Journal of Fisheries
Volume 9 Issue 1 April 2021
Peer Reviewed | Open Access | Online First

eISSN 2311-3111
pISSN 2311-729X

DOI: https://doi.org/10.17017/j.fish.274

Original Article

Growth dependent changes in protein efficiency and amino acid composition in cultured meagre *Argyrosomus regius*

Birol Baki • Dilara Kaya Öztürk • Murat Kerim

Sinop University, Fisheries Faculty, Department of Aquaculture, 57000, Sinop, Turkey

Correspondence
Dilara Kaya Öztürk; Sinop University, Fisheries Faculty, Department of Aquaculture, 57000, Sinop, Turkey
dilara.kaya55@gmail.com

Manuscript history
Received 19 August 2020 | Revised 5 February 2021 | Accepted 12 February 2021 | Published online 23 February 2021

Citation
Baki B, Kaya Öztürk D, Kerim M (2021) Growth dependent changes in protein efficiency and amino acid composition in cultured meagre *Argyrosomus regius*. Journal of Fisheries 9(1): 91202. DOI: 10.17017/j.fish.274

Abstract
The goal of this research was to determine the growth dependent changes in protein efficiency and amino acid composition of the cultured meagre *Argyrosomus regius* (Asso, 1801). The research was carried in net cages in a private company (Gokce Off-shore Sist.) in the Aegean Sea. Meagre of an initial weight of 8.22 ± 0.13 g reached to 373.96 ± 15.65 g in 420 days of production period. Average protein efficiency rate, protein store rate and protein consumption values of cultured meagre were 1.05 ± 0.11%, 11.49 ± 2.98% and 56.67 ± 14.52 g respectively. The total amino acid values varied between 14.97 ± 0.14 and 18.87 ± 0.10 g 100g^{-1}, the statistical difference among the study periods was significant ($p < 0.05$). Most of the total essential (EAA), non-essential (NEAA), and branched-chain amino acid values of cultured meagre were decreasing with increasing fish size but EAA/NEAA ratios were increasing. The findings of this study showed that the composition of amino acids and the consistency of meagre culture were adequate and appropriate for human consumption and nutrition.

Keywords: Amino acid; *Argyrosomus regius*; meagre; protein efficiency.

1 | INTRODUCTION

Significant developments have been made in recent years for aquaculture of alternative fish species or nonconventional species in different culture systems around the world (e.g. Kamal *et al.* 2010; Galib *et al.* 2013; Rahman *et al.* 2020). However, while increasing the production performance of these alternative species, it is also important to reduce the production costs. The general characteristic of a successful candidate for alternate fish species is the fish species that have evolved to commercial size in a short period and whose meat content comes to the fore of consumer tastes. The meagre (*Argyrosomus regius*) is a species belonging to the Sciaenidae family (Kružić *et al.* 2016), which has been studied for a long time due to its high culture potential and extended distribution ranging from the European Atlantic coast to Africa, from the Mediterranean to the Black Sea (Poli *et al.* 2003; Couto *et al.* 2016). In Mediterranean countries, the production of cultured meagre was reflected in the statistics reaching from 750 tons in 2007 to 23400 tons in 2016 with a good feed conversion and growth rate (Monfort 2010; FAO 2020).

The meagre have a tolerance to wide salinity (5 – 39‰) as well as temperature (13 – 28 °C) (Quemener *et al.* 2002; Suquet *et al.* 2009). This species is capable of competing other sea fish species (e.g. *Dicentrarchus labrax* and *Sparus aurata*) and offers higher nutrition with low lipid level. Due to the low fat and high unsaturated fatty acids content of meagre, studies are primarily focused on meat quality of the species (Poli *et al.* 2003; Quemener 2002; Piccolo *et al.* 2008; Baki et al. 2019). Amino acid composition of meagre was studied in relation to diet composition (Martinez-Llorens *et al.* 2011; Güroy *et al.* 2017; Saavedre *et al.* 2017; Kotzamanis *et al.* 2018) and meagre source (i.e. wild and culture) (Saavedra *et al.*

2015; Saavedra *et al.* 2018). However, study on the growth-dependent composition and quality of amino acid of meagre has not been found so far. In aquaculture, the determination of protein quality and amino acid levels of the cultivated species is very important both for the determination of the amino acid requirements of the fish and for the producers and consumers. The purpose of this study is to determine the growth-related changes in protein efficiency and amino acid composition of the meagre of aquaculture origin.

