DIOXINS AND PCB IN SALMON FROM THE SOUTHERN BALTIC SEA AND REDUCTION IN LEVELS DURING PROCESSING

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Introduction

The Baltic Sea is heavily polluted with environmental contaminants and fatty fish have high concentrations of dioxins and PCB. The largest salmon from the southern Baltic Sea exceed EU maximum levels for dioxins and dioxin-like PCB in muscle meat of fish and as a consequence they cannot be sold commercially.[1] This situation has impact on commercial fishing and consumer health.

Dioxins and PCB are chlorinated organic environmental contaminants, which are persistent and accumulate through the food chain. The compounds accumulate in the adipose tissue of the fish but as the fat is not equally distributed removal of skin, subcutaneous fat and particularly fatty tissues of the fish can reduce its total content of contaminants.[2,3,4] Smoking of fish can also change the concentration of fat accumulating compounds in fish tissue.[5,6]

The purpose of the study was:
(1) Measurement of dioxins and PCB in various weight classes of Baltic salmon from Danish catching areas.
(2) Investigation of changes in levels of dioxins and PCB in salmon fillets due to fat trimming and smoking.
(3) Finding appropriate risk management measures aimed at commercial fishery and fish consumers.

Materials and Methods

Several investigations of Baltic salmon relevant for the Danish fishery have been carried out and in this study results from two investigations are reported. In a pilot study the effects of different trimming and smoking procedures were explored and later dedicated trimming studies were conducted.

Samples: Salmon were caught in the Southern Baltic Sea in ICES square number 25 in 2004 and 2006. After removal of the guts the cleaned weight was measured and the salmon were allocated to different weight classes. For the pilot study 20 salmon from the weight class 5-6 kg were used. For the deep trimming study seven weight classes from 2 to 11 kg were included and 77 salmon were used.

Design: The salmon were divided in an un-processed fillet (left-hand side) and a processed fillet (right-hand side). The chemical analyses were performed on individual fillets in the pilot study and pooled samples of seven fillets from each weight class in the deep trimming study.

Smoking procedures: Hot-smoking: The salmon was dried for 2 hours at 40°C, smoked for 2 hours at 60°C, and then smoked for 1 hour at 70°C. Cold-smoking: The salmon was dried for 2 hours at 26°C and smoked for 5.5 hours at 26°C.

Trimming procedures: Step 1: Division into left and right fillet. Step 2: Removal of fins, etc. For the right fillet only: Step 3: Removal of skin and adipose tissue from the dorsal fin area and the belly (minimal trimming). Step 4: Removal of the dark muscle and other fatty muscular tissue (extensive fat trimming). The last step was only used for samples that were subjected to the so-called deep trimming.

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Analysis: The requirements for the analysis of dioxins and PCB as stated in the EU legislation were followed.[7] Congener specific determination were obtained for the seven 2,3,7,8-chloro substituted PCDDs, the ten 2,3,7,8-chloro substituted PCDFs, the four non-ortho PCB (PCB77, 81, 126 and 169), eight mono-ortho PCB (PCB105, 114, 118, 123, 156, 157, 167 and 189) and six marker PCB (PCB6: PCB28, 52, 101, 138, 153 and 180). After fat extraction, the fat was cleaned up on a multi-layer column containing sulphuric acid coated silica, and separated into two fractions (a) PCDD/F and non-ortho PCB and (b) di- and mono-ortho PCB (manually or automated by the use of a PowerPrep system from FMS). Dioxins and PCB were determined by gas chromatography interfaced to a high resolution mass spectrometer (GC-HRMS) using a 60 m DB5-column and at 10,000 mass resolution. Amount of extracted fat was determined gravimetrically. WHO TEQ is calculated using TEF^{1998} values.

Quality assurance: Two laboratories have been involved in the analyses. The Danish National Food Institute and the Danish Veterinary and Food Administration, Region East. Comparative test among the labs showed good agreement. The laboratories have regularly participated with satisfactory results in proficiency tests.

