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Integrated study on production performance and quality traits of European sea bass (*Dicentrarchus labrax*) fed high plant protein diets

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ABSTRACT

In the issue of fishmeal replacement, besides maintaining optimal growth, a key area of investigation for continuing to improve modern aquafeeds includes the evaluation of the effects of plant ingredients on fish quality. It is generally accepted that farmed fish quality can be influenced by the formulation of composition of their feed. Hence, the aim of the present research was to evaluate plant protein inclusion up to 84% of the overall protein content in an integrated study on growth and quality traits of European sea bass. Three diets were formulated to contain increasing plant protein levels (50, 67 and 84%; 50PP, 67PP and 84PP, respectively), with fishmeal dietary levels at 30, 20 and 10%, respectively. No significant differences due to reducing fishmeal content were observed after 118 days in terms of growth (final body weight and specific growth rate) and feed intake, even though a trend towards lower growth performance at higher fishmeal replacement levels was observed. Fish fed diet 50PP showed lower feed conversion rate in comparison to those fed diet 84PP, while no differences were recorded between diet 50PP and 67PP. No significant differences among treatments were found in protein efficiency rate. On the contrary, fish fed diet 84PP showed lower gross protein efficiency in comparison to those fed diet 50PP and 67PP. No significant differences in biometric indices and fillet composition were observed. No significant differences were found in pH, liquid holding capacity and skin colour measurements between treatments, while regarding fillet colour, significant differences were found only for H°_{ab}. In conclusion, our findings demonstrated that dietary plant proteins up to 84% of the overall protein content had no effects on quality traits of European sea bass in comparison with 50% and 67%. All experimental groups showed similar growth even though 84% plant protein inclusion negatively influenced feed and protein utilisation.

1. Introduction

In the issue of fishmeal replacement, besides maintaining optimal growth, a key area of investigation for continuing to improve modern aquafeeds includes the evaluation of the effects of plant ingredients on fish quality. With the progressive reduction of fishmeal dietary content, feeds are composed of different ingredients mixed in various proportions to complement each other. Altering the composition of feed has an important impact on several parameters directly influencing the quality of the fish, such as colour and appearance, smell and taste, texture, and nutritional quality (Lie, 2001).

Texture is an important quality attribute of acquatic foods and its shear force determination requires careful attention due to the unique fish muscle structure being organised in myotomes held together by thin membranous myocommata (Cheng et al., 2014). Variable blade and Allo-Kramer shear have been proposed in literature as instrumental texture methods and comparable sensitivity in detecting variation in fillet texture were evidenced (Aussanasuwannakul et al., 2012). Among the many plant proteins available for aquafeed, soy products are one of the most interesting alternatives because of the advantages of supply, price, protein and amino acid composition (Parma et al., 2016). Glutens have high protein level, are low in fibre, rich in vitamins B and E and are known to contain no antinutritional factors (Bonaldo et al., 2011, 2015). European sea bass (*Dicentrarchus labrax*) is an important aquaculture marine finfish species in Europe, particularly in the Mediterranean, cultured for food production. Several studies have compared wild *vs* cultured (Alasalvar et al., 2002; Fasolato et al., 2010; Fuentes et al., 2010) and organic *vs* conventionally-farmed (Trocino et al., 2012; Di Marco et al., 2017) European sea bass in terms of quality traits. To our knowledge, limited information are available on the effects of

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Table 1
Ingredients and proximate composition of the experimental diets.

	Experimental diets		
	50PP	67PP	84PP
Ingredients, % of the diet			
Wheat gluten	8.00	10.00	16.19
SPC 60%	8.00	13.00	17.00
Fishmeal LT	30.00	20.00	10.00
Corn gluten	9.62	8.91	9.00
Soya extract	18.18	17.00	15.94
Wheat	11.62	8.60	7.00
Fish oil	9.62	10.11	10.59
Rapeseed oil	9.62	10.11	10.59
DL-Methionine	0.06	0.12	0.20
Phosphate	0.23	1.11	2.02
L-Lysine	0.20	0.59	1.00
Vit/Min premix[a]	0.46	0.46	0.46
Proximate composition, %[b]			
Protein	44.4	43.0	43.5
Lipid	25.0	24.9	24.9
Ash	6.2	5.5	4.7
Moisture	5.7	6.1	6.5
Gross energy (MJ)	23.3	23.5	23.2

[a] Vitamin and mineral premix; Skretting, Stavanger, Norway (fulfilling recommendations for marine fish species given by NRC (2011)).
[b] Values are reported as mean of duplicate analyses.

dietary plant proteins on fillet quality of European sea bass. Hence, the aim of the present research was to evaluate plant protein inclusion up to 84% of the overall protein content in an integrated study on growth and quality traits of European sea bass.