2 | METHODOLOGY

The study was conducted in the open sea cage system of a commercial corporation (Gokce Off-shore Sist.) based in the province of Aydın (Town of Didim) on the Turkish coast of the Aegean Sea between September 2015 and November 2016. Meagre with an average weight of 8.22 ± 0.13 g were stocked in net cages. During the study, feeds containing 48.21 – 51.82% protein and 16.33 – 16.38% lipid (size: 1.8 – 5 mm) were used to fed the fish. Fish samples were taken randomly every two-month from the net cages (n = 100). Fish were euthanized with an overdose of the anesthetic MS-222 and samples were transported to the laboratory in cold chain conditions. Fish weights considered in this study were P1 (September – November), P2 (November – February), P3 (February – April), P4 (April – June), P5 (June – September) and final (September – November) were 8.22 ± 0.13 g, 50.23 ± 1.59 g, 141.46 ± 10.39 g, 153.48 ± 3.71 g, 214.79 ± 12.39 g, 314.95 ± 24.43 g and 373.96 ± 15.65 g respectively (after Baki *et al.* 2018).

After biometric measurements of fish fillets were mixed together and crude protein and amino acid analyses were done. Crude protein content was determined as total nitrogen content by Kieldahl method at The Scientific and Technological Research Council of Turkey Marmara Research Center (TUBITAK MAM) (AOAC 2000). Amino acid analysis of fish fillets was performed according to the Hydrolysis method using Eppendorf LC 3000 Amino acid analyser at TUBITAK MAM Food Institute. All analyses were performed in triplicates. The following equations were used for the calculation of Protein Efficiency Ratio (PER), Protein Store Rate (PSR) and Protein Consumption (PC): PER = Weight gain / Protein intake; PSR = [(Final weight x Final fish muscle crude protein) – (Initial weight × Initial fish muscle crude protein) / (Amount of feed × Feed crude protein)] × 100; PC = Total amount of feed consumed / Feed crude protein. Water temperature, dissolved oxygen (DO), salinity and pH were measured monthly using the YSI 556 MPS multiparameter device (Yellow Springs, OH, USA).

The results were presented as mean values ± SE. Statistical analysis was done in the IBM SPSS 21 statistical package programme. The normality and equality of variance of the data were analysed by Shapiro–Wilk normality and Levene's tests, respectively. The significance of differences between the results was analysed using one-way ANOVA, followed by Tukey's method for multiple comparisons.

3 | RESULTS

During the study, the average (± SE) water temperature, salinity, oxygen and pH values in the production area were 20.06 ± 0.88 (range: 15.66 – 24.32°C), 35.56 ± 0.05 (34.77 – 35.70‰), 9.34 ± 0.20 (8.77 – 9.91 mgL^{-1}) and 8.43±0.03 (8.31 – 8.55) respectively. Culture meagre with initial weight of 8.22 ± 0.13g reached to 373.96 ± 15.65 g weight after 14 months (see Baki *et al.* 2018 for details). The protein efficiency rate (PER), protein storage rate (PSR) and protein consumption (PC) values of culture meagre are given in Table 1. The mean (± SE) PER, PSR and PC values of culture meagre were 1.05 ± 0.11%, 11.49 ± 2.98% and 56.67 ± 14.52 g respectively.

TABLE 1 Protein efficiency rate (PER), protein storage rate (PSR) and protein consumption (PC) values.

Sample periods	PER (%)	PSR (%)	PC (g)
Initial – P1	0.98	19.33	43.04
P1 – P2	1.06	21.07	82.56
P2 – P3	1.05	2.78	10.99
P3 – P4	1.55	7.35	34.26
P4 – P5	0.79	11.32	110.32
P6 – Final	0.87	7.08	58.82
Mean (± SE)	1.05±0.11	11.49±2.98	56.67±14.52

Crude protein (CP) and amino acid compositions of culture meagre fillets are presented in Table 2. The CP values of culture meagre fillets varied between 18.69 ± 0.25 (in P4) and 20.10 ± 0.04% (in Final period) and the difference was significant between two groups ($p < 0.05$).

The highest amount of essential amino acids (EAA) among the study periods were lysine (1.61 ± 0.01 – 2.40 ± 0.02 g $100g^{-1}$) and leucine (0.97 ± 0.01 – 1.44 ± 0.01 g $100g^{-1}$) which also varied significantly across groups ($p < 0.05$) (Table 2). The highest amount of non-essential amino acids (NEAA) among the periods were aspartic acid (1.57 ± 0.01 – 2.40 ± 0.04 g $100g^{-1}$) and glutamic acid (2.44 ± 0.02 – 3.15 ± 0.04 g $100g^{-1}$), significant variation was also recorded among groups ($p < 0.05$). The statistical difference among all EAA and NEAA values across periods were significant ($p < 0.05$).

