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Original research article

Wild and farmed meagre, *Argyrosomus regius*: A nutritional, sensory and histological assessment of quality differences

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ABSTRACT

Meagre, *Argyrosomus regius*, is a promising new species for aquaculture due to its flesh quality, taste and growth performance in captivity. This study evaluated the quality of wild and farmed meagre in terms of flesh texture and nutritional profile. Texture traits were characterized using sensory analysis and instrumental measurements. Furthermore, muscle cellularity was analysed to determine potential relationships with flesh texture. Nutritional profile was evaluated focusing on protein and fat contents, as well as on fatty acid and amino acid profiles. Results showed that the most pronounced difference between wild and farmed meagre was the fat content, which was six times higher in the latter (3.93% *versus* 0.64%). This was reflected in a higher contribution of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), fulfilling completely the European Food Safety Authority (EFSA) recommendations in the case of farmed fish fillets (125% compared to 45% in farmed and wild meagre, respectively). Protein content was also higher in farmed fish (19.74% *versus* 17.18%) and amino acids scores were above 100% when compared to FAO/WHO amino acid standard. Raw fillet hardness was higher in wild meagre (96.05 N *versus* 60.35 N), but sensory analysis showed higher scores for firmness and oiliness in farmed fish. Muscle fibre density and area were similar in both wild and farmed meagre and therefore could not have been responsible for the differences found in fillet texture traits. In conclusion, this study shows that farmed meagre flesh may have some higher quality aspects in comparison to wild meagre and its overall attribute profile makes it an attractive food, thereby justifying its farming.

1. Introduction

Mediterranean aquaculture is currently focussed on meagre intensive farming to diversify the offer of farmed fish and mitigate market saturation in this region. Meagre, *Argyrosomus regius*, production started in the 90's and has been growing in the past two decades, reaching a production above 10 000 t in recent years (Monfort, 2010). Meagre has the potential of becoming one of the top farmed species in the Mediterranean region owing to its good adaptation to captivity, high rate of fecundity, impressive growth rate compared to seabream and seabass (approximately 800 g per year), good flesh quality, and high commercial price (Soares et al., 2015; Saavedra et al., 2015). Meagre also shows a high potential to be used as a transformed product, such as fillets and fresh or frozen portions (Saavedra et al., 2015).

To be successful, aquaculture needs to produce fish with high consumer acceptance. Flesh quality comprises several factors, such as texture, chemical composition, in particular, fat content, and composition (Grigorakis et al., 2007; Johnston, 2008). Among all flesh quality traits, texture is one of the most relevant and crucial for consumer acceptance (Hyldig and Nielsen, 2001; Matos et al., 2013). In general, wild fish shows a firmer texture compared to farmed fish (Johnston et al., 2006; Ribeiro et al., 2013), which is the result of different fish nutrition and rearing *versus* natural conditions. How different factors influence flesh texture is still not fully understood. However, several studies have shown a relationship between texture and white muscle cellularity (density and area of muscle fibres) (Johnston et al., 2000; Periago et al., 2005; López-Albors et al., 2008) suggesting that muscle fibre area and density may influence the textural properties of the flesh (Hurling et al., 1996).

This study aims to compare wild and farmed meagre of approximately 3.7 kg in terms of flesh quality, in particular, texture properties and nutritional value, determined on the basis of fat content, fatty acids composition (in particular the n-3 fatty acids contribution), and protein quality (amino acids profile). Texture traits were characterized based

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on instrumental measurements and sensory analysis. Furthermore, muscle cellularity was also analysed to evaluate the potential relationships to fillet texture.

2. Material and methods

2.1. Fish origin and sampling

Wild fish were captured by long line fishing in the Atlantic coast, in Cascais (38° 42′ N, 9° 25′ W), Portugal, in September 2014. Farmed fish were reared in fibre tanks during the larval and juvenile stages and in earthen ponds from 300 g in the Aquaculture Research Station of the Portuguese Institute of the Sea and Atmosphere (IPMA), located in Olhão (37° 2′ N, 7° 50′ W), in the South of Portugal. During the growth period, farmed meagre was fed on a commercial feed (composition is presented in Table 2). Farmed fish were slaughtered by hypothermia.

In this study, nine wild and nine farmed meagre, *Argyrosomus regius*, were sampled approximately 24 h after slaughtered. Wild and farmed fish weighed 3.7 ± 0.4 kg and 3.8 ± 0.2 kg, respectively, and had a total length of 78.7 ± 3.0 cm and 79.9 ± 1.6 cm, respectively. All fish were weighed and measured. Once scaled and eviscerated, both fillets (with skin) were taken and weighed. For every fish, sections of both fillets were used for sensory analysis and instrumental texture. For chemical composition analysis, representative samples of each fillet were taken, stored at −80 °C and then freeze-dried.

2.2. Proximate composition

Moisture was quantified according to the reference method (AOAC, 1998, method 950.46). Samples were dried at 105 °C during 16 h in a drying oven with circulation and air forced renewal until a constant weight was achieved.

Crude protein was determined using an automatic analyser LECO model FP-528 (LECO Corp., St. Joseph, MI, USA). In this technique, nitrogen is released by combustion at a high temperature into pure oxygen, detected by thermal conductivity (AOAC, 1998, method 992.15) and converted into protein after multiplying by appropriate factor of 6.25 for animal proteins.

