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The omega-3 fatty acid metabolism in different Atlantic salmon families changes during the smoltification period

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The aquaculture industry is challenged by reduced availability of fish oil, and thereby the omega-3 fatty acids EPA and DHA, for feed production. Atlantic salmon is able to convert 18:3n-3 of plant origin to EPA and DHA. This conversion is higher in the freshwater stage prior to smoltification, than at later life stages in seawater. The regulatory mechanisms involved in synthesis of EPA and DHA are complex, but the results show that the capacity is affected by factors like environment (light, salinity), genetics and feed. Salmon following a delayed smoltification regime had higher capacity for EPA and DHA production and increased DHA content in fillet. Gene expression of all desaturases seemed to be down-regulated by light, whereas increased salinity up-regulated two of the Δ6 desaturases (b and c).

Materials and methods

Salmon from High and Low desaturase families were following one of two smoltification regimes; standard smoltification at ca 80g or delayed smoltification at ca 400g (Figure 1). Smoltification was induced by light treatment and transfer to saltwater. The fish were fed either 1.7 or 5.4g/100g EPA and DHA in the feed. Tissue samples were selected at four time points during smoltification.

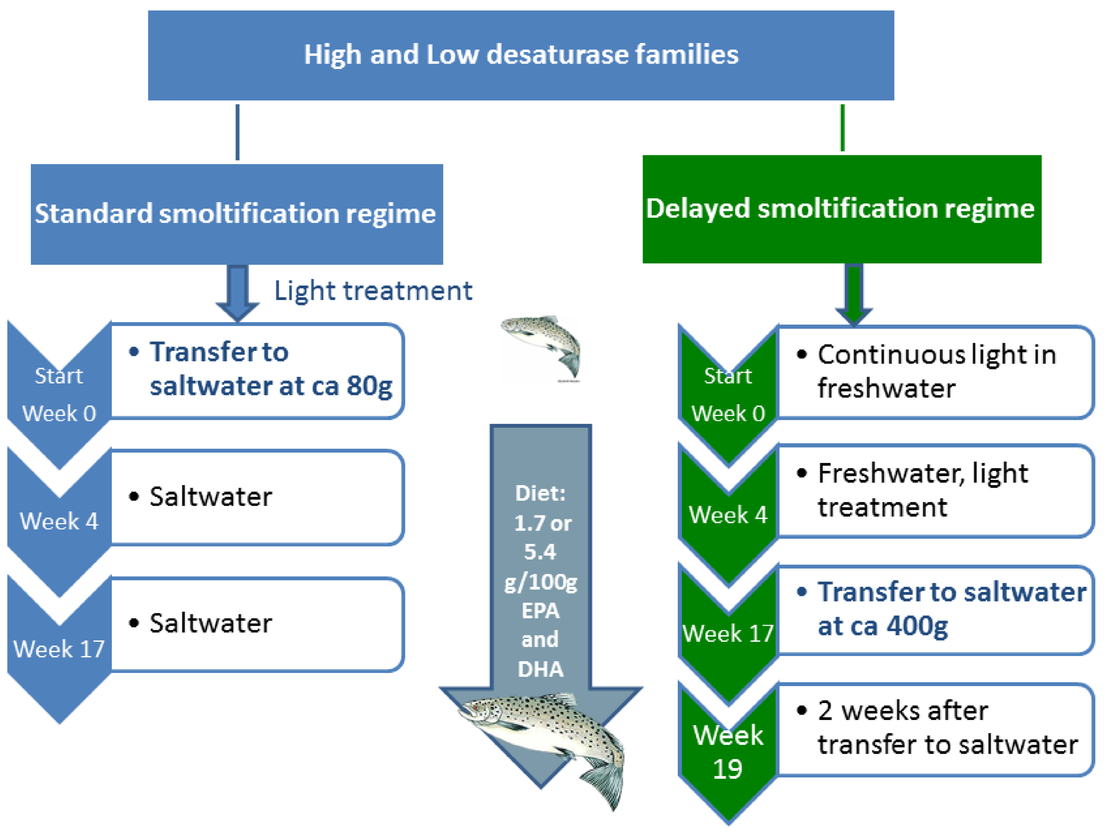

Figure 1 Experimental design.