Amino acid properties of cultured meagre fillets are given in Table 3. The average (± SD) values of amino acid quality of cultured meagre fillets were Branched-chain amino acid (BcAA), 2.06 ± 0.02 – 3.10 ± 0.02 g $100g^{-1}$; sulphur-containing amino acid (SAA), 0.33 ± 0.01 – 0.65 ± 0.01 g $100g^{-1}$; aromatic amino acid (ArAA), 1.01±0.01 – 1.44 ± 0.01 g $100g^{-1}$; basic (alkaline) amino acid (BAA) 4.25 ± 0.03 – 5.54 ± 0.08 g $100g^{-1}$ and acidic amino acid (AAA), 2.67 ± 0.01 – 3.89 ± 0.02 g $100g^{-1}$. However, the differences in these values across study periods were significant ($p < 0.05$). The total amino acid (TA) content varied from 14.97 ± 0.14 to 18.87 ± 0.10 g 100g^{-1} and differed significantly across periods ($p < 0.05$). Essential amino acid (EAA) and non-essential amino acid (NEAA) values decreased in the final period than initial ones. The lowest and highest EAA / NEAA ratio were in P2 and P1 respectively.

TABLE 2 Crude protein and amino acid compositions of cultured meagre fillets.

Parameters	Periods						
	Initial	**P1**	**P2**	**P3**	**P4**	**P5**	**Final**
Crude protein (%)	19.54±0.16^{ab}	19.13±0.18^{ab}	18.94$^{\wedge}$	19.38$^{\wedge}$	18.69±0.25^{a}	19.10±0.22^{ab}	20.10±0.04^{b}
Essential amino acids (g 100g^{-1})							
Methionine	0.54±0.00^{b}	0.59±0.01^{e}	0.55±0.01^{d}	0.65±0.00^{f}	0.33±0.01^{a}	0.37±0.01^{b}	0.47±0.00^{a}
Phenylalanine	0.82±0.00^{b}	0.79±0.01^{cd}	0.69±0.01^{b}	0.77±0.01^{c}	0.54±0.01^{a}	0.53±0.01^{a}	0.67±0.00^{a}
Lysine	2.21±0.00^{b}	2.22±0.02^{c}	1.61±0.01^{a}	1.96±0.04^{b}	2.14±0.02^{c}	2.40±0.02^{d}	1.91±0.01^{a}
Leucine	1.44±0.01^{b}	1.30±0.01^{bc}	1.36±0.01^{c}	1.58±0.03^{d}	1.04±0.02^{a}	0.97±0.01^{a}	1.23±0.01^{a}
Isoleucine	0.83±0.01^{a}	0.78±0.01^{ab}	0.78±0.01^{ab}	0.83±0.02^{a}	0.63±0.16^{b}	0.59±0.01^{ab}	0.71±0.00^{a}
Arginine	1.01±0.01^{b}	1.09±0.01^{f}	0.36±0.01^{a}	0.40±0.01^{b}	0.69±0.01^{c}	0.70±0.01^{c}	0.86±0.00^{a}
Histidine	0.67±0.01^{b}	0.58±0.01^{b}	0.70±0.01^{cd}	0.76±0.03^{d}	0.44±0.01^{a}	0.44±0.01^{a}	0.58±0.01^{a}
Valine	0.84±0.00^{b}	0.80±0.01^{d}	0.67±0.01^{c}	0.78±0.01^{d}	0.54±0.00^{b}	0.50±0.01^{a}	0.70±0.00^{a}
Threonine	1.13±0.01^{b}	1.10±0.01^{de}	0.86±0.02^{c}	1.14±0.02^{e}	0.61±0.01^{a}	0.71±0.01^{b}	1.03±0.00^{a}
Non-essential amino acids (g 100g^{-1})							
Alanine	0.68±0.00^{b}	0.58±0.01^{a}	1.05±0.01^{d}	1.13±0.02^{e}	0.77±0.01^{c}	0.80±0.01^{c}	0.56±0.00^{a}
Aspartic acid	1.87±0.01^{b}	1.89±0.01^{b}	2.35±0.03^{d}	2.40±0.04^{d}	2.23±0.01^{c}	1.81±0.01^{b}	1.57±0.01^{a}
Glutamic acid	2.89±0.01^{b}	2.63±0.01^{b}	2.90±0.04^{c}	3.15±0.04^{d}	2.54±0.01^{a}	2.44±0.02^{ab}	2.68±0.01^{a}
Tyrosine	0.62±0.00^{b}	0.62±0.01^{e}	0.51±0.00^{c}	0.48±0.01^{ab}	0.46±0.01^{a}	0.50±0.01^{bc}	0.56±0.00^{a}
Glycine	1.41±0.00^{b}	1.01±0.01^{c}	0.99±0.00^{c}	0.97±0.02^{bc}	0.93±0.01^{ab}	0.99±0.01^{c}	0.90±0.00^{a}
Serine	0.91±0.00^{b}	0.79±0.01^{b}	1.06±0.01^{d}	1.16±0.02^{e}	0.67±0.01^{a}	0.77±0.03^{b}	0.78±0.00^{a}
Proline	0.80±0.00^{b}	0.62±0.01^{a}	0.58±0.02^{a}	0.73±0.03^{b}	0.56±0.01^{a}	0.55±0.01^{a}	0.62±0.00^{a}

