Mercury content in the meat and organs of cattle and pigs

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Abstract

This paper presents the results of testing and assessment of total mercury (Hg) content in meat, liver and kidneys of cattle and pigs in the Czech Republic in the years 2010 – 2013. The results document increasing Hg concentrations in kidneys depending on the livestock age.

Tissues of cattle and pigs, total mercury content

Introduction

Mercury (Hg) exists in the environment in the form of elementary, inorganic and organic Hg (principally as methylmercury). Hg gets into the atmosphere from mining (the gold extraction), the foundry industry, other industrial activity and the combustion of fossil fuels. It is stored in the soil and water, and thereby in sediment, where is Hg turned into more toxic methylmercury by the action of microflora and microfauna. Organic Hg compounds have also been used as fungicides and pharmaceuticals (Mercurochrome as a local antiseptic; the still-used Thiomersal (ethylmercury) as a preservative in vaccines) (EFSA 2008). Fish meal is the most common source of Hg in feed of livestock animals. The published results indicate that Hg is primarily present in feed as a methylmercury. Chromatographic techniques are available for differentiating organic Hg from its inorganic form. These techniques have been validated, although they are not routinely used as they are complicated and costly. In consequence, only the total Hg content is generally determined, primarily by atomic absorption spectrometry (EFSA 2008). The food Hg intake is considered the most important source for man outside accidental or occupational exposure to Hg (ATSDR 1999). Gastrointestinal absorption of inorganic Hg falls within a range of 10 to 30%. Following absorption, inorganic Hg is distributed mainly in the kidneys and, to a lesser extent, the liver. Inorganic Hg has a crucial effect on kidney damage. No data is available on the carcinogenic effects of inorganic Hg in man (EFSA 2008). Urine and faeces represent the main pathways for the excretion of inorganic Hg. In view of the poor absorption of inorganic Hg ingested orally, most of the ingested dose (of the order of 80%) is excreted in the faeces in man. The half-life for the excretion of absorbed Hg is around 40 days in man (Clarkson et al. 1988).

The aim of this study was to assess the total Hg content in the meat and organs of cattle and pigs. To draw attention to the absence of a maximum limit (ML) for total Hg in these tissues, and to propose a resolution of this situation for bodies of state food safety monitoring in the Czech Republic.

Materials and Methods

The results of tests for total Hg content in samples of muscle, liver and kidney taken at random from calves, young cattle to the age of two years, cows and pigs at slaughter weight, including culled sows, were evaluated. Samples were taken by veterinary inspectors in the Czech Republic in the years 2010 – 2013. Test results were obtained within the framework of the performance of the national plan for the monitoring of residues and contaminants in accordance with Council Directive No. 96/23/EC and associated legislation. The minimum numbers of animals from which samples were taken for the determination of Hg were stipulated according to the

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methodology given in the directive in question. Commission Regulation (EC) No. 1881/2006 does not stipulate maximum limits (ML) of Hg for the meat and organs of livestock animals. The concentrations of Hg in the tested tissues were, for this reason, evaluated according to the maximum residue limits (MRL) stipulated by the Regulation (EC) No. 396/2005 of the European Parliament and of the Council as amended. A maximum limit for Hg of 0.01 $mg \cdot kg^{-1}$ is stipulated with the note that the value indicates the limit of quantification (LOQ). Determination of the Hg content was performed by the AMA technique (direct determination of Hg by an atomic absorption spectrometer) with an LOQ of 0.001 $mg \cdot kg^{-1}$ (at a sample weight of 50 mg) for muscle, liver and kidneys in accredited laboratories of State Veterinary Institutes in the Czech Republic. Evaluation of the Hg content in cattle and pig tissues was performed by basic statistical calculations characterising data sets.

Results

All samples of kidney from the cattle in the age categories tested contained measurable concentrations of Hg (values above the LOQ). The values of the median, average and maximum concentrations of Hg in cattle (with the exception of calves) were in all cases higher in the kidneys than in the liver and, in particular, the muscles, in which the concentrations were the lowest (Table 1).

