Replacement of fish meal with rapeseed protein concentrate in fish diets

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Introduction

While aquaculture production has increased tremendously (annual growth rate 7–8 %) over the past thirty years, the most important protein source for fish feeds, fish meal, is a limited resource, with an annual production volume of 6-7 million tons. Therefore alternatives for fish meal in fish feeds are needed. Wide availability, low prices, high protein content and a desirable amino acid profile have caused an interest in rapeseed oilcakes as starting product for the production of protein rich products to be used in fish nutrition. Either simple oilcakes or rapeseed meals with increased protein content produced from oilcakes that were de-oiled with organic solvents have been tested as protein sources in feeding trials with several fish species, among them rainbow trout *Oncorhynchus mykiss* W. (Thiessen et al. 2004), tilapia *Oreochromis niloticus* L. (Yigit & Olmez 2009) and common carp *Cyprinus carpio* L. (Dabrowski & Kozlowska 1981). It was found, that the nutritional quality of rapeseed products as fish meal alternative largely depends on their level of antinutritional factors (ANF), such as glucosinolates, phytic acid and indigestible carbohydrates (Francis et al. 2001). Contents of ANF in rapeseed products can be reduced by several processing techniques thereby improving its value for fish nutrition (Mawson et al. 1994; 1995; Mwachireya et al. 1999). In this study rapeseed protein concentrate (RPC) with a crude protein content of 71% and low levels of ANF was tested as fish meal replacement in diets for rainbow trout and turbot (*Psetta maxima* L.).

Materials and methods

For rainbow trout, 3 diets (crude protein: 47.7 ± 0.6%) were formulated in which fish meal (fish meal level in control diet: 300 g kg^{-1}) was replaced with RPC at 0, 66, or 100% (designated as R0, R66, or R100, respectively). In diets for turbot (CP: 58.1 ± 0.9%), 0, 33, or 66% of fish meal (level in control diet: 450 g kg^{-1}) was replaced with RPC (designated as: T0, T33, or T100, respectively). The RPC was obtained from PPM. Essential amino acid concentrations did not differ considerably between experimental diets for each fish species. Diets were manufactured into pellets of 4mm in diameter. For the growth trial, 12 rainbow trout (initial weight: 37.8 ± 1.4 g) were distributed into each of nine 40 L tanks connected to a flow through system. Twelve turbot (IW: 73.5 ± 0.7 g) were stocked in each of nine experimental tanks (100 L) of a saltwater recirculation system. Triplicate groups of fish were fed the experimental diets once daily to apparent satiation for 84 days. At the end of the feeding period fish growth was determined and feed efficiencies calculated. Data were checked for normal distribution using the Kolmogoroff Smirnov Test and eventually subjected to transformation. Data were subjected to one-way analysis of variance (ANOVA) using "R" statistical software. When differences among groups were identified, multiple comparisons among means were made using Tukey's HSD test. Statistical significance was determined by setting the aggregate type I error at 5% ($P<0.05$) for each set of comparisons.

Results and discussion

In rainbow trout, fish growth, feed intake and feed conversion were not compromised when RPC replaced 100 % of dietary fish meal (Table 1). In turbot, growth and feed intake were not significantly different between control group and fish fed diet T33 (Table 2). However, feed conversion was significantly lower in turbot fed diets T33 or T66 than in the control group.

Table 1 Growth, feed efficiencies and survival of rainbow trout fed experimental diets

Parameter	R0	R66	R100
Initial weight (g)	37.6 ± 1.9	37.4 ± 1.6	38.5 ± 1.0
Final weight (g)	102.8 ± 11.5	94.0 ± 2.4	97.0 ± 6.6
Daily growth (%)	1.19 ± 0.08	1.10 ± 0.06	1.10 ± 0.08
Feed intake (g TS)	78.5 ± 10.9	75.8 ± 3.4	74.7 ± 5.1
Feed conversion ratio	1.09^{a} ± 0.02	1.22^{b} ± 0.03	1.18^{ab} ± 0.06
Protein efficiency ratio	1.91^{a} ± 0.04	1.70^{b} ± 0.03	1.89^{ab} ± 0.04
Survival (%)	100 ± 0.0	97.2 ± 4.8	91.7 ± 8.3

Values in the same row with different superscripts are significantly different (Tukey's test; P<0.05)

Table 2 Growth, feed efficiencies and survival of turbot fed experimental diets

Parameter	T0	T33	T66
Initial weight (g)	73.1 ± 1.0	74.1 ± 0.4	73.3 ± 0.4
Final weight (g)	147.5^{a} ± 10.3	145.0^{a} ± 7.5	122.2^{b} ± 4.5
Daily growth (%)	0.83^{a} ± 0.07	0.80^{a} ± 0.07	0.61^{b} ± 0.05
Feed intake (g TS)	73.9^{a} ± 8.2	82.6^{a} ± 10.8	58.2^{b} ± 1.1
Feed conversion ratio	1.00^{a} ± 0.06	1.16^{b} ± 0.03	1.20^{b} ± 0.09
Protein efficiency ratio	1.75^{a} ± 0.11	1.49^{b} ± 0.04	1.42^{b} ± 0.11
Survival (%)	94.4 ± 9.6	100 ± 0.0	100 ± 0.0

Values in the same row with different superscripts are significantly different (Tukey's test; P<0.05)

Reduced diet acceptance of turbot fed on diet T66 may result from negative influences on diet taste induced by antinutritional factors present in RPC. It is known that the bitter taste exuded by glucosinolate metabolites, such as isothiocyanates and vinyloxazolidinethiones, present in rapeseed meals can potentially retard diet acceptance in fish. This was found in *O. mykiss* and *P. maxima* at dietary glucosinolate levels of 7.3 µmol g^{-1} or 18.7 µmol g^{-1}, respectively (Burel et al. 2000ab). The RPC used in our study contained 1.32 µmol glucosinolates g^{-1}. Accordingly, highest calculated dietary glucosinolate concentrations were 0.4 µmol g^{-1} in diet R100 and T66. These values are far below the level when glucosinolates become detrimental on food intake of *O. mykiss* and *P. maxima* as stated by Burel *et al.* (2000ab). But, to our observation a typical mustard smell of glucosinolates was still noticeable in diets R100 and T66. We assume therefore, that diet taste was negatively affected by RPC inclusion, playing a more significant role in diet acceptance by turbot as stated by Burel et al. (2000b) compared to rainbow trout. Different feed efficiencies between turbot fed on the control diet and fish fed diet T33 or T66 may result from antinutritional factors present in RPC (e.g. polysaccharides, phytic acid) that are known to reduce diet digestibility and nutrient as well as mineral availability especially in turbot (Burel et al. 2000b; Francis et al. 2001). Consecutive feeding trials will clarify, if successful fish meal replacement level with RPC in diets for carnivorous fish can be increased by adding feed attractants and phytase to diets in order to overcome problems with antinutritional factors present in RPC.

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