

# The results of monitoring non-dioxin-like PCBs in beef and pork in the Czech Republic

Jiří Drápal<sup>1,3</sup>, Petr Hedbávný<sup>1</sup>, Milan Malena<sup>1</sup>, Jan Rosmus<sup>2</sup>, Veronika Střechová<sup>1</sup>

<sup>1</sup>Central Veterinary Administration  
State Veterinary Administration

<sup>2</sup>State Veterinary Institute  
Prague, Czech Republic

<sup>3</sup>Faculty of Veterinary Hygiene and Ecology  
University of Veterinary and Pharmaceutical Sciences Brno  
Brno, Czech Republic

## Abstract

The assessment of results for non-dioxin-like polychlorinated biphenyls (NDL PCBs) in the years 2009–2011 and 2012 demonstrated average concentrations of NDL PCBs in a range of 6.13 to 10.34 ng.g<sup>-1</sup> of fat in beef and 5.48 to 8.02 ng.g<sup>-1</sup> of fat in pork. For highly chlorinated PCBs, the average values of individual congeners were ranked in order 153 > 138 > 180. Congeners with a lower number of chlorine atoms (PCBs 118, 52, 101 and 28) were found in low concentrations or beneath the limit of quantification.

*Polychlorinated biphenyls, monitoring, meat*

## Introduction

Polychlorinated biphenyls (PCBs) are a group of substances that theoretically includes 209 individual compounds (congeners) that differ in terms of their physical and chemical properties and toxicity. They can be divided into two groups according to their toxicological properties. One of these groups is made up of 12 congeners that have toxicological properties similar to those of dioxins and are therefore known as dioxin-like PCBs (DL PCBs). The other PCBs do not show a toxicity similar to that of dioxins and have a different toxicological profile, and are therefore known as non-dioxin-like PCBs (NDL PCBs) (Commission Regulation (EC) 2011). NDL PCBs have been shown to have neurological, endocrine, immunologic and carcinogenic effects. A number of international agencies classify NDL PCBs as probable human carcinogens (EFSA 2010). While certain lower chlorinated PCBs congeners are metabolised relatively quickly, highly chlorinated congeners are more stable and are accumulated in the food chain. They are deposited in fat tissues and are metabolised extremely slowly in the body. For the majority of the population, the main pathway of human exposure is via food, with the exception of specific cases of accidental exposure or exposure at work (EFSA 2005, 2010). Polychlorinated biphenyls were synthesised on the turn of the 19<sup>th</sup> and the 20<sup>th</sup> centuries and used in industry from the nineteen thirties onwards. Breivik et al. (2002) estimate, that a total of 1.3 million tons of PCBs have been produced around the world, with about 97% of this quantity being used in the northern hemisphere. In the 1970s, it was discovered that PCBs degrade slowly in the environment and accumulate in food chains and that they can be dangerous to human health, for which reason their production was gradually brought to a halt. In Czechoslovakia, PCBs were made at Chemko Strážské plant in eastern Slovakia until 1984. A total of 21 482 tons of PCBs were made there, of which nearly half was exported, primarily to the former East Germany (Holoubek et al. 2003). Polychlorinated biphenyls were among the most significant pollutants in agriculture (and in livestock production in particular) and water pollutants in this country in the 1980s and the beginning of the 1990s. Livestock farms were highly polluted by these substances, and it required enormous effort on the part of veterinary doctors at all levels of the veterinary organisation to gradually

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### Address for correspondence:

MVDr. Jiří Drápal  
Central Veterinary Administration  
State Veterinary Administration  
Slezská 7/100, 120 56 Praha 2, Czech Republic

Phone: +420 227 140  
Fax: +420 010 193  
E-mail: j.drupal@svscr.cz  
www.maso-international.cz

identify all the farms affected, eliminate contaminated feedstuffs, dispose of contaminated raw materials and foods of animal origin, and thereby protect society (consumers) against these substances that pose a threat to health (Drápal 2012). At 2011, only eight EU member states had national limits for PCBs (including the Czech Republic and Slovakia). Maximum limits were stipulated for varying numbers of congeners. For the purposes of harmonisation, the European Commission (EC) issued Regulation (EC) 1259/2011, valid from 1<sup>st</sup> January 2012, stipulating a maximum limit (ML) for PCBs in the meat and offal of animals for slaughter (the sum of PCBs indicator congeners No. 28, 52, 101, 138, 153 and 180 in accordance with the IUPAC) of 40 ng.g<sup>-1</sup> of fat (Comm. Reg. 2006). According to the EFSA Scientific Panel on Contaminants in the Food Chain (CONTAM Panel), these indicator congeners comprise around 50% of the total quantity of NDL PCBs in foodstuffs (EFSA 2010).

We performed an assessment of the results for the last three years in which the national limit for PCBs in beef and pork of 200 ng.g<sup>-1</sup> of fat (the sum of indicator congeners + PCB 118) applied in the Czech Republic, and the results for 2012, when the results were expressed and evaluated in accordance with Regulation (EC) 1259/2011, including an assessment of the profile (frequency) of individual congeners.

### Materials and Methods

#### Animals

Test results were obtained from the performance of the national plan for monitoring residues and contaminants in accordance with Council Directive 96/23/EC (1996). The animals were selected at random by veterinary inspectors at various slaughterhouses in the Czech Republic. Samples of meat (at least 0.5 kg) were taken from young cattle up to the age of two years (with the exception of calves to the age by six months) and cows, and from pigs at slaughter weight (90–110 kg) and culled sows. After collection, the samples were frozen to –18 °C and transported to State Veterinary Institute in Prague, Jihlava and Olomouc.