Results and Discussion

In the pilot study the results for the minimal trimming showed a reduction in the dioxin content by 5% to 20% while the extensive trimming showed a reduction by 38% to 50% (figure 1). Hot smoking of the salmon fillets resulted in increased levels of dioxins and PCB measured on fresh weight basis of 10% to 30%. Cold smoking showed on average no change in the content of dioxins and PCB.

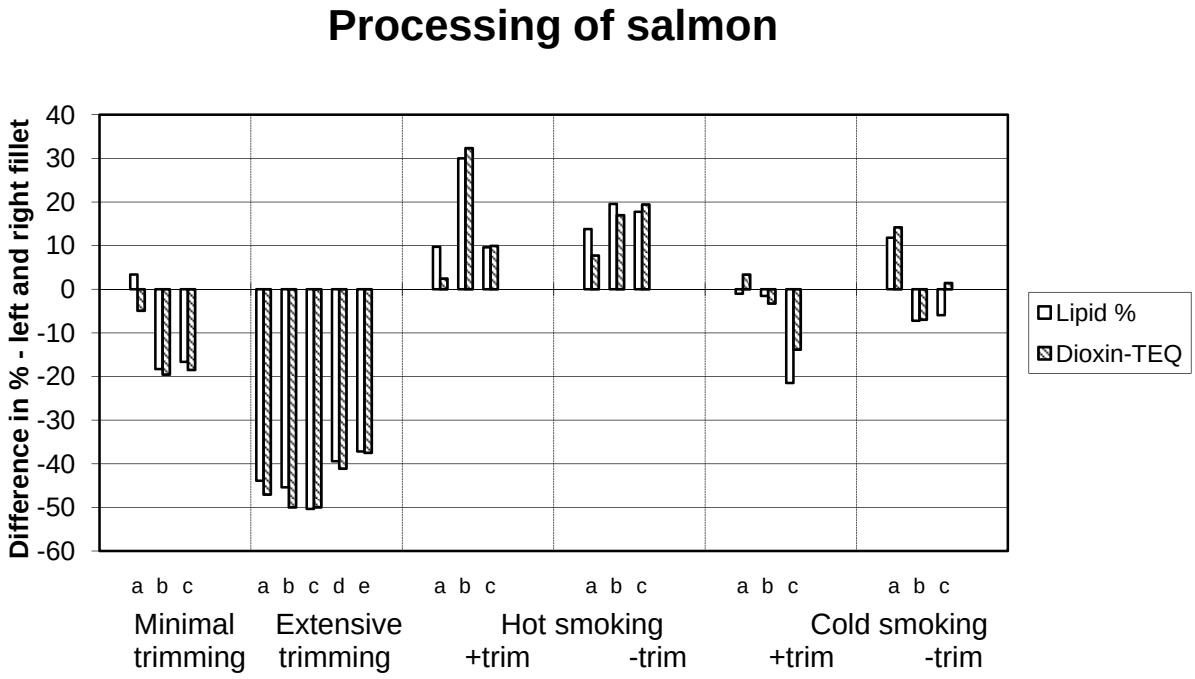

Figure 1 Difference in levels of WHO-TEQ dioxins between the un-processed left and processed right salmon fillet.

