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Alternatives to fish oil substitution - An assessment of strategies for sustaining n-3 long chain polyunsaturated fatty acids (n-3 LC-PUFA) levels in salmonids

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**Alternatives to fish oil substitution - An assessment of strategies for  
sustaining n-3 long chain polyunsaturated fatty acids (n-3 LC-PUFA)  
levels in salmonids**

**By Mohamed Basseer Codabaccus  
M.Sc Aquaculture**

**Submitted in fulfilment of  
the requirements of the degree of  
Doctor of Philosophy  
University of Tasmania  
July 2011**

## **DECLARATION**

This thesis contains no material which has been accepted for a degree or diploma by any tertiary institution. To the best of my knowledge the thesis does not contain any material written or published by another person, except where due reference is made.

Mohamed Basseer Codabaccus

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## ABSTRACT

The use of alternate oils (AO) in aquafeeds is now a reality due to the rise in the price of fish oil (FO). The lack of n-3 long-chain ( $\geq C_{20}$ ) polyunsaturated fatty acid (n-3 LC-PUFA) in AO is a major constraint due to the resulting low levels of n-3 LC-PUFA obtained in farmed fish. The aim of this study was to understand the metabolic basis underlying current and innovative strategies to maintain n-3 LC-PUFA levels in salmonids, particularly for Atlantic salmon, fed diets in which fish oil (FO) is substituted with AO in a series of four independent experiments. Use of *Echium* oil (EO) rich in stearidonic acid (SDA) has the potential to bypass the initial  $\Delta 6$  desaturase enzyme which is a rate limiting step for n-3 LC-PUFA biosynthesis. This hypothesis was tested by growing Atlantic salmon in freshwater and seawater on diets where FO was completely substituted by either EO or rapeseed oil (RO) with comparison to a FO diet. The results indicated that SDA rich oil is a more suitable candidate for FO replacement in aquafeeds for Atlantic salmon compared to conventional vegetable oils due to enhanced n-3 LC-PUFA biosynthesis. The use of a FO finishing diet (FOFD) is a suitable way to restore n-3 LC-PUFA in fish after a growth period with AO. Preferential FA metabolism may contribute to n-3 LC-PUFA restoration by favouring  $\beta$ -oxidation of saturated fatty acids and/or monosaturated fatty acids. Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) restoration was investigated in rainbow trout fed a diet where FO was substituted by 50% palm fatty acid distillate (PFAD) and 75% PFAD followed by a FOFD period. There was no evidence for preferential FA metabolism occurring and the dilution model was a good predictor of FA changes after dietary change. In aiming at improving the n-3 LC-PUFA restoration by the FOFD strategy, a short term food deprivation after growth on 75% PFAD prior to feeding the FOFD was undertaken for Atlantic salmon smolts. Short term food deprivation reduced lipid content especially in the fillet of fish which lead to an increase in n-3 LC-PUFA % composition.

Subsequent feeding to satiation with a FO/D improved the restoration of n-3 LC-PUFA in the fillet of unfed fish. This thesis also examined the use of oil blends in aquafeeds with emphasis on varied DHA and EPA ratio as a strategy for sustaining n-3 LC-PUFA in Atlantic salmon. The DHA and EPA ratio of FO is typically 1:1.5 in any blend of FO and AO. According to EPA and DHA metabolism in fish, higher dietary DHA content to EPA might be more suitable for optimizing their deposition. We tested whether altering the dietary DHA: EPA ratio in Atlantic salmon by increasing dietary DHA inclusion in conjunction with low dietary n-3 LC-PUFA content may enable efficient n-3 LC-PUFA deposition in fish. The results indicated that a diet having a higher DHA: EPA ratio than usually encountered in FO or FO/AO blend diets is better suited for optimizing n-3 LC-PUFA deposition in Atlantic salmon.

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