Results and discussion

Gene expression

Gene expression of Δ5 and the multiple Δ6 desaturases (a/b/c) involved in synthesis of EPA and DHA was affected by the smoltification process, dietary treatment and the genetic background. Light treatment down-regulated gene expression of all desaturases, whereas transfer to saltwater up-regulated the b and c variant of the Δ6 desaturases (Figure 2). Increased dietary level of EPA and DHA down-regulated gene expression of the desaturases compared to the lower dietary level, and confirms previous findings that DHA inhibits gene expression of the desaturases. Differential expression of the various desaturases indicate different functions and regulation during smoltification.

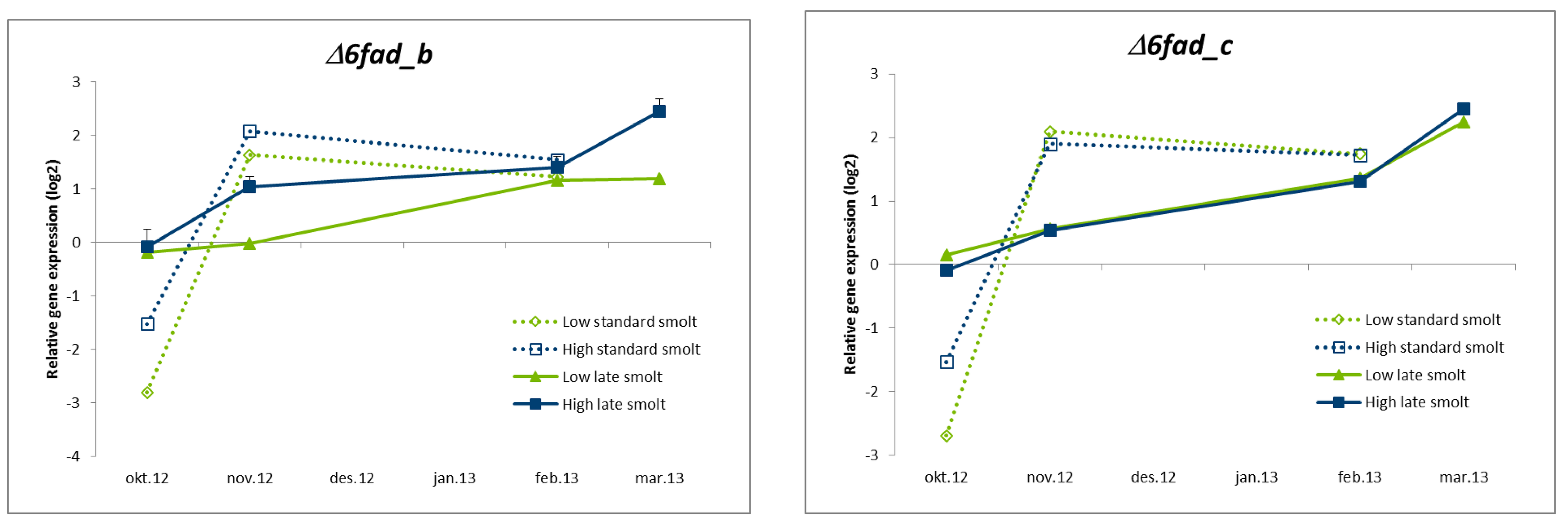

Figure 2 Gene expression of Δ6 desaturase isoform b and c in liver of salmon from High or Low desaturase families going through standard or normal smoltification regime. The fish were fed 1.7 g/100g EPA+DHA in the feed. The results are also representative for the group fed 5.4 g/100g EPA+DHA the feed.

Capacity for EPA and DHA synthesis

Salmon that went through a postponed smoltification regime showed higher capacity to synthesize EPA and DHA compared to salmon that followed a standard smoltification regime (Figure 3). The High desaturase families had a higher capacity than the Low desaturase families. This shows that the capacity for EPA and DHA synthesis in the High families may be kept at a higher level by keeping the salmon in freshwater untill they reach 400g before smoltification.

