Intestinal Lipid Droplet Accumulation of Dietary Oils in Fish

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Due to over-exploitation of natural marine fish stocks, one of the greatest challenges in the field of fish nutrition research is to reduce marine oils (MO) in diets for carnivorous aquacultured fish species while maintaining eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) levels in the muscle (fillet) that are beneficial for human health. One of the most sustainable alternative dietary lipid sources are vegetable oils (VO). However, the substitution with VO as dietary lipid source has revealed potentially deleterious effects to fish health and welfare. In salmonid fish, and other fish species, VO supplementation has resulted in enterocytic supranuclear lipid droplet accumulation. In some cases, lipid droplet accumulation is so severe that the intestinal epithelium is disrupted which could result in malabsorption of nutrients, reduced capacity for osmoregulation, and an enhanced route of infection for pathogenic bacteria. It is clear that the divergent fatty acid (FA) profile of VOs, compared to MOs, has a profound effect on intestinal processes in carnivorous fish.

Studies have shown that lipid droplet accumulation in enterocytes of salmonid fish can be significantly attenuated by increasing the proportion of the saturate palmitic acid (16:0) in VO-diets. However, this effect was not significant when another saturate, myristic acid (14:0) was used. Similarly, lipid droplet accumulation is reduced by feeding a source of phospholipids: soybean lecithin. Recent research utilising isolated enterocytes and intestinal segments mounted in Ussing chambers have also suggested that fatty acids abundant in VOs may ‘over-stimulate’ triacylglycerol synthesis in salmonid fish. Therefore it is apparent that numerous luminal and/or intracellular mechanisms may be responsible for intestinal lipid droplet accumulation.

Possible explanations for these observations are: phase behaviour of saturated fatty acids in the luminal aqueous bulk at low temperatures experienced by poikilotherms; specificity of bile salt-activated lipase; specificity of acyltransferases towards fatty acyl-CoAs; and imbalance in the intracellular triacylglycerol:phospholipid ratio required for chylomicron/VLDL formation. Recent findings on alternative dietary lipid sources and intestinal lipid metabolism in salmonids from our research group are presented.