Opportunities and challenges in the use of plant protein concentrates in feeds for carnivorous fish

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Water and eventually alcohol extraction of defatted oilseeds into plant protein concentrates (PPC) efficiently removes soluble indigestible carbohydrates. Formulation space is increased by higher concentration of protein. The extraction also removes unpalatable components, and factors in soybean and pea causing distal enteritis in several fish species. Carnivorous fish can efficiently utilize diets high in PPC when supplemented with essential amino acids and taurine. PPC can account for up to 95% of the protein in diets for Atlantic salmon or rainbow trout. Experiments show feed intakes, growth rates and feed conversions similar to those obtained with high-quality fishmeal (FM). Ingredients with attractant effect, such as FM or krill meals, supplied the remainder of the protein. Vital wheat gluten (VWG) and hydrolyzed wheat gluten (HVG) are examples of PPC processed by other methods, and have virtually no antinutrients effects.

Phytic acid (IP6) is concentrated during extraction, and may be as high as 2 and 3% in soy protein (SPC) and rapeseed protein concentrates. Phosphate from IP6 is not available to the fish, and IP6 chelates cationic elements such as Zn^{2+}, causing incomplete mineralization and skeletal deformities when these PPC are used at high levels. Application of phytase to diets for coldwater fish is limited by the low body temperature of the fish much of the year. SPC still gives very good growth results, and has become a major source of protein in European fish feeds. Thus, development of a phytase that works at low temperatures would represent a breakthrough to secure healthy fish production. Alternatively, cost effective and hygienically safe hydrolysis of IP6 prior to incorporation in the feed mix can solve the same challenges.

Extrusion technology dominates in production of fish feeds. Limitations in utilization of and tolerance to starch limits its use to control physical pellet quality in diets for salmonids. Growout diets require formulation space, expansion and porosity to hold up to 40% oil. This sets high demands on the selection of ingredients. Different PPC have different effects during extrusion, and cause different physical quality of the pellet. Generally, specific mechanical energy (SME), torque, expansion and pellet durability (pellet breakage in response to standardized mechanical stress) increase when PPC substitutes FM. Some PPC like HWG, however, reduces SME. The viscosity created by this ingredient limits incorporation higher than around ¼ of dietary protein. The protein in VWG and HWG remains virtually completely digestible after extrusion processing.

PPC may find increased application in food in the future. Sustainability challenges of PPC in salmonid diets are linked to transport distance, and the need for arable land and freshwater for their production. When fed to marine fish, fecal and metabolic loss of elements like phosphate and potassium complicates recycling for fertilization of land-based plant production.