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Black soldier fly larvae meal can replace fish meal in diets of sea-water phase Atlantic salmon (*Salmo salar*)

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Abstract

A feeding trial was conducted to test the growth potential, nutritional utilization, liver health and fillet sensory parameters of sea-water Atlantic salmon (*Salmo salar* L.) fed diets with increasing substitution of fish meal with insect meal. The insect meal was produced from black soldier fly larvae (*Hermetia illucens*, L.). Triplicate sea-cages of salmon were fed one of four isonitrogenous and isolipidic diets for 16 weeks. The control diet (IM_0) contained 100 g kg^{-1} fish meal, which was replaced up to 100% with insect meal (33% (IM_{33}), 66% (IM_{66}) and 100% (IM_{100})), corresponding to dietary insect meal inclusion levels at 50 g kg^{-1}, 100 g kg^{-1} and 150 g kg^{-1}, respectively. Replacing the dietary fish meal with insect meal did not affect the apparent digestibility coefficients (ADC) of protein, lipid, amino acids and fatty acids, or the digestive enzyme activities. Feed intake, daily growth increase, and feed conversion ratio were also unaffected by the inclusion of insect meal in the diets. Whole body protein, lipid and amino acid composition were not affected by dietary substitution of fish meal with insect meal, while the whole body fatty acid composition generally reflected that of the diets. Liver lipid accumulation was not affected by replacing the fishmeal with insect meal, as assessed by both histological examinations and chemical analyses. The sensory testing of the fillet revealed only small changes in the fillet sensory quality. In general, this study showed that a total replacement of fish meal with black soldier fly larvae meal in the diets of sea-water Atlantic salmon was possible without negative effects on growth performance, feed utilization, nutrient digestibility, liver traits or the sensory qualities of the fillet.

Keywords:
Insect meal,Atlantic salmon, Growth performances,Fillet sensory quality

Introduction

The choice of ingredients and formulation of the fish diets can greatly influence the environmental impact of the aquaculture industry (Boyd and McNevin, 2015). Therefore, continuous improvement in this sector is crucial. Finding nutritionally appropriate and sustainable alternatives to fishmeal (FM) and –oil is an area of intense research, with possible alternative sources of ingredients coming from terrestrial plants, animal by-products, microalgae, macroalgae or insects, to mention some (Barroso et al., 2014; Boyd and McNevin, 2015; Gatlin et al., 2007; Olsen and Hasan, 2012; Wan et al., 2018). The interest in insects as feed ingredients for terrestrial and aquatic animals continues to grow every year, with increasing numbers of new scientific articles being published on the subject (Vargas-Abúndez et al., 2018; Barroso et al., 2014; Belghit et al., 2018a; Borgogno et al., 2017; Dumas et al., 2018; Lock et al., 2016; Magalhães et al., 2017; Van Huis, 2013; Veldkamp et al., 2012, Nogales-Mérida et al., 2018). The black soldier fly (BSF) (*Hermetia illucens*) larvae is considered an important candidate species to be used for animal feeds (Cammack and Tomberlin, 2017; Van Huis, 2013). Since the 1970s, this species has been used as a protein source in animal feed, mainly due to its ability to convert food waste (vegetable, fruit, factory waste, and animal tissues) into high-quality protein (Hale, 1973; Newton et al., 1977). The research and industrial-scale production of BSF larvae as feed ingredients have been intensified the last few years (FAO, 2013; Wang and Shelomi, 2017).

Available documentation of the nutritional composition and value of different insect species considered as candidates for use in animal feeds has become substantial (Alegbeleye et al., 2012; Barroso et al., 2014; Henry et al., 2015; Makkar et al., 2014). BSF larvae contain high amounts of protein (≈ 40% of dry weight (DW)) and have a well-balanced profile of essential amino acids (AA) (Henry et al., 2015; Liland et al., 2017; Wang and Shelomi, 2017). The larvae of BSF are also a good source of lipids, reaching up to 30% lipids (on DW basis) if grown on optimal growth media. The lipid is dominated by saturated fatty acids (FA), being especially rich in the medium-chained FA 12:0 lauric acid (Liland et al., 2017; Sealey et al., 2011; St-Hilaire et al., 2007). Replacement of FM with BSF larvae meal in aquafeeds without negative effects on growth or performance has successfully been demonstrated in some fish feeding trials (Belghit et al., 2018a; Cummins et al., 2017; Dumas et al., 2018; Elia et al., 2018; Lock et al., 2016; Magalhães et al., 2017; Renna et al., 2017), but not in others (Gasco et al., 2016; Kroeckel et al., 2012; St-Hilaire et al., 2007). Replacement of dietary FM with BSF meal reduced the growth of juvenile turbot (165–756 g insect meal (IM) kg^{-1} diet, *Psetta maxima*) and rainbow trout (300 g IM kg^{-1} diet, *Oncorhynchus mykiss*) (Kroeckel et al., 2012; St-Hilaire et al., 2007). We previously demonstrated that it is possible to include as much as 600 g kg^{-1} of IM in combination with insect oil in the diets of fresh-water Atlantic salmon without affecting the growth performance or the feed utilization (Belghit et al., 2018a). In the current trial, we aimed to study the effects of partial or total dietary replacement of FM with IM on Atlantic salmon in the sea-water stage. By rearing the fish up to a typical commercial slaughter size (~4 kg) we could gain consumer-relevant knowledge on how such a dietary change would affect both the nutritional and sensory quality of the fish fillet. To our knowledge, this is the first trial using dietary insect ingredients to grow Atlantic salmon up to slaughter-size.

Conclusions

In this study, we evaluated the effects of graded inclusion level of a partially defatted black solider fly larvae meal on growth performances, digestibility, nutrient utilization, liver health and fillet sensory qualities of Atlantic salmon of a commercially relevant size. Only minor effects were detected of replacing up to 100% of the fishmeal with the insect meal. Therefore, our conclusion is that the insect meal made from BSF is a nutritionally appropriate source of protein for sea-water stage Atlantic salmon.

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