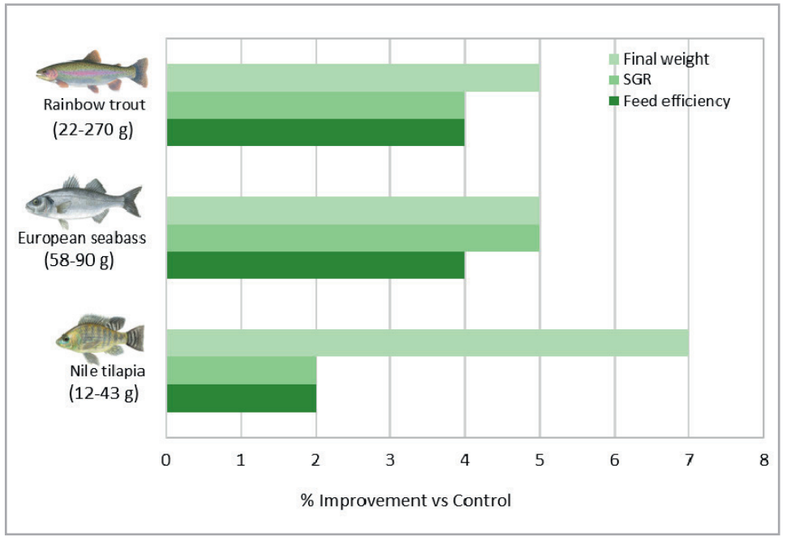
Lipid essentials

Optimising lipid utilisation in current fish feed formulations



THE current trends in aquafeed formulation force the nutritionist to not only optimise nutritional inputs and ingredient selection as affordably as possible but also pay attention to the optimal functioning of the digestive system of fish. Digestibility enhancers that maximise efficiency of digestive and metabolic processes give the formulator flexibility in the use of alternative ingredients and formulation of least cost and high quality feeds.

Although a wide variety of concepts and products aiming to improve nutrient absorption and utilisation have been investigated in livestock species, the feeding behaviour, digestive physiology and nutritional requirements of aquaculture organisms differ from those of livestock species. It is therefore difficult to predict the functionality of many of these products for a wide range of fish species. Two key considerations for the formulator are the heat stability required under extrusion conditions if post-extrusion application is not possible, and the target nutrient or group of nutrients with potential margin for optimisation. Oils and fats are important sources of essential lipids and energy to the animal and contribute to the absorption of lipo-soluble micronutrients. It is well known that the increasing inclusion of plant ingredients compromises the supply of essential lipids (van Halteren and Coutteau, 2017) and may induce gut health issues in carnivorous fish, ultimately affecting lipid absorption and utilisation (Krogdahl et al., 2003; Romarheim et al., 2006).

Digestibility enhancers aiming at maximising lipid absorption and utilisation are categorised as emulsifiers. The general mode of action of emulsifiers is by lowering the tension between water and lipids, causing the lipids to be broken down into smaller droplets and allowing more efficient digestion of triglycerides by lipases. After lipase action, emulsifiers associate with the monoglycerides and free fatty acids to form micelles that transport them to the enterocyte surface for absorption. It is important to highlight that although phospholipids (also referred to as lecithin) are considered as emulsifiers, their activity is weak in a water rich environment such as that of the digestive gut, and thus their use in animal feed should be driven as a source to meet requirements rather than as strategy to optimise lipid absorption. Two strong emulsifiers with practical application in aquafeeds and which efficacy has been validated in a range of fish species are AQUALYSO and LIPOGEST.

Above: Improvements in growth performance parameters in carnivorous and herbivorous species following AQUALYSO supplementation.
Opposite: Improvements in growth performance parameters in carnivorous and herbivorous species following bile salt supplementation from different sources to plant-based feeds. Modified from Yakamoto et al. 2007; Gu et al, 2017; and Jiang et al. 2017.

AQUALYSO is a lyso-phospholipid based product derived from the enzymatic hydrolysis of phospholipids. Unlike phospholipids, lyso-phospholipids contain only one fatty acid tail, with this structure making them more hydrophilic. This translates into a better emulsifying capacity (better capacity to disperse lipids and form smaller and increased number of micelles) and, consequently, into better absorption of lipidic components.

