Cetoleic acid in North Atlantic fish oils stimulate the synthesis of EPA and DHA from ALA in human liver cells and salmon

North Atlantic fish oils from herring, sand eel and capelin are characterized by high levels of the long chain monounsaturated fatty acid cetoleic acid (22:1n-11) and moderate levels of the healthy fatty acids EPA and DHA. New results show that cetoleic acid has bioactive properties being able to stimulate the conversion of the α-linolenic acid (ALA) to eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in several species.

Background

With the estimated future growth in the world aquaculture production and the increase in human population, there will probably be a lack of Ω-3 fatty acids for production of both fish feed and Ω-3 products for human consumption in near future. It is therefore of high importance to develop strategies to enhance the utilization of existing EPA and DHA sources by improving the different species' innate capacities for EPA and DHA production from the shorter chain Ω-3 fatty acid ALA.

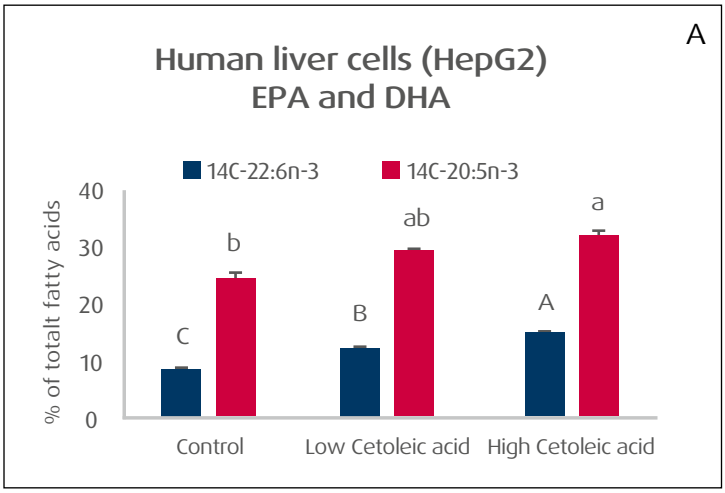
Trial designs of *in vitro* and *in vivo* studies

The effect of cetoleic acid on the Ω-3 fatty acid pathway was investigated in two different *in vitro* cell models; a human liver cell line (HepG2) and primary salmon liver cells. Further, the cetoleic acid was tested as part of a North Atlantic herring oil in two separate salmon feeding trials. In the first feeding trial the salmon was fed two levels of either herring oil or sardine oil containing high or low levels, respectively, of cetoleic acid. The EPA and DHA levels in the diets were balanced. In the second feeding trial the salmon were fed three different inclusion levels of either herring oil or sardine. In these diets the total sum of EPA+DHA was balanced, but the ratio between EPA and DHA in the herring and sardine diets were different. The herring diet was higher in DHA, whereas the sardine diet was higher in EPA. This was done to investigate if cetoleic acid could compensate for the known inhibitory effect of DHA on the Ω-3 fatty acid synthesis.

Herring from the North Atlantic. PHOTO: TOMMY ELLINGSEN ©NOFIMA

Results:
Cetoleic acid stimulates the EPA and DHA synthesis in human and salmon liver cells.

Enrichment of a human liver cell line (HepG2) and salmon primary liver cells in culture with cetoleic acid, resulted in approximately 40% and 11% increased production of EPA and DHA from ALA, respectively (Figure 1).



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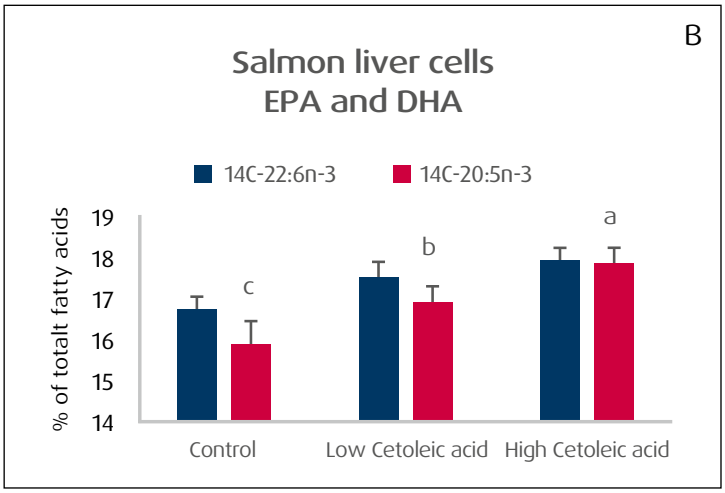

Figure 1. In vitro studies in human (A) and salmon (B) liver cells showed that cetoleic acid stimulates the synthesis of EPA and DHA from ALA in both cell types.