Values in same row marked with different letters are significantly different ($p < 0.05$).
^ Statistical analyses could not be performed since the data obtained from TUBITAK MAM were single values

TABLE 3 Amino acids (total amino acids, TA; essential amino acids, EAA; semi-essential amino acids, SEAA; non-essential amino acids, NEAA; branched-chain amino acid, BcAA; sulphur-containing amino acids, SAA; aromatic amino acids, ArAA; basic (alkaline) amino acids, BAA; acidic amino acids, AAA; essential amino acids index, EAAI) quality of cultured meagre fillets (g 100g^{-1}).

Amino acids	Periods						
	Initial	**P1**	**P2**	**P3**	**P4**	**P5**	**Final**
TA	18.66±0.09^{e}	17.38±0.09^{d}	17.02±0.18^{c}	18.87±0.10^{ef}	14.97±0.14^{a}	15.03±0.11^{b}	15.05±0.06^{b}
EAA	9.48±0.06^{g}	9.25±0.05^{f}	7.58±0.07^{c}	8.87±0.05^{e}	6.80±0.15^{a}	7.20±0.07^{b}	8.18±0.03^{d}
SEAA	3.22±0.01^{f}	3.31±0.02^{g}	1.97±0.02^{a}	2.36±0.03^{b}	2.83±0.02^{cd}	3.10±0.02^{e}	2.77±0.01^{c}
NEAA	9.18±0.03^{d}	8.12±0.04^{c}	9.44±0.12^{e}	10.00±0.15^{f}	8.16±0.01^{c}	7.83±0.04^{b}	7.68±0.02^{a}
EAA/NEAA	1.03±0.01^{d}	1.14±0.01^{f}	0.80±0.01^{a}	0.89±0.02^{b}	0.83±0.02^{ab}	0.92±0.01^{c}	1.07±0.01^{de}
BcAA	3.10±0.02^{e}	2.88±0.01^{d}	2.81±0.03^{c}	3.20±0.01^{f}	2.06±0.17^{a}	2.06±0.02^{a}	2.65±0.01^{b}
SAA	0.54±0.01^{d}	0.59±0.01^{e}	0.55±0.01^{d}	0.65±0.01^{f}	0.33±0.01^{a}	0.37±0.01^{ab}	0.47±0.01^{c}
ArAA	1.44±0.01^{e}	1.40±0.01^{d}	1.21±0.01^{b}	1.24±0.02^{bc}	1.01±0.01^{a}	1.03±0.01^{a}	1.24±0.01^{bc}
BAA	3.89±0.02^{f}	3.89±0.03^{f}	2.67±0.01^{a}	3.12±0.06^{b}	3.26±0.02^{c}	3.54±0.03^{e}	3.35±0.01^{d}
AAA	4.75±0.02^{d}	4.53±0.03^{c}	5.24±0.07^{e}	5.54±0.08^{f}	4.47±0.01^{b}	4.25±0.03^{a}	4.26±0.02^{a}
EAAI	0.98±0.01^{f}	0.97±0.01^{f}	0.88±0.01^{bc}	0.95±0.01^{e}	0.83±0.01^{a}	0.86±0.01^{b}	0.91±0.01^{d}

Values in same row marked with different letters are significantly different ($p < 0.05$).
TA, Histidine + Lysine + Phenylalanine + Methionine + Threonine + Leucine + Isoleucine + Valine + Arginine + Alanine + Aspartic acid + Glutamic acid + Tyrosine + Glycine + Serine + Proline; EAA, Histidine + Lysine + Phenylalanine + Methionine + Threonine + Leucine + Isoleucine + Valine + Arginine; SEAA, Histidine + Arginine; NEAA, Alanine + Aspartic acid + Glutamic acid + Tyrosine + Glycine + Serine + Proline; BcAA, Leucine + Isoleucine + Valine; SAA, Cystine + Methionine; ArAA, Phenylalanine + Tyrosine; BAA, Lysine + Arginine + Histidine; AAA, Aspartic acid + Glutamic acid; EAAI, √(aa1 / AA1 × aa2 / AA2 × aa*n* / AA*n*) where aa1 = EAA of diets; AA1= EAA of fish; *n* = number of EAA.