Supplementation at 0.2% during 56 days in carnivorous rainbow trout feed containing 15% fish meal and 30% soybean meal protein improved final weight by 5% as well as specific growth rate (SGR %/day) and feed conversion ratio (FCR) by 4%.

In carnivorous European sea bass, supplementation at 0.1% in feed containing only 16% marine protein during 75 days resulted in 5% improvement in SGR and 4% reduction in FCR.

Improved performance following AQUALYSO supplementation was also corroborated in herbivorous Nile tilapia, in which 0.1% inclusion during 75 days in juvenile commercial feed devoid of marine ingredients resulted in 7% improvement in final weight and 2% improvement in SGR and FCR.

These positive effects could be explained by the more efficient action digestion and likely metabolic use of dietary lipids which in turn results in protein sparing and more effective utilisation of protein for muscle growth.

LIPOGEST is a bile salt based emulsifier. Bile salts promote formation of small size micelles that are more quickly transported to the enterocyte surface and thus they are considered stronger emulsifiers in relation to phospholipids (Cabral and Small, 1989).

Besides lipid emulsifiers, bile salts are the major end metabolites of cholesterol, and participate in cholesterol homeostasis and in the activation of the pancreatic lipase that enables fat hydrolysis into monoglycerides (Buchinger et al., 2014; Gu et al. 2017). Recent data in fish also associate bile salts with intestinal physiology regulation by altering ionic transport and enhancing the absorptive pathway (Fuentes et al. 2018).

The inclusion of vegetable proteins, particularly soybean meal, in carnivorous fish species has been associated with reduced levels or activity of bile salts and, consequently, with reduced lipid digestibility (Yamamoto et al., 2007; Romarheim et al., 2008). This has been attributed firstly to impaired bile salt re-absorption due to intestinal inflammation (Kortner et al., 2013), and secondly to a high loss due to binding to plant fibers (Refstie et al., 2006). Furthermore, dietary components such as taurine or cholesterol, that are critical for the synthesis of bile salts, may be low or missing in plant ingredients (NRC 2011).

The above mentioned functions and the consequent benefits of supplementing bile salts to plant based feeds fed to carnivorous species have been validated by positive effects on performance observed in feeding trials with rainbow trout (Yamamoto et al., 2007; Iwashita et al., 2008) and turbot (Gu et al. 2017). Positive effects have also been confirmed in herbivorous tilapia and associated with improved lipase activities and reduced demand for endogenous cholesterol biosynthesis (Jiang et al, 2017).

In conclusion, least cost formulation supports the application of digestibility enhancing additives such as lyso-phospholipids and bile salts which improve the absorption efficiency of major nutrients, particularly lipids, and the increasingly limited levels of essential nutrients. This implies the possibility of extracting more nutritional value from each kilogram of feed, and is particularly important when aiming to compensate the depressed fat utilisation derived from high plant formulations.

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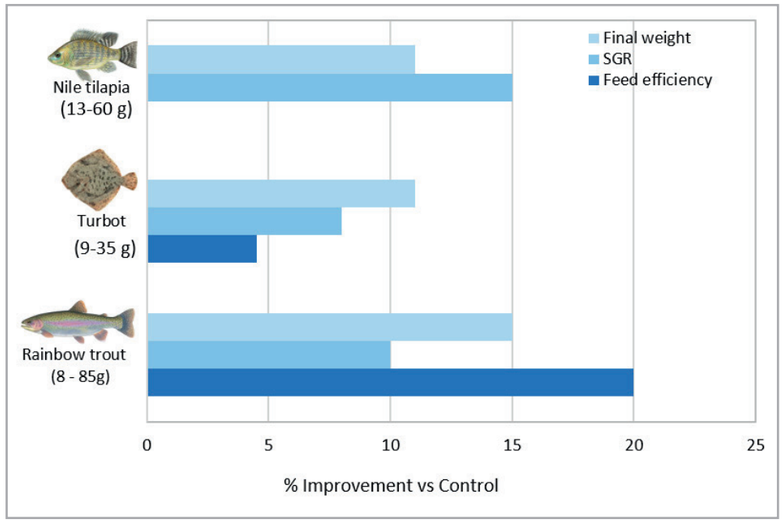

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