2. Materials and methods

2.1. Experimental diets

Three isonitrogenous and isolipidic experimental sinking diets were formulated to contain increasing plant protein levels (50, 67 and 84%; 50PP, 67PP and 84PP, respectively), with fishmeal dietary levels at 30, 20 and 10%, respectively. Fishmeal was replaced by adding a combination of wheat gluten and soy protein concentrate. The small variation of soya extract between diets was due to the balancing of nutrient composition of the diets. DL-methionine and L-lysin were added in order to obtain similar diets in terms of amino acid content when changing the inclusion of the protein raw materials. The diets were produced by extruded process by Skretting Aquaculture Research Centre, Stavanger, Norway. The diameter of the pellet was 4 mm. Ingredients and proximate composition of the experimental diets are presented in Table 1, while proximate and amino acid composition of the plant protein ingredients used are shown in Table 2 as provided by NRC (2011).

2.2. Fish and feeding trial

The experiment was carried out at the Laboratory of Aquaculture, Department of Veterinary Medical Sciences of the University of Bologna, Cesenatico, Italy. European sea bass juveniles were obtained from Panittica Pugliese (Torre Canne di Fasano, Brindisi, Italy). At the beginning of the trial 60 fish (initial average weight: 66.2 ± 1.7 g) per tank were randomly distributed into nine 900 L square tanks with a conical bottom. Each diet was administered to triplicate groups, assigned in a completely random manner, over 118 days. Tanks were provided with natural seawater and connected to a closed recirculating system (overall water volume: 18 m^3). The rearing system consisted of a mechanical sand filter (PTK 1200, Astralpool, Barcelona, Spain), ultraviolet lights (SH-2500 38 W, Philips, Amsterdam, the Netherlands) and a biofilter (PTK 1200, Astralpool, Barcelona, Spain). The water

Table 2
Proximate and amino acid composition of the plant protein ingredients (as-fed basis) used for the experimental diets (data from NRC (2011)).

	Wheat gluten	SPC 60%	Corn gluten	Soya extract
Proximate composition, %				
Dry matter	89	92	91	90
Protein	80.7	63.6	63.7	48.5
Lipid	1.5	0.5	2.2	0.9
Ash	0.7	—	1.6	5.8
Amino acid composition, %				
Arginine	3.80	4.64	1.90	3.60
Histidine	2.00	1.58	1.20	1.30
Isoleucine	3.70	2.94	2.30	2.60
Leucine	6.30	4.92	9.40	3.80
Lysine	4.90	3.93	1.07	2.24
Methionine	1.60	0.81	1.90	0.70
Cystine	–	0.89	1.10	0.71
Phenylalanine	4.50	3.28	3.80	2.70
Tyrosine	–	2.30	0.87	1.25
Threonine	1.60	2.47	2.00	2.00
Tryptophan	1.05	0.84	0.30	0.70
Valine	4.00	3.06	2.70	2.70

exchange rate within each tank was 100% every hour, while the overall water renewal amount in the system was 5% daily. During the trial, the temperature was kept constant at 22 ± 1.0 °C and the photoperiod was maintained at 12 h light and 12 h dark through artificial light. The oxygen level was kept constant at 100% saturation by a liquid oxygen system regulated by a software program (B&G Sinergia snc, Chioggia, Italy). Ammonia (total ammonia nitrogen - TAN), nitrite and salinity (25 g L^{-1}) were daily monitored spectrophotometrically (Spectroquant Nova 60, Merck, Lab business, Darmstadt, Germany). Values recorded for TAN and nitrite during the trial have been always below 0.1 ppm and 0.2 ppm, respectively. Sodium bicarbonate was added on a daily basis to keep pH constant at 7.8–8.0.

Feed was provided to apparent satiation by oversupplying the feed by approximately 10% of the daily ration, twice a day for six days a week, while one meal was supplied on Sundays, as reported by Mongile et al. (2014). Each meal lasted 1 h. Feed delivered was recorded daily and the uneaten feed was collected by an uplift system 30 min post feeding. The uneaten pellets of each tank were gathered, dried overnight at 105 °C and their weight was deducted for overall calculation.

2.3. Sampling

At the beginning and at the end of the experiment, all the fish in each tank were anaesthetised and individually weighed. In case of any mortality, fish were immediately removed and the weight was recorded for overall calculation. Specific growth rate (SGR), voluntary feed intake (VFI) and feed conversion ratio (FCR) were calculated. Survival rate was calculated as a percentage of the initial number of fish. The proximate composition of the carcasses was determined at the beginning of the trial on a pooled sample of 10 fish and on a pooled sample of 5 fish per tank at the end of the trial. Protein efficiency ratio (PER) and gross protein efficiency (GPE) were calculated. Furthermore, at the end of the trial, wet weight, viscera, liver, mesenteric fat and fillet weight were individually recorded for 10 fish per tank to determine viscerosomatic index (VSI), hepatosomatic index (HSI), mesenteric fat index (MFI) and fillet yield (FY). The proximate composition of the fillet was determined at the end of the trial on a pooled sample of 5 fish per tank. Moreover, at the end of the trial, quality assessment was performed. All experimental procedures were evaluated and approved by the Ethical-Scientific Committee for Animal Experimentation of the University of Bologna, in accordance with European directive 2010/63/UE on the protection of animals used for scientific purposes.