4 | DISCUSSION

This study provides knowledge about different protein contents of cage-cultured meagre and the results are important from the commercial producers' and consumers' perspectives. In this study the growth-dependent changes in protein efficiency and amino acid composition of cultured meagre, produced net cages, were evaluated for the first time. Of the environmental factors that could affect the fish development, water temperature has the single most influential effect. The temperatures of the waters in the study did not differ from those reported suitable in literature (14 – 23°C) and may not be affected the growth (Quemener *et al.* 2002; Suquet *et al.* 2009).

A variety of factors are being considered by the consumers at the time of buying a fish in the market (Samad *et al.* 2010; Galib *et al.* 2013). For meagre it is usually the weight which is generally over 500 g (Monfort 2010). In this study, protein and amino acid assessments were performed based on individuals between 8.22 and 373.96 g. It has been stated that the crude protein ratios of meagre fillets of similar total weight varies from 20 – 21% (Costa *et al.* 2013; Giogios *et al.* 2013; Martelli *et al.* 2013). In the current study, the highest CP value of cultured meagre fillets was detected in the final period, while the lowest CP value was recorded in P4. The CP ratios of the cultured meagre fillet of similar weight were reported to be varied between 15.22 and 21.09% (Piccolo *et al.* 2008; Martinez-Llorens *et al.* 2011; Velazco-Vargas *et al.* 2013, 2014; Couto *et al.* 2016; Rodriguez-Lozano *et al.* 2016; Güroy *et al.* 2017; de Moura *et al.* 2018). It is assumed that the variations between the CP values of the meagre fillet in this study and the literature may be due to the quality of the fish feed and the culture environments. Abdel-Rahim *et al.* (2020) recorded a CP value of 16.33% (5 g) and 15.71% (23.93 g) in meagre farmed at differing salinity levels (from 8 to 32‰).

The PER of cultured meagre did not indicate much difference between the sampling time. Protein storage values, unlike PER, varied between sample periods. It is concluded that there are differences in the protein consumption values of fish between periods since the water temperature values can affect the feed intake of meagre. The PER decreased between the P4 and P5 and there was more feed consumption compared to other periods (see Baki *et al.* 2018 for details). Changes in protein storage values are closely linked to water parameters, growth and feed intake, and variations in water temperature can affect the protein consumption. The PER ranged from 0.40 to 2.39 was detected in studies with cultured meagre of same weight (e.g. Estevez *et al.* 2011; Martinez-Llorens *et al.* 2011; Velazco-Vargas *et al.* 2013; Couto *et al.* 2016; Emre *et al.* 2016; Abdel-Rahim *et al.* 2020). The raw material in feed, fish sizes and water parameters were reported to affect the protein efficiency ratios of cultivated meagre (Chatzifotis *et al.* 2010; Martinez-Llores *et al.* 2011; Velazco-Vargas *et al.* 2013; Emre *et al.* 2016) which is also the case in the present study.

Oliva-Teles (2012) stated that the amount of amino acids in fish meats is usually parallel to the amount of amino acids that fish need. For this reason, Saavedra *et al.* (2017) suggest that feeds of high protein and amino acid quality should be used, particularly during the larval phases. It has been observed that all amino acid values in meagre fillet decreased at the end compared to the initial period. Individuals (juvenile) in the present study were fed a higher quality protein diet. The amino acid values determined at the end of the study in the meagre fillet differed in relation to the size of the fish. The fillet was rich in lysine, leucine, aspartic and glutamic acid. In the study, the glutamic acid, lysine, leucine and aspartic acid, the most detected amino acids in marine fish (such as sea bream and sea bass), were present in higher amount (Tibaldi and Kaushik 2005; Özyurt and Polat 2006; Erkan and Özden 2007; Özden and Erkan 2008; Erdem *et al.* 2009; Kaba *et al.* 2009; Peres and Oliva-Teles 2009; Baki *et al.* 2015, 2017; Gaber *et al.* 2016; Moutinho *et al.* 2017). Nine EAAs with high levels of lysine followed by leucine and threonine were detected in the meagre fillet. Arginine, lysine, and leucine are the major EAAs in seafood (Rosa and Nunes 2004). Oladapa *et al.* (1984), in their study with seafood, stated that the main NEAAs were aspartic acid and glutamic acid which are also found in the present study. The EAA/NEAA ratios of cultured meagre fillets ranged from 0.80 to 1.14 and the differences among periods were significant. In other studies conducted with cultured meagre of same weight groups the EAA/NEAA ratios ranged has been reported to be varied from 0.70 to 0.92 (Martinez-Llorens *et al.* 2011; Rodriguez-Lozano *et al.* 2016; Saavedra *et al.* 2018). The EAA/NEAA ratios in this study are higher which may be due to feed efficiency and environmental parameters. The branched-chain, sulphur-containing, aromatic, basic, and acidic amino acids values calculated in the fillets of the cultured meagre in this study were suitable for human consumption.