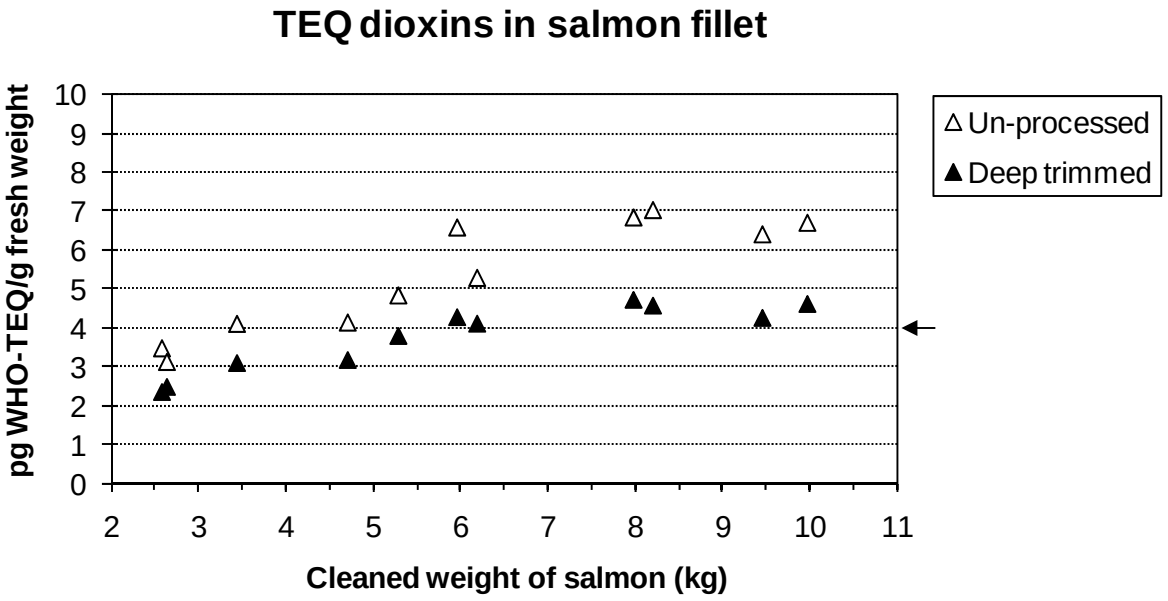

Figure 2 WHO-TEQ dioxins of un-processed left salmon fillets and deep trimmed right fillets. EU maximum level for dioxin in muscle meat of fish at 4 pg WHO-TEQ/fresh weight is shown as an arrow.