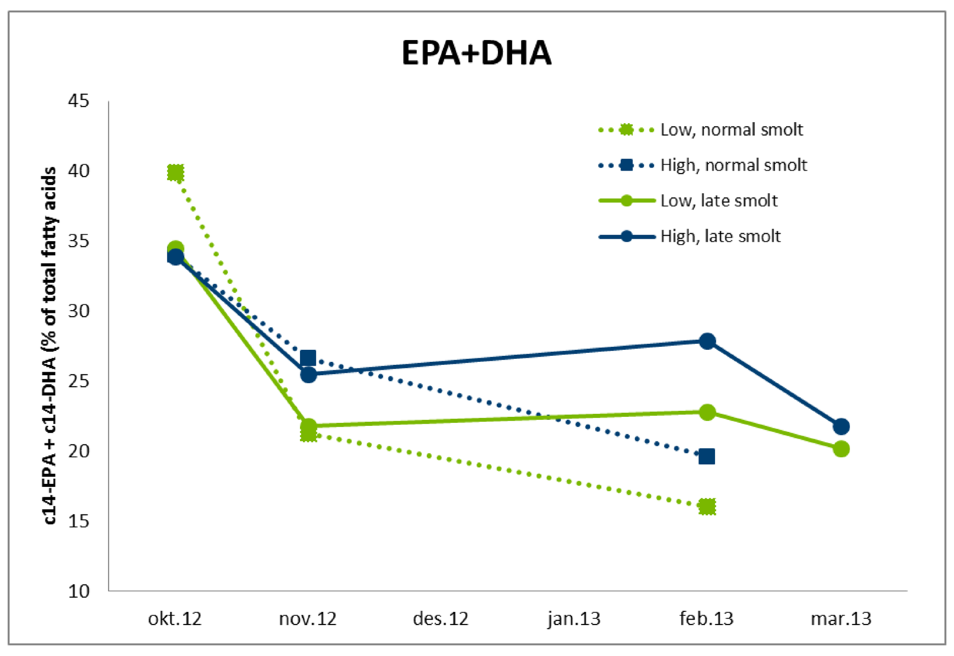

Figure 3. Capacity for EPA and DHA synthesis in hepatocytes isolated from High or Low desaturase families going through standard or normal smoltification regime. The fish were fed 1.7 g/100g EPA+DHA in the feed. The results are also representative for the group fed 5.4 g/100g EPA+DHA the feed.

EPA and DHA in fillet

Both High and Low salmon families following a postponed smoltification regime showed higher level of DHA in fillet, than salmon going through a standard smoltification regime (Figure 4). These results correspond to the capacity for EPA and DHA synthesis measured in hepatocytes. The level of EPA and DHA in the fillet is reflected by the dietary fatty acid composition.

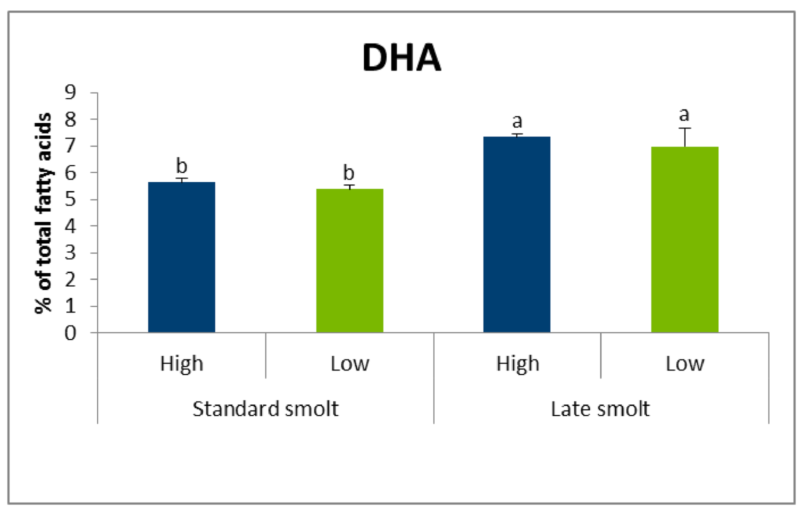

Figure 4. DHA in salmon fillet from High or Low desaturase families going through standard or late smoltification regime. The fish were fed 1.7 g/100g EPA+DHA in the feed. The results are also representative for the group fed 5.4 g/100g EPA+DHA the feed.

Conclusion

- There is a potential for maintaining the capacity for EPA+DHA synthesis in salmon, and thereby a higher DHA level in fillet, by keeping the salmon in freshwater until it reaches about 400 grams.
- Salmon from High desaturase families had a higher capacity for EPA and DHA synthesis.
- The regulation of EPA+DHA synthesis is complex and is controlled by factors such as environment, genetics and feed.