Temporal dynamics of dioxin contamination of reindeer offal from Russian Far North regions

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Abstract. Reindeer herding is vitally important activity in Russian Far North regions. Meat and offal (liver, kidneys, etc.) are readily consumed by indigenous people and also exported, therefore the problem of reindeer products safety in view of chemical contamination is of both scientific and practical interest. Here, we report levels of dioxins in 64 individual samples of reindeer liver (Rangifer tarandus tarandus and Rangifer tarandus sibiricus) originating from four main reindeer-herding regions of Russia with broad geographical distribution from western to eastern border of the country, including Murmansk Oblast, Komi Republic, Nenets Autonomous Okrug and Yamalo-Nenets Autonomous Okrug. Persistent organic pollutants (polychlorinated dibenzo-p-dioxins and polychlorinated dibenzo-p-furans) were determined by high-resolution gas chromatography-mass spectrometry and expressed as WHO toxic equivalents (WHO-TEQ). Dioxin pollution has shown clear geographical distribution. It is the highest at the Kola Peninsula and generally decreases to the east. In particular, dioxins concentration in reindeer liver varied from 40.5 ± 10.1 pg WHO-TEQ/g of fat in Nenets Autonomous Okrug to 14.8 ± 3.7 pg WHO-TEQ/g of fat in Yamalo-Nenets Autonomous Okrug. A comparison with the previous data showed significant increase of dioxin levels in reindeer liver from selected regions over the last 2 years. Taking into account growing interest to reindeer liver processing for food production, our data give further insight in possible risk of longtime consumption of reindeer offal.

1. Introduction

Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzo-p-furans (PCDFs) belong to a large group of toxic persistent organic pollutants often referred to as “dioxins”. The 17 isomers (congeners) halogenated in positions 2,3,7,8 are the most toxic. They were assigned toxicity coefficients so that any given mixture of dioxins can be characterized by its toxicity equivalent relative to 2,3,7,8-tetrachlorodioxin Dioxins are formed as by-products during combustion of organic materials, and also in cellulose bleaching and organochlorine pesticides synthesis. Due to their persistent nature and lipophilic properties, dioxins are transferred in food chains and accumulated in lipid-containing food, such as milk, meat, offal, eggs, fish [1]. As a result, such food is a source of dioxins intake in humans.

Northern ecosystems are known to accumulate persistent organic pollutants because of specific climate processes and characteristic trophic chains. Xenobiotics are accumulated in animals depending on species, feeding habits and metabolic activity [2]. In the Far North regions, reindeer are known to accumulate dioxins. Seasonal variations of the accumulated fat, which is mobilized in winter, causes
dioxins transfer to various organs and tissues [3]. Selective accumulation of dioxins in livers of reindeer and sheep (in contrast to cattle, pigs and poultry) was demonstrated previously. Dioxins are mostly transferred from feed and soil [4]. In the Far North, the local mining industry of the Kola Peninsula and Krasnoyarsky Krai are contributing to dioxin pollution.

Reindeer breeding is an important part of agriculture. There are ca. 1.5 million reindeer in the Russian Federation [5]. Reindeer are the staple food of indigenous people in the Russian Far North. Reindeer meat, liver and kidneys are actively consumed and also exported [6]. Long-term exposure to dioxins negatively affects the immune, nervous, reproductive and endocrinal systems, and causes oncological disease [7]. Therefore, studying dioxin concentrations in reindeer products is of practical importance.

Our goal was to determine dioxin concentrations in reindeer (Rangifer tarandus tarandus L. и Rangifer tarandus sibiricus Murray) liver and other offal from four geographic regions (Murmansk area, Republic of Komi, Nenets Autonomous Region, and Yamalo-Nenets Autonomous Region) and to study the temporal dynamics of the dioxin concentrations by comparing with the literature data [8, 11].

2. Materials and methods

2.1. Sampling

Reindeer liver samples (64 in total) were collected in 2017-2018 by Rosselkhoznadzor authorities for food safety monitoring in the four reindeer-herding regions (Murmansk area, Republic of Komi, Nenets Autonomous Region, and Yamalo-Nenets Autonomous Region). The samples were shipped to the analytical laboratory deep-frozen.

2.2. Analysis method

Dioxins were determined according to the accepted standard method [9]. Defrosted samples were homogenized and lyophilized. To a prepared sample (10-15 g), a mixture of isotopically labelled internal standards was added, the sample mixed with PrepDE (Dionex) sorbent and extracted by a hexane-isopropanol (1:1) mixture on an ASE 350 (Dionex) extractor. The extract was purified on a column packed with silica gel impregnated with sulfuric acid, then on a column with activated alumina and finally on activated carbon. The purified extract was concentrated to 1 ml using a Rotovapor (Buchi, Switzerland), transferred to a chromatographic vial, recovery standards (Wellington Labs, Canada) added, diluted with 0.01 ml undecane, and concentrated under stream of nitrogen to the final volume. Dioxins were analyzed on a high-resolution AutoSpec GC-MS system (Waters Corp.) using a VF-xms capillary column (60 m x 0.25 mm) in SIM mode at 10 000 resolution. Toxicity equivalents (WHO 2005) were calculated based on lipid content, which was determined gravimetrically according to GOST 23042-86.

3. Results

Dioxin concentrations in all reindeer liver samples were found to exceed the maximum residue limit of 6.0 pg TEQ/g fat [10]. The highest concentrations were detected in samples from Murmansk area and Nenets okrug (20- and 14-fold excess, resp.). The results are summarized in Table 1.

Table 1. Measured dioxin concentrations (pg TEQ/g fat ± Δ) in reindeer liver samples collected in 2017-2018.

| Region / no. of samples | Average concentration ± Δ | Minimal concentration ± Δ | Maximum concentration ± Δ |
|-------------------------|---------------------------|---------------------------|---------------------------|
| Murmansk area / 20      | 39.74 ± 9.94              | 13.1 ± 3.28               | 118.5 ± 29.63             |
| Nenets / 30             | 40.51 ± 10.13             | 3.6 ± 0.9                 | 83.97 ± 20.99             |
| Republic of Komi / 10   | 30.15 ± 7.54              | 4.52 ± 1.13               | 49.83 ± 12.46             |
| Yamalo-Nenets / 4       | 14.76 ± 3.69              | 8.45 ± 2.11               | 23.63 ± 5.91              |
It is seen that dioxin concentrations are generally decreasing from west to east, in accordance with previous studies dated 2014-2016 [8]. The temporal changes are shown in Fig. 1. We conclude that in the past two years the dioxin contamination of reindeer liver did not changed in Murmansk area and Yamalo-Nenets Autonomous Okrug, but it significantly increased in Nenets Autonomous Okrug and Republic of Komi.

Therefore, our results indicate that dioxin contamination of reindeer liver is not decreasing with time and is characterized by permanent geographic distribution, decreasing eastwards from the Kola Peninsula.

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