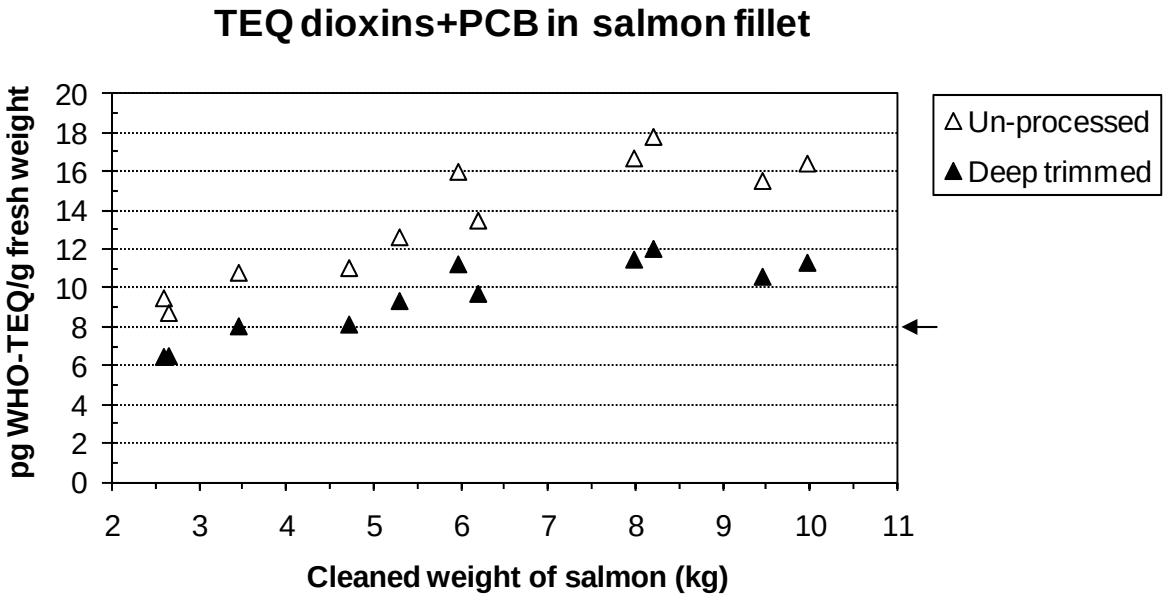

Figure 3 WHO-TEQ dioxins and PCB of un-processed left salmon fillets and deep trimmed right fillets. EU maximum level for the sum of dioxins and PCB in muscle meat of fish at 8 pg WHO-TEQ/fresh weight is shown as an arrow.

The effect of extensive trimming was investigated on fillets from salmon over a wide range of weight classes. In figure 2 the measured concentrations of dioxins in the un-processed left fillets and deep trimmed fillets are displayed and in figure 3 the corresponding concentrations of the sum of dioxins and PCB are shown. In the seven investigated weight classes, from 2 kg to 11 kg, the decrease was on average 28% with respect to dioxin content and 30% with respect to the sum of dioxins and dioxin-like PCB. The loss of weight by processing of the fillets was in total 32%-33% on average within each weight class, and the extensive trimming contributed 16%-17%.

If the analytical uncertainty is taking into account the measured concentrations of dioxins in the extensively trimmed fillets of salmon meet the current maximum limit for dioxins at 4 pg TEQ/g fresh weight. From approximately 6 kg cleaned weight and above the limit is met only by a small safety margin.

The measured concentrations of the sum of dioxins and dioxin-like PCB show that several of the extensively trimmed fillets significantly exceed the current maximum limit at 8 pg TEQ/g fresh weight. This relates to a cleaned weight of the salmon of approximately 6 kg and above.

The regulatory aspects of the findings resulted in a Danish order, which state that salmon from the Danish catching areas in the Baltic Sea can only be sold if the cleaned weight is 5.5 kg at a maximum, and if the fillets have undergone an extensive trimming procedure.[8]

In addition dietary guidelines were issued aimed at fish consumers and certain risk groups: Women of childbearing age, pregnant or breastfeeding can eat a maximum of one portion (approximately 125 g) of salmon from the Baltic Sea per month. All other consumers can eat a maximum of two portions per month.

Acknowledgements
The authors would like to thank the following persons for contribution to the project: Ulrik Cold, Kirsten Hansen, Anni Helleskov, Inge Holmberg, Janne Julø, Sanne Kuhlmann, Ellen Larsen, Vera Lykkerask, Ann-Marie Pedersen, Anne S. Rasmussen, Jannie Rasmussen and Tom Vestbo.

The projects have been financed by grants from EU Financial Instrument for Fisheries Guidance and The Danish Food Industry Agency (3704-3-04-0122 and 3704-3-06-0146).

References

1. Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs
2. Zhou S, Ackman RG, Morrison C (1995) *Fish Physiology and Biochemistry* 14:171-178
3. Voiland MP, Gall KL, Lisk DJ, MacNeill DB (1991) *J. Great Lakes Res.* 17: 454-460
4. Zabik ME, Zabik MJ, Booren AM, Nettles JH, Song JH, Welch R, Humphrey H (1995) *J. Agric. Food Chem.* 43: 993-1001
5. Leeuwen SPJ van, Traag WA, Hoogenboom LAP, de Boer J (2002) *Organohalogen Comp.* 57: 217-220
6. Witczak A, Ciereszko W (2008) *J. Agric. Food Chem.* 56: 4278-4282
7. Commission Regulation (EC) No 1883/2006 of 19 December 2006 laying down methods of sampling and analysis for the official control of levels of dioxins and dioxin-like PCBs in certain foodstuffs
8. BEK 101 February 9, 2009 https://www.retsinformation.dk/Forms/R0710.aspx?id=123406 (in Danish)