5 | CONCLUSIONS

This study generates the knowledge of the growth dependent changes in protein efficiency and amino acid composition of the cultured meagre *Argyrosomus regius* which might be of interest to both producers and consumers. In this study, protein evaluation of cultured meagre was found similar to literature. The amino acid composition and quality of the species were suitable for human nutrition and balanced for human health.

ACKNOWLEDGEMENTS

This work was supported by Sinop University Scientific Research Coordination Unit (Project Number: SÜF-1901-15-01). This study was presented as a poster presentation

with English abstract in the ECOLOGY 2018, International Symposium Ecology 19–23 June 2018, Kastamonu Turkey.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS' CONTRIBUTION

All authors contributed equally. All authors gave final approval for publication and agree to be held accountable for the work performed therein.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on reasonable request from the corresponding author.

REFERENCES

Abdel-Rahim MM, Lotfy AM, Toutou MM, Aly HA, Sallam GR, ... Helal AM (2020) Effects of salinity level on the survival, growth, feed utilization, carcass composition, haematological and serum biochemical changes of juvenile meagre (*Argyrosomus regius*) (Asso, 1801) grown in ground saltwater. Aquaculture Research 91(3): 1038–1050.

AOAC (2000) Official methods of analysis. Gaithersburg, MD: Association of Official Analytical Chemists.

Baki B, Gönener S, Kaya D (2015) Comparison of food, amino acid and fatty acid compositions of wild and cultivated sea bass (*Dicentrarchus labrax* L.,1758). Turkish Journal of Fisheries and Aquatic Sciences 15: 175–179.

Baki B, Kaya Öztürk D, Kerim M (2017) Determination of essential amino acid changes related to the growth of sea bass (*Dicentrarchus labrax*). Turkish Journal of Fisheries and Aquatic Sciences 17(7): 1425–1429.

Baki B, Kaya Öztürk D, Kerim M (2018) Determination of rowth and nutrıent composıtıon values in meagre (*Argyrosomus regius*) aquaculture. International Journal of Ecosystems and Ecology Science 8(2): 257–262.

Baki B, Kaya Öztürk D, Kerim M (2019) Determination of fatty acid composition in relation to the growth of meagre (*Argyrosomus regius*) cultured in net cages. Journal of Fisheries 7(2): 685–691.

Chatzifotis S, Panagiotidou M, Papaioannou N, Pavlidis M, Nengas I, Mylonas CC (2010) Effect of dietary lipid levels on growth, feed utilization, body composition and serum metabolites of meagre (*Argyrosomus regius*) juveniles. Aquaculture 307: 65–70.

Costa S, Afonso C, Bandarra NM, Gueifao S, Castanheira I, ... Nunes ML (2013) The emerging farmed fish species meagre (*Argyrosomus regius*): how culinary treatment affects nutrients and contaminants concentration and associated benefitrisk balance. Food and Chemical Toxicology 60: 277– 285.

Couto A, Barroso C, Guerreiro I, Pousao-Ferreira P, Matos E, ... Enes A (2016) Carob seed germ meal in diets for meagre (*Argyrosomus regius*) juveniles: growth, digestive enzymes, intermediary metabolism, liver and gut histology. Aquaculture 451: 396–404.

de Moura LB, Diogenes AF, Campelo DAV, de Almeida FLA, Pousao-Ferreira PM, ... Peres H (2018) Taurine and methionine supplementation as a nutritional strategy for growth promotion of meagre (*Argyrosomus regius*) fed high plant protein diets. Aquaculture 497: 389–395.

Emre Y, Kurtoğlu A, Emre N, Güroy B, Güroy D (2016) Effect of replacing dietary fish oil with soybean oil on growth performance, fatty acid composition and haematological parameters of juvenile meagre, *Argyrosomus regius*. Aquaculture Research 47: 2256–2265.

Erdem ME, Baki B, Samsun S (2009) Fatty acid and amino acid compositions of cultured and wild sea bass (*Dicentrarchus labrax*, L., 1758) from different regions in Turkey. Journal of Animal and Veterinary Advantages 8(10): 1959–1963.

