

Invited Commentary

The health benefits of farmed salmon: fish oil decontamination processing removes persistent organic pollutants

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The beneficial health effects of inclusion of *n*-3 PUFA from fish and fish oils in the human diet have been extensively investigated in the past three decades beginning with the initial reports on the reduced prevalence of IHD in Greenland Inuit⁽¹⁾. Extensive nutritional and clinical studies continue to indicate that higher intakes of EPA and DHA derived from marine sources can reduce the risk of cardiac diseases as well as treat and perhaps prevent several inflammatory diseases. Since the natural stocks of many of the popular fatty fish rich in EPA and DHA have declined, farmed fish such as Atlantic and Pacific salmon, sea bream, sea bass, halibut and other marine fish can help to meet the consumer demand for fish as a source of *n*-3 PUFA.

Two recent reports have alarmed consumers that the flesh of farmed salmon, especially those from Europe, contains significantly more organic contaminants than that of wild salmon. In particular, the levels of polychlorinated biphenyls (PCB), polychlorinated dibenzo dioxins (PCDD), polychlorinated dibenzo furans (PCDF), the legacy organohalogen pesticides and the new-era environmental contaminants the polybrominated diphenyl ethers (flame retardants) are reported to be higher than in wild salmon^(2,3). However, the data interpretations of the findings of these papers have been controversial and potentially detract from the benefits associated with the consumption of salmon by consumers^(4,5). Quantitative analysis of the benefits and risks of consuming farmed and wild salmon by humans has been conducted and the need to reduce the contaminants in fish feeds has been emphasised⁽⁶⁾. Fish meal and oils derived from fish such as anchovy, herring, capelin and mackerel that provide protein, EPA and DHA, and energy are the main contributors of persistent organic pollutants in salmon feeds. Recent research has shown that it is possible to replace the major proportion of the marine fish oil (MFO) with vegetable oils and still maintain optimum growth and feed utilisation during the salmon lifecycle. Since partial substitution of MFO with vegetable and/or animal lipid sources in fish diets affects tissue and cellular lipid composition, a 'finishing' diet based on MFO can be used to tailor the desired level of EPA and DHA in the final fish product. To date, no adverse effects of either partial or full replacement of MFO with vegetable oils (canola, rapeseed and flaxseed oils) on flesh and sensory quality of fish have been observed⁽⁷⁾.

Fish accumulate lipophilic contaminants, particularly dioxins and dioxin-like (DL) compounds such as PCDD and PCDF (or PCDD/F) and non-*ortho*- and mono-*ortho*-PCB. These persistent contaminants with long half-lives originate from incomplete combustion of dioxins from industry and other

human activities as well as from natural events such as forest fires. They can enter the aquatic environment, accumulate in sediment and be passed through invertebrates to fish in the marine food chain. Removal of contaminants, particularly polycyclic aromatic hydrocarbons and pesticides, has been practised by industry for decades through refining processes, and food safety concerns have resulted in regulations that limit dioxins in food and food oils. In 1997, the WHO established toxic equivalency factors (TEF) for seventeen PCDD/F congeners and twelve DL-PCB congeners⁽⁸⁾ and later re-evaluated human and mammalian TEF for these compounds⁽⁹⁾. On the basis of these TEF, it is possible to calculate toxic equivalents (TEQ) of individual PCDD/F and PCB congeners in fish oils, feeds and fish. Although a wide variation in contaminant concentrations has been found in oils from fish captured in different geographic locations, PCDD/F and DL-PCB concentrations in oils of Pacific origin are typically lower than those processed from the North Atlantic and North Baltic seas⁽¹⁰⁾. Many of these latter oils exceed the maximum permitted TEQ set for feeds under the European Commission regulations and must be destroyed by incineration⁽¹¹⁾ or decontaminated.

It is widely recognised that disposal of contaminated fish oils rich in valuable nutrients is a wasteful practice and processing technologies should be developed to decontaminate these oils. Initial refining technology using an activated carbon treatment system was effective in the removal of dioxins from fish oils but only partially effective in the removal of mono-*ortho*-PCB (20–70% removal), with most of the *ortho*-PCB residues remaining in the fish oil after treatment. More innovative processing technologies now exist to decontaminate such oils. Recently, PCDD/F and DL-PCB have been successfully removed by coupling activated carbon with either short-path distillation or supercritical CO₂ extraction⁽¹²⁾. In the current issue of the *British Journal of Nutrition*, Sprague *et al.*⁽¹³⁾ used decontaminated northern fish oil to reduce the concentration of persistent organic pollutants in farmed Atlantic salmon. Interestingly, the concentrations of PCDD/F and DL-PCB were significantly reduced in the flesh from salmon fed diets based on these refined fish oils. These lower persistent organic pollutant values were in the range of those observed in wild Pacific salmon⁽²⁾. Salmon fed these diets also showed rapid growth, feed utilisation and high levels of *n*-3 PUFA. Although the findings were based on an 11-week study, it is apparent that progress in fish oil refining technology has significant potential to decontaminate persistent organic contaminants in fish oils, reducing the need to dispose of valuable oils in great

demand by the nutraceutical and animal feed industries. In summary, continued advances in refining processes for fish oils will allow the safety of farmed salmon to be similar to that of other animal products consumed by humans but provide additional health benefits associated with *n*-3 PUFA.

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