*., 1998).

Conclusions

The results of the current study show that meagre is a fish that provides low-fat meat even under intensive farming conditions. The low presence of mesenteric fat and of intramuscular fat, also with the diet at the highest fat content, can promote the use of high-fat diets and, considering the high growth potential, the production of a large commercial size useful for the transformation industry. However, these results need to be confirmed by further research also aiming to identify the most suitable diets to enhance such favourable quality characteristics.

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