



Effects of removal of three proteinaceous antinutrients from a soybean variety and level of heat treatment on nutritional value, gut microbiota and capacity for induction of enteritis in Atlantic salmon (*Salmo salar*, L)

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The primary aim of this study was to find whether the new soybean cultivar Triple Null (TN) in which three proteinaceous antinutrients, i.e. soybean lectin, soybean Kunitz trypsin inhibitor and the immune-dominant soybean allergen P34/Gly m Bd 30k nulls have been stacked might reduce soybeans' potency to induce gut inflammation in Atlantic salmon, compared that of its conventional soybean counterpart (CSBM). To elucidate whether this new, non-GM cultivar might have higher nutritional value was also a goal. Since all of the antinutrients removed from the TN cultivar are heat labile molecules, a third aim was included, i.e. to assess whether the nutritional value of the ingredients would be influenced by variation in energy input during extrusion, using low specific mechanic energy (SME) vs high SME. A commercially available, alcohol-water washed soy protein concentrate (SPC) was used as a negative control. Thus, 6 diets were evaluated, with 3 sources of soy protein, each processed at 2 SME levels during the extrusion process. These soy ingredients were the major dietary sources of protein in diets fed to pre-smolt Atlantic salmon. Each diet was fed for 56 days to three groups of salmon kept in fresh water, with an initial weigh of 45g. Thereafter the fish were continued on the experimental diets for another 28 days for repeated collection of feces for digestibility assessment.

The results showed that, regardless of SME, the TN and FFS were quite similar, and clearly differed from SPC, for all investigated markers, i.e. nutritional value, induction of enteritis, intestinal gene expression of immune and metabolic, antioxidant and stress markers, as well as alteration in microbiota profiles of the content of the distal intestine. The effects of level of heat treatment were also minor, but high SME clearly improved digestibility compared to the low SME for crude protein, most amino acids, lipid and energy. The greatest increase was seen for cysteine digestibility, from 77.6 to 82.4%.



The utilisation of soy protein in aquafeeds by gold-spot grouper *Epinephelus coioides*

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There are limited published data available assessing the inclusion of soybean meal (SBM) in diets for grouper and even less when considering soy protein concentrate (SPC). Of those studies most have shown a negative correlation with increasing soy inclusion and performance when substituting fishmeal (FM) as the main protein source; however, almost without exception these studies have substituted FM with soy products without maintaining nutritionally balanced diets with regard to essential nutrients, particularly when considering methionine. The aim of this study was to evaluate the substitution of FM with SBM or SPC at 0, 10, 20, 30 or 40% inclusion on various performance parameters of gold-spot grouper including growth, feed conversion efficiencies, nutrient retention, digestibility and digestive histology.

Three replicate 200 l cages per dietary treatment were stocked with 44 individual grouper (initial weight = 84.0g) in saltwater at 28°C. Experiment fish were fed daily to satiation for eight weeks before being subsampled for carcass composition and histology. The remaining fish were then used for determination of diet digestibility.

There was 100% survival at the conclusion of the eight week feed trial. Growth and feed conversion efficiencies were excellent across all diet treatments. On average all diet treatments except for SBM40 and SPC40 approximately tripled in body weight. Fish fed SBM30 were significantly larger than those fed the SBM40 and SPC40 diets. There were no differences among grouper fed SBM and SPC diets with up to 40% inclusion when compared to a FM control diet. There was a strong negative correlation with hepatosomatic index and increasing soy inclusion.

Gold-spot grouper have a good capacity to utilize soy ingredients as protein sources for FM replacement up to 30% inclusion in diets if diets are nutritionally balanced. Above this level there is a decline in growth and a decrease in feed conversion efficiency. While grouper are considered carnivorous they have a relative gut length far greater than that of pelagic marine carnivores. This may be indicative of a greater omnivorous capacity than that of a strict carnivore; an elongated intestinal tract may promote greater nutrient absorption through prolonged gut transit time.



Aquatic macrophytes and almond oil-cake: Potential source of protein for Labeo rohita

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The impact of plant ingredients on the digestive physiology of rohu *Labeo rohita* was evaluated. Four plant-based diets were formulated using almond oil-cake, *Terminalia catappa* (diet 1, D1), duckweed, *Lemna minor* (diet 2, D2), water fern *Salvania molesta* (diet 3, D3) and combination of almond oil-cake, duckweed and water fern (diet 4, D4). The diet containing fish meal served as control (diet 5, D5). The average weight was significantly ($P < 0.05$) higher in rohu fed with D2 diet compared to the fish cultured under other feeding regimes. There was no significant ($P > 0.05$) difference in average weight of fish fed with diets D4 and D5. Average weight was minimum in D3 diets fed fish. Amylase activity was significantly ($P < 0.05$) higher in D2 diet fed rohu compared to the fish cultured under other feeding regimes. This group was followed by D3, D4, D1 and D5 diets fed rohu. Total protease activity was significantly ($P < 0.05$) higher in D1 diet fed rohu compared to the other treatments. Significantly ($P < 0.05$) higher trypsin and chymotrypsin activities were recorded in duckweed-based diet (D2) fed rohu compared to the fish cultured in other feeding regimes. Minimum trypsin and chymotrypsin activities were recorded in almond oil-cake-based diet (D1) fed rohu. Lipase activity was significantly ($P < 0.05$) higher in D1 diet fed rohu compared to the other feeding regimes. This group was followed by fish meal based diet fed rohu.



