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Levels of non-essential elements in muscle from harp seal (*Phagophilus groenlandicus*) and hooded seal (*Cystophora cristata*) caught in the Greenland Sea area

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Abstract

The non-essential elements, arsenic, cadmium, mercury and lead, inevitably accumulate in marine top predators such as seals. The concentration of these elements and the essential element selenium, due to its proposed protective properties against mercury toxicity in marine mammals, were measured in muscle, liver and kidney from reproductive active females of harp seal (*Phagophilus groenlandicus*) and hooded seal (*Cystophora cristata*) caught in the drift ice between Iceland and East Greenland. Arsenic levels were below 1 μg/g w.w. in all analysed samples, and were therefore low compared to other seafood products. The concentrations of arsenic found in the present study were comparable to the results reported in a similar study from 1985. Mean concentrations of total mercury in muscle from the present study were higher than levels in other seafood products. The levels of total mercury from the present study showed a tendency of lower levels in all tissue samples compared to the study from 1985. Methyl mercury displayed a trend of a lower ratio of methyl mercury to total mercury as the concentration of total mercury increased, indicating a demethylation of methyl mercury at high total mercury concentrations (e.g. mercury in liver of hooded seal). The concentration ratio of methyl mercury to total mercury in muscle samples was more than 75%, with total mercury concentration less than 0.5 μg/g w.w., whereas the ratio for liver was as low as 0.2% with a total mercury concentration of 128 μg/g w.w. The molar concentration ratios of selenium to mercury showed that selenium was present in a molar surplus to mercury in all tissues with low mercury concentration. However, there seemed to be a general mobilisation of selenium in liver and kidney tissues of harp seal and hooded seal, whereas an extraordinary mobilisation seemed to take place at hepatic mercury concentrations exceeding 50 μg/g w.w. The mean concentrations of lead in muscles in the present study were higher than in fish and other seafood products from the Barents Sea. The lead concentrations from the present study were lower than levels reported in the 1985 study. However, the levels of the non-essential elements analysed in muscle from the two seal species in the present study should not prevent the use of seal meat in human nutrition.

Keywords: Non-essential elements; Harp seal; Hooded seal; Arsenic; Cadmium; Methyl mercury; Selenium-to-mercury ratio; Lead

1. Introduction

Harp seal (*Phagophilus groenlandicus*) is the third most abundant seal species of the world, with average length and weight of 165 cm and 135 kg, respectively.

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There are three subpopulations; one breeding in the Barents Sea/White Sea, one in the area between Jan Mayen and East Greenland, and one around Newfoundland (Commeau, 1989). The hooded seal (*Cystophora cristata*) is one of the larger members of the seal family (e.i. 240–300 cm and weighing 270–400 kg). There are two hooded seal stocks; one in the West Ice and the other one off Newfoundland in the Gulf of St. Lawrence (King, 1983).

Seals are among the top predators in the marine food web, and their life expectancy may be up to 35 years. Slowly growth patterns, due to low temperatures, make the prey items older and with higher levels of the non-essential elements (Dietz et al., 1996, 1998) arsenic, cadmium, mercury and lead, and this in combination with a low clearance of these elements, inevitably leads to their biomagnification in marine mammals (Shahidi, 1998). Harp seal and hooded seal share much of their biotope, but hooded seals tend to remain further offshore and dive much deeper compared to harp seal. Harp seals are known to prefer pelagic fatty fish species (Nilssen, 1995; Nilssen et al., 1995). The eating habits of hooded seal are less well known, but in addition to pelagic fish, hooded seals are known to feed on leaner benthic fish species (Kapel, 1995; Potelov et al., 1997). The diet, feeding habits, and biotope are important factors with respect to the levels of non-essential elements (Dietz et al., 1996; Muir et al., 1999; Riget et al., 2004).

Data on the levels of non-essential elements in muscle, liver and kidney of harp seal and hooded seal in the Greenland Sea area are sparse. However, Julshamn and Grahl-Nielsen (2000) report levels of arsenic, cadmium, mercury, lead and selenium in muscle, liver and kidney from harp seal and hooded seal caught in the Greenland Sea in the winter season of 1985. Furthermore, the essential element selenium was analysed due to its proposed protective properties against mercury toxicity in marine mammals (Julshamn et al., 1989; Cuvinaralar and Furness, 1991).

Food safety may be evaluated in different ways. The Food and Agriculture Organisation (FAO) and World Health Organisation (WHO) have given maximum intake levels for contaminants, known as “Provisional Tolerable Weekly Intake” (PTWI), i.e. the estimated maximum amount of an agent, expressed on a body mass basis, to which an individual may be exposed weekly (or daily, hence PTDI) over a lifetime without appreciable health risk (www.codexalimentarius.net). In addition, the European Union (EU) has set maximum levels for selected contaminants in different foods and feeding stuffs (EU, 2001), but at present there are no legislations established for non-essential elements in marine mammals. The limits given for terrestrial muscle tissues are not comparable, since the occurrence of these contaminants are dissimilar in the marine and terrestrial food webs. It should be noted that the issue of food safety is very dependent on the chemical form of the non-essential elements; e.g. inorganic mercury is considered to be relatively harmless, while methyl mercury is considered very toxic. This is contrary to the case of arsenic; where the organic forms, e.g. arsenobetaine, are regarded to be of little toxic concern, while the inorganic chemical forms of arsenic (V), and especially arsenic (III) are considered very toxic (Hughes, 2002). Except for seaweed, arsenobetaine constitutes the bulk of the arsenic in seafood (Francesconi, 1997).

The Norwegian food safety authority advise against including whale meat in the weekly eating plan for pregnant and breast-feeding women, due to the possibility of high mercury levels, which may also concern seal meat. The Norwegian government, however, emphasis the need for better utilisation of other parts of the seal than the fur, e.g. blubber and meat, but before guidelines on consumption of such food items can be given, the nutritional and food safety aspects related to consumption must be thoroughly investigated. The focus on seafood consumption is moving from the beneficial effects of e.g. n-3 PUFAs to the food safety aspects regarding the presence of non-essential elements. Integrated knowledge on weighing both the positive (nutrient) and negative (contaminant) aspects of consumption is lacking, which reflects the limited knowledge about the bioavailability and the levels required to exert biological effects of nutrients and contaminants in seafood. Therefore we find it important to determine the levels of the non-essential elements in the meat of seals which are likely to be on the Norwegian market in the present study, but also the levels of POPs in future studies before recommendations on human consumption of seal meat may be given.

The aims of the present study were: To determine and compare the concentrations of non-essential elements (i.e. arsenic, cadmium, mercury and lead) in muscle, liver and kidney tissues of harp seal and hooded seal with a similar study performed in 1985; further to determine the relationship between methyl mercury and total mercury in muscle, selected liver and kidney samples; to examine the relationship between the selenium and mercury tissue concentrations of harp seal and hooded seal; and to evaluate the food safety of