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Effects of the partial substitution of dietary fish meal by differently processed soybean meals on growth performance, nutrient digestibility and activity of intestinal brush border enzymes in the European sea bass (*Dicentrarchus labrax*)

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Abstract

This study evaluated the effects of replacing fish meal (FM) in the diet of European sea bass (*Dicentrarchus labrax*) with differently processed soybean meals on growth performance; apparent digestibility coefficients (ADCs); the activity of alkaline phosphatase and the brush border digestive enzymes: leucine amino peptidase, maltase and γ-glutamyl transpeptidase; and the fish morphometric and flesh quality. European sea bass with an initial average body weight of 187.8±1.4 g, were fed either a FM based (control) diet or a soy replacement isoproteic, isolipidic and isocaloric diet. The treatments consisted replacing FM protein by: 25% toasted, dehulled and solvent-extracted soybean meal (SE25); 50% dehulled and toasted soy seeds subjected to dry extrusion and mechanical oil extraction (ME50); 50% enzyme-treated soybean meal (ET50) and an inclusion of 60% composed of 30% toasted, dehulled and solvent-extracted soybean meal and 30% enzyme-treated soybean meal (SE+ET/60). ADCs values of dry matter, crude protein, crude lipid and gross energy did not significantly differ between ME50 and SE+ET/60 but both of them were inferior to the other treatments ($P<0.05$). Compared with the control FM-based diet, only the group that consumed the ME50 diet had lower specific growth rate, feed conversion ratio and gross protein retention efficiency values ($P<0.05$). The protein efficiency ratio did not differ between the FM-based control group and all other soy derivate groups ($P>0.05$). In order to gain more insight on the effects of the diet on fish growth, activity of the brush border enzymes was measured. No significant differences were found in leucine amino peptidase and maltase activities, between the control group and the other soy derivate groups. The activity of γ-glutamyl transpeptidase was significantly higher in the upper section in fish that consumed the control diet compared with fish that consumed the soy derivate diets. Yet, the main activity of this enzyme was found in the lower intestinal section. In all the soy derivate diets except for the SE25 diet, the activity of alkaline phosphatase was significantly lower than its activity in the control diet. Feeding diets that include various types and levels of soybean derivatives did not affect the whole body composition and slaughter yield but significantly reduced liver weight. The results show that in methionine supplemented diets, FM can be replaced

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in terms of protein by 25% SE, 50% ET or 60% soy composed of 30% SE and 30% ET without hampering fish performance. The inclusion of 50% protein from ME resulted in significantly lower growth performance and feed utilization.

Keywords: European sea bass (*Dicentrarchus labrax*); Feeds; Soybean meal; Digestibility; Brush border enzymes

1. Introduction

Since dehulled oil-extracted soybean meal (SBM) has high protein content, availability and competitive price, it represents a major dietary alternative to fish meal (FM) in diets for carnivorous fish species. It is well established that, although the nutritive value of SBM to fish, as in higher vertebrates, is largely determined by a deficiency in sulfur-amino acids in soy protein, with methionine being the first-limiting one, its full nutritional potential is attained only after appropriate heat-treatment to inactivate constitutive soy anti-nutritional factors such as protease inhibitors, anti-vitamins and lectins which may have detrimental effects on nutrient utilization and growth in fish (Sandholm et al., 1976; Viola et al., 1983; Wilson and Poe, 1985; Van der Ingh et al., 1991).

Soybean meal has been the focus of a number of studies which show large variability among and within various carnivorous fish species in the utilization of this ingredient, with growth performance feed and nutrient conversion efficiencies being generally impaired when used to replace high proportions of dietary FM protein (Tacon et al., 1983; Shimeno et al., 1992; Watanabe et al., 1992; Robaina et al., 1995, Krogdahl et al., 2003). In the European sea bass (*Dicentrarchus labrax*, L), a major fish species in Mediterranean aquaculture, a few earlier studies on the use of SBM as a feed ingredient have shown growth depression to occur either in juvenile or adult fish within a wide range of dietary inclusion levels varying from 15% up to 40% in the case of met-supplemented diets (Alliot et al., 1979; Amerio et al., 1991; Lanari et al., 1998; Oliva-Teles et al., 1998, Tibaldi and Tulli, 1998). As with most of the fish species investigated to date, there is convincing evidence in sea bass as well, that reduced overall performance with diets including substantial amounts of conventionally processed SBMs, is primarily a response to reduced nutrient and energy bioavailability. This is in addition to the growth reduction caused by a limiting supply of sulfur amino acids and shortage of certain minerals (Gomes de Silva and Oliva-Teles, 1998; Tibaldi and Tulli, 1998). However, very limited research has been done, to ascertain to what extent the indigestible components and the anti-nutritional factors (ANFs) in differently processed soybean derivatives, may adversely affect growth response and feed utilization in this fish species. In salmonids, reduced nutrient digestibility and digestive–absorptive capabilities caused by soy non-starch carbohydrates and/or heat-stable ANFs have been claimed as major factors responsible for impaired growth performance. This was found when substantial levels of fish meal were replaced by properly heat-treated, dehulled soybean meal in methionine-adequate diets (Rumsey et al., 1993; Kaushik et al., 1995; Refstie et al., 1998; Krogdahl et al., 2003). This is consistent with findings that soy preparations such as alcohol-extracted concentrates and enzyme-treated SBMs, obtained through processes which enable substantial removal of and/or inactivation of certain heat-stable ANFs, result in improved digestibility, growth and nutrient utilization in salmonids (Olli et al., 1994a,b; Kaushik et al., 1995; Olli and Krogdahl, 1995; Refstie et al., 1998), yellowtail (Shimeno et al., 1992) and gilthead sea bream (Kissil et al., 2000).

Digestion and absorption of nutrients depends on the activity of the digestive enzymes, in particular those located in the brush border section of the intestine, which are responsible for the final stages of breaking down and assimilation of the food (Klein et al., 1998). In salmonids, higher inclusion levels of solvent-extracted SBM led to a marked reduction in the activities of such enzymes in enterocytes of the distal intestine (Krogdahl et al., 1995, 2003; Bureau et al., 1998; Bakke-McKellep et al., 2000). This suggests that measuring the activities of intestinal brush border enzymes may represent a sensitive tool to study the effects of differently-processed SBMs on nutrient bioavailability and to ascertain tolerability to certain soy-ANFs in various fish species.

The objectives of the present study were to evaluate growth response, nutrient apparent digestibility and the activities of intestinal brush border enzymes in sea bass fed

Table 1
Proximate compositions, starch level, gross energy content and trypsin inhibitor activity (TIA) of the three soy products

Chemical composition	SESBM	MESBM	ETSBM
Moisture (%)	9.3	6.9	8.4
Crude protein (% DM)	53.3	47.8	58.4
Crude lipid (% DM)	1.4	14.1	1.0
Ash (% DM)	7.1	6.3	7.5
Crude fiber (% DM)	5.1	3.7	3.9
Starch (% DM)	6.0	3.5	4.4
Gross energy (kJ/g DM)	19.14	21.24	18.75
TIA (mg/g)	1.99	2.96	0.93