Erkan N, Özden Ö (2007). The changes of fatty acid and amino acid compositions in sea bream (*Sparus aurata*) during irradiation process. Radiation Physics and Chemistry 76(10): 1636–1641.

Estevez A, Trevino L, Kotzamanis Y, Karacostas I, Tort L, Gisbert E (2011) Effect of different levels of plant proteins on the ongrowing of meagre (*Argyrosomus regius*) juveniles at low temperature. Aquaculture Nutrition 17: e572–e582.

FAO (2020) Cultured Aquatic Species Information Programme *Argyrosomus regius* (Asso, 1801) http://www.fao.org/fishery/culturedspecies/Argyrosomus_regius/en. Retrieved on 4 July 2020.

Gaber MM, El- Salem S, Zaki M, Nour MA (2016) Amino acid requirements of gilthead bream (*Sparus aurata*) Juveniles. World Journal of Engineering and Technology 4: 18–24.

Galib SM, Mohsin ABM, Chaki N, Fahad MFH, Haque SMM (2013) An overview of the traditional rice-prawn-fish farming in Kalia of Narail district, Bangladesh. Journal of Fisheries 1(1): 1–6.

Galib SM, Naser SMA, Mohsin ABM, Chaki N, Fahad MFH (2013) Choice of fishes for consumption by the rural people of Bangladesh. Trends in Fisheries Research 2(1): 20–23.

Giogios I, Grigorakis K, Kalogeropoulos N (2013) Organoleptic and chemical quality of farmed meagre (*Argyrosomus regius*) as affected by size. Food Chemistry 141: 3153–3159.

Güroy D, Karadal O, Güroy B, Mantoğlu S, Çelebi K, Şimşek O, ... Genç E (2017) The effects of dietary protein levels with amino acid supplementation on the growth performance, haematological profile and histology of meagre (*Argyrosomus regius*) in two different size classes. Aquaculture Research 48: 5751–5764.

Kaba N, Yücel Ş, Baki B (2009) Comparative analysis of nutritive composition, fatty acids, amino acids and vitamin contents of wild and cultured gilthead seabream (*Sparus aurata* L.,1758). Journal of Animal and Veterinary Advances 8(3): 541–544.

Kamal MM, Mondol RK, Galib SM, Nahar MDG (2010) A study on traditional prawn farming systems at Manirampur Upazila of Jessore, south-west district of Bangladesh. Journal of Environmental Science & Natural Resources 3(1): 143–146.

Kotzamanis Y, Kouroupakis E, Ilia V, Haralabous J, Papaioannou N, ... Gisbert E (2018) Effects of high-level fishmeal replacement by plant proteins supplemented with different levels of lysine on growth performance and incidence of systemic noninfectious granulomatosis in meagre (*Argyrosomus regius*). Aquaculture Nutrition 24: 1738–1751.

Kružić N, Mustać B, Župan I, Čolak S (2016). Meagre (*Argyrosomus regius* Asso, 1801) aquaculture in Croatia. Croatian Journal of Fisheries 74(1): 14–19.

Martelli R, Dalle Zotte A, Bonelli A, Lupi P, Franci O, Parisi G (2013) Macronutrient and fatty acid profiles of meagre (*Argyrosomus regius*) fillets as influenced by harvesting time and boiling. Italian Journal of Animal Science 12(88): 538–545.

Martinez-Llorens S, Espert J, Moya J, Cerda MJ, Tomas-Vidal A (2011) Growth and nutrient efficiency of meagre (*Argyrosomus regius*, Asso 1801) fed extruded diets with different protein and lipid levels. International Journal of Fisheries and Aquaculture 3(10): 195–203.

Monfor MC (2010) Present market situation and prospects of meagre (*Argyrosomus regius*), as an emerging species in Mediterranean aquaculture. Studies and Reviews. General Fisheries Commission for the Mediterranean, 28. No. 89. Rome, FAO.

Moutinho S, Martínez-Llorens S, Tomás-Vidal A, Jover Cerdá M, Oliva-Tele A, Peres H, (2017) Meat and bone meal as partial replacement for fish meal in diets for gilthead seabream (*Sparus aurata*) juveniles: Growth, feed efficiency, amino acid utilization, and economic efficiency. Aquaculture 468: 271–277.

Oladapa A, Akın MAS, Olusegun LO (1984) Quality changes of Nigerian traditionally processed freshwater fish species. II. Chemical composition. Journal of Food Technology 19: 341–348.

Oliva-Teles A (2012) Nutrition and health of aquaculture fish. Journal of Fish Diseases 35: 83–108.

Özden Ö. Erkan N (2008) Comparison of biochemical composition of three aqua cultured fishes (*Dicentrarchus labrax*, *Sparus aurata*, *Dentex dentex*). International Journal of Food Sciences and Nutrition 59(7-8): 545–557.