Table 1. Tests results of Hg content in the meat and organs of cattle in the Czech Republic in the years 2010 – 2013 ($mg \cdot kg^{-1}$)

Category of cattle	Tissue	No of samples (n)	No of samples ≤ LOQ	Median	Average Hg content	10% quantile	90% quantile	Max. Hg content
Calves	Muscle	28	15	nd	0.0008	nd	0.0014	0.0067
	Liver	17	1	0.0020	0.0195	0.0007	0.0089	0.2910
	Kidneys	17	0	0.0020	0.0128	0.0010	0.0132	0.1630
Bulls and heifers	Muscle	64	34	nd	0.0006	nd	0.0011	0.0027
to the age	Liver	45	1	0.0024	0.0034	0.0010	0.0073	0.0128
of 2 years	Kidneys	45	0	0.0059	0.0069	0.0029	0.0127	0.0190
	Muscle	96	43	0.0005	0.0008	nd	0.0015	0.0046
Dairy cows	Liver	65	0	0.0028	0.0035	0.0010	0.0079	0.0194
	Kidneys	65	0	0.0074	0.0090	0.0043	0.0146	0.0250

nd – not detected

All the samples of kidneys from the tested pigs contained measurable concentrations of Hg (values above the LOQ). The values of median, average and maximum Hg concentrations in the pigs were in all cases higher in the kidneys than in the liver and, in particular, the muscles, in which the Hg concentrations were the lowest (Table 2).

If we take the median Hg content in the muscle (or the LOQ value in the case of a not detected result) to be equal to 1, then the proportions of the median values for muscle : liver : kidney are 1 : 2.0 : 2.0 in calves, 1 : 2.4 : 5.9 in young cattle to the age of two years, and 1 : 5.6 : 14.8 in cows. The ratio between the Hg content in muscle in comparison with liver and, in particular, kidney increases with the age of the cattle. The distribution of mercury in the muscle, liver and kidney of pigs (fattening pigs and culled sows) was similar as in young cattle – 1 : 2.4 : 6.2.

Discussion

The exceeding Hg limit content of 0.01 $mg \cdot kg^{-1}$, particularly in the kidneys of cattle and pigs, was highlighted in a report from the European Food Safety Authority

Table 2. Tests results of mercury content in the meat and organs of pigs in the Czech Republic in the years 2010 – 2013 (mg·kg^{-1})

Category of cattle	Tissue	No of samples (n)	No of samples ≤ LOQ	Median	Average Hg content	10% quantile	90% quantile	Max. Hg content
Fattening	Muscle	308	133	0.0005	0.0007	nd	0.0014	0.0053
Pigs +	Liver	211	24	0.0012	0.0020	nd	0.0047	0.0130
Sows	Kidneys	211	0	0.0031	0.0075	0.0014	0.0207	0.0558

nd – not detected

(EFSA 2014). The MRL stipulated in Regulation (EC) No. 396/2005, as amended, has been used since 2009 to assess foodstuffs from the viewpoint of Hg content (with the exception of aquaculture), and this has led to a significant increase in the proportion of unsatisfactory samples of foodstuffs in the EU member states that are performing these tests.

The EFSA report (EFSA 2014) states that 269 and 218 of all the samples of foodstuffs in the EU member states in 2010 and 2011 were above the limit in terms of the values of Hg (in 2007 and 2008 there were just 30 and 47 samples, respectively). The same report states that there were 16 unsatisfactory tissue samples from cattle and 109 unsatisfactory samples from pigs over the limit for Hg concentration in the EU states in 2012. Three out of 230 samples from cattle were unsatisfactory (1.3%), and 9 out of 231 samples from pigs were unsatisfactory (3.9%) in the Czech Republic in the same year. Thirteen out of 307 tissue samples from cattle were unsatisfactory (4.2%), and 100 of 1 485 samples from pigs were unsatisfactory (6.7%) in Germany. The Hg content exceeding the MRL stipulated in the legislation (0.01 mg·kg^{-1}), particularly in the kidneys of cattle and pigs, though in isolated cases in the liver as well, is a problem encountered by supervisory bodies.

Conclusions

The total Hg content in the liver and, in particular, in the kidneys of cattle and pigs increases with the age of the animals. Safety assessment of these organs used as a food according to the maximum Hg limit given in the legislation may be problematic. The relatively large number of unsatisfactory samples of kidney in particular, and occasionally liver, from cattle and pigs may cause considerable losses as the result of condemnation in the meat industry. A possible solution lies in the elimination of all potential sources of Hg in feed batches and from the environment in which livestock animals live. Also a reassessment of the existing maximum residue limit (MRL) for Hg given in the legislation for pesticide residues (where the MRL = LOQ), or the performance of an assessment of the risk of Hg from cattle and pig kidneys and liver at the national level should be performed.

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