Salmon fed North Atlantic fish oil rich in cetoleic acid

In the first feeding trial, salmon fed the highest inclusion level of herring oil had a 15 % greater retention of EPA+DHA than salmon fed the comparable sardine oil diet (Figure 2).

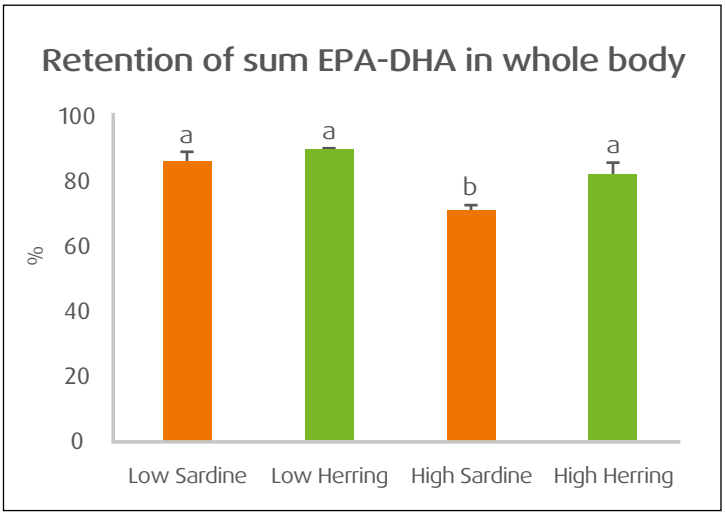

Figure 2. Salmon fed the highest inclusion level of herring oil in the diet had higher retention of EPA+DHA in whole body than salmon fed the comparable sardine diet.

In the second feeding trial, salmon fed the highest inclusion level of herring oil confirmed the results from the first feeding trial showing 17 % higher retention of the sum EPA+DHA in whole body compared to the corresponding sardine group (Figure 3). The higher level of cetoleic acid of the herring diets seemed to counteract the inhibiting effect of DHA on the Ω-3 synthesis pathway.

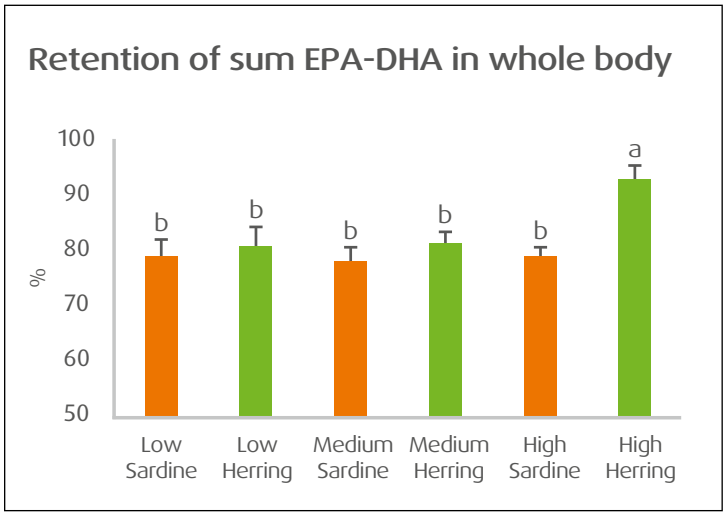

Figure 3. Salmon fed the highest inclusion level of herring oil in the diet had higher retention of EPA+DHA in whole body than salmon fed the comparable sardine diet.

Conclusion

- Cetoleic acid stimulates the synthesis of EPA and DHA from ALA in human- and salmon liver cells.
- Salmon fed a diet with herring oil high in cetoleic acid showed increased retention of EPA+DHA in whole body compared with salmon fed sardine oil low in cetoleic acid, despite the higher level of DHA in the herring diets.

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