Effects of α -Ketoglutarate Supplementation in Low-phosphorous Diets on Growth Performance, Phosphorus Metabolism and NaPi- II mRNA Expression of Songpu Mirror Carp

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To study the effects of α -ketoglutarate (AKG) supplementation in low phosphorous diets on growth, phosphorus metabolisms and NaPi- II mRNA expression of carp, triplicate groups of Songpu mirror carp (6.67 ± 0.08 g) were fed with diets containing available P (AP) 0.65% (normal-P) and 0.49% (low-P) with graded levels of 0, 0.2%, 0.4%, 0.6%, 0.8% and 1.0% of AKG to satiation for 8 weeks, respectively. The results showed that the feed coefficient (FCR) of the low-P group was significantly higher and the weight gain rate (WGR), specific growth rate (SGR) was significantly lower than that of the normal-P group ($P < 0.05$). Compared with low-P group, FCR of 0.6% AKG group were significantly decreased ($P < 0.05$) and the WGR, SGR and CF in 0.4%, 0.6% and 0.8% AKG group were significantly increased ($P < 0.05$), respectively. Compared with normal-P group, the deposition rate of calcium and phosphorus and the level of vertebra calcium and phosphorus were decreased significantly in low-P group ($P < 0.05$). AKG had no effect on the level of vertebra calcium ($P > 0.05$), but the deposition rate of calcium and phosphorus in 0.4, 0.6, 0.8 or 1.0% AKG group and the level of vertebra phosphorus in 0.6% AKG group were significantly higher than low-P group ($P < 0.05$). The total P apparent digestibility of carp by AKG supplementation in low-P diets increased significantly ($P < 0.05$). Compared with low-P group, the Na⁺, K⁺-ATPase activity in foregut and hindgut of the 1% AKG group was significantly increased ($P < 0.05$). AKG supplementation in low-P diets had no effect on NaPi- II b mRNA expression of midgut, kidney and vertebra, but NaPi- II b mRNA expression of foregut and hindgut decreased significantly ($P < 0.05$). The content of collagen increased with the supplementation of AKG in low-P diets. Thus, supplementation of AKG in the low-P diets can improve the growth performance, the retention of calcium and phosphorus, collagen in vertebra of Songpu mirror carp.



Feed resources in Norwegian salmon farming in 2016

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The world's growing population, increased need for feed production, and climate changes due to human activities calls for effective utilization of the resources. This requires detailed information of the flow of nutrients in feed production systems. Earlier, the complete feed resource budget of Norwegian aquaculture in 2013 has been reported (Ytrestøyl et al., 2015). The data are now updated for 2016. While Norwegian salmon feed in 1990 contained 90% marine ingredients, Ytrestøyl et al. (2015) reported that in 2013, the average Norwegian salmon feed contained 18.3% marine protein ingredients, 10.9% marine oil, 36.7% plant protein ingredients, 19.2% plant oil, 11.2% starch ingredients and 3.7% microingredients. Preliminary data show that in 2016, the amount of marine protein ingredients was further reduced to 14.8%, whereas plant protein ingredients was increased accordingly, to 40.7%. The amount of marine and plant oils was unchanged (10.6% and 20.4%, respectively).

The total use of feed ingredients in Norwegian salmon farming in 2016 was 1,693,671 tons ('as is'), and a total of 1,252,573 tons of salmon were produced. This results in an economic feed factor of 1.35 ('as is') for the total Norwegian salmon production in 2016.

In conclusion, the content of marine protein in Norwegian salmon feed was lower in 2016 than in 2013, whereas the content of marine oil was similar. The complete use and retention of protein, lipid, energy, phosphorus and zinc in Norwegian salmon farming in 2016 will be presented.



Effects of low fishmeal diets on growth and gastro-intestinal luminal and digestive conditions of European sea bass (*Dicentrarchus labrax* L.) juveniles

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Feed ingredients are known to possess different buffer capacities which might influence pH ranges along the digestive tract. Fishmeal (FM) have one of the highest buffer capacities among raw materials and its decreasing content in aquafeed formulations might affect the ideal gastrointestinal environment for digestive enzyme action. In addition data on gastric and intestinal pH in carnivorous marine fish species under different feeding regimes are scarce. A study was undertaken, therefore, to assess growth response, gastric and intestinal pH of European sea bass (*Dicentrarchus labrax* L.) fed diets with low fishmeal levels added with or without buffering agents in comparison to a standard fishmeal diet. Three isonitrogenous (45% protein) and isolipidic (16% lipid) extruded diets containing 10% FM with or without buffering agent (FM10b, FM10, respectively) and one control diet containing 20% FM (FM20) were fed to triplicate fish groups of 80 individuals (initial weight: 23 g) to overfeeding over 64 days. At the end of the trial there were no significant differences between diets for final body weight, feed intake and feed conversion rate even if specific growth rate was slightly higher in FM10 compared to FM10b. Hepatosomatic index was higher in FM20 compared to FM10 while no significant differences were observed in the viscerosomatic index. pH was measured in the stomach and along the intestinal tracts (anterior, middle, posterior) of three fish per tank at 0, 4, 8 and 12 hours post prandial and correlated to the different diets. At the same time enzymatic activity of digestive enzymes and gut microbiota by next generation sequencing were also analysed. In conclusion, low FM diet (FM10) led to equal growth and feed utilization in comparison to standard FM level (FM20) and the inclusion of buffering feed agent did not seem to promote the overall growth performance.