Özyurt G, Polat A (2006) Amino acid and fatty acid composition of wild sea bass (*Dicentrarchus labrax*): a seasonal differentiation. European Food Research and Technology 222: 316–320.

Peres H, Oliva-Teles A (2009) The optimum dietary essential amino acid profile for gilthead seabream (*Sparus aurata*) juveniles. Aquaculture 296: 81–86.

Piccolo G, Bovera F, De Riu N, Marono S, Salati F, ... Moniello G (2008) Effect of two different protein/fat ratios of the diet on meagre; (*Argyrosomus regius*) traits. Italian Journal of Animal Science 7: 363–371.

Poli BM, Parisi G, Zampacavallo G, Lurzan F, Mecatti M, ... Bonelli A (2003) Preliminary results on quality and quality changes in reared meagre (*Argyrosomus regius*): body and fillet traits and freshness changes in refrigerated commercial-size fish. Aquaculture International 11: 301–311.

Quemener L (2002) Le maigre commun (*Argyrosomus regius*). Biologie, peche, marche et potential aquacole. Ifremer, Plouzane (In French).

Quemener L, Suquet M, Mero D, Gaignon JL (2002) Selection method of new candidates for finfish aquaculture: the case of the French Atlantic, the Channel and the North Sea coasts. Aquatic Living Resource 15: 293–302.

Rahman MM, Haque SM, Galib SM, Islam MA, Parvez MT, ... Brown C (2020) Mud crab fishery in climate vulnerable coastal Bangladesh: an analysis towards sustainable development. Aquaculture International 28: 1243–1268.

Rodriguez Lozano A, Borges P, Robaina L, Betancor M, Hernandez-Cruz CM, ... Izquierdo M (2016) Effect of different dietary vitamin E levels on growth, fish composition, fillet quality and liver histology of meagre (*Argyrosomus regius*). Aquaculture 468(1): 175–183.

Rosa R, Nunes ML (2004) Nutritional quality of red shrimp, *Aristeus antennatus* (Risso), pink shrimp, *Parapenaeus longirostris* (Lucas), and Norway lobster, *Nephrops norvegicus* (Linnaeus). Journal of the Science of Food and Agriculture 84: 89–94.

Saavedra M, Pereira TG, Candeias-Mendes A, Conceiçao LEC, Teixeira B, ... Pousão-Ferreira P (2018) Dietary amino acid profile affects muscle cellularity, growth, survival and ammonia excretion of meagre (*Argyrosomus regius*) larvae. Aquaculture Nutrition 24(2): 814–820.

Saavedra M, Pereira TG, Grade A, Barbeiro M, Pousao-Ferreira P, ... Gonçalves A (2015) Farmed meagre, *Argyrosomus regius* of three different sizes: what are the differences in flesh quality and muscle cellularity? International Journal of Food Science and Technology 50: 1311–1316.

Saavedra M, Pereiraa TG, Carvalhoa LM, Pousão-Ferreirab

P, Gradea A, ... Gonçalvesa A (2017) Wild and farmed meagre, *Argyrosomus regius*: a nutritional, sensory and histological assessment of quality differences. Journal of Food Composition and Analysis 63: 8–14.

Samad MA, Asaduzzaman M, Galib SM, Kamal MM, Haque MR (2010) Availability and consumer preference of Small Indigenous Species (SIS) of the River Padma at Rajshahi, Bangladesh. International Journal of BioResearch 1(5): 27–31.

Suquet M, Divanach P, Hussenot J, Coves D, Fauvel C (2009) Marine fish culture of "new species" farmed in Europe. Cahiers Agricultures 18: 148–156.

Tibaldi E, Kaushik SJ (2005) Amino acid requirements of Mediterranean fish species. Cahiers Options Méditerranéennes 63: 59–65.

Velazco-Vargas J, Martinez-Llorens S, Jover Cerda M, Tomas-Vidal A (2013) Evaluation of soybean meal as protein source for *Argyrosomus regius* (Asso, 1801) (Sciaenidae). International Journal of Fisheries and Aquaculture 5(3): 35–44.

Velazco-Vargas J, Tomas-Vidal A, Hamdan M, Moyano Lopez FJ, ... Martinez-Llorens S (2014) Influence of digestible protein levels on growth and feed utilization of juvenile meagre *Argyrosomus regius*. Aquaculture Nutrition 20: 520–531.

B Baki https://orcid.org/0000-0002-2414-1145
DK Öztürk https://orcid.org/0000-0003-2505-231X
M Kerim https://orcid.org/0000-0003-2189-5395