Total fat was determined according to Folch et al. (1957). Lipid extraction was carried using 100 mg of dried sample and 3 ml of a chloroform:methanol (2:1) solution. The mixture was stirred in vortex at low-moderate rotation during 50 s (to avoid heating). Another 3 ml of hydrochloric acid (0.1 N) and 300 µl magnesium chloride (0.5%) were added and the mixture was stirred again as previously described. The mixture was centrifuged during 5 min at 2000*g* at 4 °C (to assure a correct separation of aqueous and organic phases). The organic phase containing lipids was collected to a dry tube. The process was repeated twice. The chloroform in the collector tube was then evaporated in a nitrogen flow and the fat content was quantified by weighing the fat residue.

2.2.1. Fatty acids

The fatty acid composition of meagre fillets was analysed using the transesterification method by acid catalysis (Park et al., 2001). Each replicate sample (300–330 mg of dry mass) was dissolved in 5 ml of acetyl chloride/methanol (1:19 v/v; Merck, Kenilworth, NJ, USA), shaken, and heated (80 °C for 1 h). After cooling, 1 ml of Milli-Q distilled water and 2 ml of *n*-heptane pro analysis (Merck, Kenilworth, NJ, USA) were added and samples were shaken and centrifuged (2300*g*, 5 min) until phase separation. The moisture content of the upper phase was removed using anhydrous sodium sulfate (Panreac Química SLU, Barcelona, Spain). Following, an aliquot (2 µl) of the upper phase was injected onto a gas chromatograph (Varian Star 3800 Cp, Varian Medical Systems, INC., Palo Alto, CA, USA) equipped with an autosampler and fitted with a flame ionization detector at 250 °C for fatty acids methyl esters (FAME) analysis. The separation was carried out with helium as carrier gas at a flow rate of 1 ml min^{-1}, in a capillary column DB-WAX (30 m length × 0.32 mm internal diameter; 0.25 µm film thickness; Hewlett–Packard INC, Palo Alto, CA, USA) programmed at 180 °C for 5 min, raised to 220 at 4 °C min^{-1}, and maintained at 220 °C for 25 min, with the injector at 250 °C. FAME identification was accomplished through comparison of retention times with those of Sigma standards (Sigma-Aldrich Corp., St. Louis, MI, USA): Supelco PUFA No.1 (Marine Source, 99%- Ref. 47033) and PUFA No.3 (Menhaden oil 99%- Ref. 47085-U). Fatty acid analysis was carried in duplicate for each individual fish.

Fatty acids data were expressed as percentage of total fatty acids and in g/100 g using the lipid conversion factor for finfish [0.933 − 0.143/Total lipids content (% wet weight)] determined by Weihrauch et al. (1977).

2.2.2. Amino acids

Quantification of the amino acids (AA) profiles of meagre fillets was done using the hydrolysis method described in AOAC (1998). For total AA extraction, 20–40 mg of sample (1.5–2.0 mg Nitrogen) was acid hydrolysed in 10 ml Nalgene Oak Ridge Teflon Fep tubes (Nalge Nunc International Corp., Rochester, NY, USA), with 3 ml of 6 M HCl (Merck, Kenilworth, NJ, USA) containing 0.1% phenol (Merck, Kenilworth, NJ, USA). Norvaline (99%, Sigma-Aldrich Corp., St Louis, MI, USA) and sarcosine (98%, Sigma-Aldrich Corp., St. Louis, MI, USA) were further added to samples (final concentration 500 pmol/µl) before hydrolysis and used as internal standards respectively for quantification of primary AA (OPA derivatized) and secondary AA (FMOC derivatized). Nalgene tubes were vacuumed, fluxed, and capped under nitrogen atmosphere, and samples hydrolysed at 110–115 °C for 24 h. After the hydrolysis samples were neutralised with 6 M NaOH, quantitatively transferred into 20 ml volumetric flasks with ultrapure water, filtered using 0.2 µm pore size cellulose membrane syringe filters and stored at −80 °C until analysis. The chromatographic conditions used were in accordance with the Agilent method (Henderson et al., 2000) and AA separation was performed by high-performance liquid chromatography (Agilent 1100 HPLC, Agilent Technologies, Palo Alto, CA, USA) in a Phenomenex Gemini ODS C18 guard column (4 × 3 mm), and a Phenomenex Gemini ODS C18 110 Å column (4.6 × 150 mm, 5 µm) (Phenomenex Inc., Torrence, CA, USA) using pre-column derivatization with *o*-phthalaldehyde and 3-mercaptopropionic acid in borate buffer (OPA, Agilent Technologies, Palo alto, CA, USA) for primary AA detection and 9-fluorenylmethyl chloroformate in acetonitrile (FMOC, Agilent Technologies, Palo Alto, CA, USA), for secondary AA detection. Separation was performed at a flow of 2 ml/min using a gradient of solvents 40 mM Na_2HPO_4 pH 7.8 and ACN:MeOH:water (45:45:10, v/v/v) and detection wavelengths set by fluorescence (340/450 nm and 266/305 nm). AA identification and quantification was assessed by comparison to the retention times and peak areas of standard AA (Sigma, Missouri, USA) within the range 9–900 pmol/µL (r^2 = 0.9999) with the software Agilent ChemStation for LC (Agilent Technologies, Palo Alto, CA, USA). All determinations were carried in triplicate (repeatability 0.28–2.6% RSD; recovery 93–110%). Cysteine and tryptophan were not determined due to its destruction during acid hydrolysis.

2.3. Nutritional contribution of EPA + DHA and protein quality evaluation

The nutritional contribution of meagre consumption, considering a meal of 160 g/day, was estimated using the concentrations of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in 100 g of fish sample. The recommended intake of EPA and DHA for primary cardiovascular prevention is between 250 and 500 mg/day, according to European Food Safety Authority (EFSA, 2010). In this study 500 mg was used. Nutritional contribution of EPA and DHA was calculated according to the following formula:

Nutritional contribution (%) = ((C × M)/DRI)