#### Analytic methods

Homogenised samples of muscle tissue were extracted with a mixture of dichloromethane and acetone 2:1 v/v and an aliquot part of the extract obtained purified by gel permeation chromatography (GPC) with a mixture of cyclohexane and ethyl acetate in a column filled with styrene-divinylbenzene gel and used for gas chromatography analysis (GC/ECD). Identification and quantification of individual PCB congeners was performed according to retention times on the basis of analysis of a standard mix of 6 (7) PCB indicator congeners by parallel analysis in columns with differing stationary phase polarity (DB – 5 ms and DB – 17) with two electron capture detectors. The results are given in ng.g<sup>-1</sup> of extracted fat, with the exception of samples with a fat content of less than 2%, for which values are given in ng.g<sup>-1</sup> of fresh weight. As of 1 January 2012, the limit of quantification (LOQ) for the sum of PCBs in accordance with a note <sup>(32)</sup> to the Annex to Commission Regulation (EC) 1881/2006 has been set at 14 ng.g<sup>-1</sup> of fat or 0.6 ng.g<sup>-1</sup> (Commission Regulation (EC) 2006). Until 31<sup>st</sup> December 2011, the LOQ were stipulated as 0.005 mg.kg<sup>-1</sup> of fat (5 ng.g<sup>-1</sup> of fat) in accordance with national legislation (Ministry of Health of the Czech Republic Decree 2004).

#### Statistical evaluation of the results

The results of tests of the sum content of PCBs (6 indicator congeners + PCB 118) for the period 2009–2011 and the results of tests of the sum content of PCBs (6 indicator congeners) for 2012 were used for basic statistical evaluation (average, median, 10% quantile, 90% quantile).

### Results and Discussion

Measurement of PCBs (PCB-7) in cattle meat (Table 1) demonstrated that around 80% of the results relative to fat were beneath the limit of quantification (LOQ) in the period 2009–2011. In 2012, almost 67% of results (PCB-6) were beneath the LOQ (relative to fat). In beef with a content of less than 2% fat, 92% of the results were beneath the LOQ. The average values of sum PCBs (PCB-7) in the period 2009–2011 and the average concentrations of PCBs (PCB-6) in 2012 (range 6.13–10.34 ng.g<sup>-1</sup> of fat) were beneath the maximum limit (ML) of 40 ng.g<sup>-1</sup> fat valid at the present time. Similar findings as for cattle were also made in the muscle tissue of pigs, for which

Table 1. The sum content of NDL PCBs in the meat of cattle and pigs in the Czech Republic in 2009–2011 and 2012 (ng.kg<sup>-1</sup> of fat)

Year	tissue	Cattle (> 6 months old) ng.g <sup>-1</sup> fat						Pigs (fattening pigs and sows) ng.g <sup>-1</sup> fat					
		n	n < LOQ (%)	median	$\bar{x}$	10% quantile	90% quantile	n	n < LOQ (%)	median	$\bar{x}$	10% quantile	90% quantile
2009		79	81.00	n.d.	6.13	n.d.	15.0	102	85.29	n.d.	8.02	n.d.	19.2
2010	meat	78	80.77	n.d.	6.88	n.d.	20.5	103	83.50	n.d.	6.27	n.d.	20.0
2011		90	80.00	n.d.	10.34	n.d.	34.9	96	83.33	n.d.	5.48	n.d.	17.9
		247						301					
2012	meat	36	66.66	n.d.	7.50	n.d.	16.1	82	80.49	n.d.	7.78	n.d.	14.0
	meat*	13	92.21	n.d.	0.32	n.d.	n.d.	-	-	-	-	-	-

n = number; n.d. = not detected; \*) ng.g<sup>-1</sup> (content of fat < 2%);  $\bar{x}$  = arithmetic mean

Table 2. Average content of NDL PCB congeners in the meat of cattle and pigs in the Czech Republic in 2009–2011 and 2012 (ng.kg<sup>-1</sup> of fat)

Year	PCB	Cattle (> 6 months old) ng.g <sup>-1</sup> fat						Pigs (fattening pigs and sows) ng.g <sup>-1</sup> fat					
		n	n < LOQ (%)	median	$\bar{x}$	10% quantile	90% quantile	n	n < LOQ (%)	median	$\bar{x}$	10% quantile	90% quantile
2009-2011	28	2476	100.00	n.d.	1.23	n.d.	n.d.	301	100.00	n.d.	1.26	n.d.	n.d.
	52	2476	100.00	n.d.	1.79	n.d.	n.d.	301	100.00	n.d.	1.79	n.d.	n.d.
	101	247	100.00	n.d.	1.42	n.d.	n.d.	301	100.00	n.d.	1.43	n.d.	n.d.
	[118]	2476	99.59	n.d.	1.88	n.d.	n.d.	301	99.67	n.d.	1.89	n.d.	n.d.
	138	2476	81.71	n.d.	2.98	n.d.	6.3	301	86.38	n.d.	2.84	n.d.	6.0
	153	2476	78.86	n.d.	3.90	n.d.	9.0	301	85.38	n.d.	3.02	n.d.	6.8
	180	2476	82.93	n.d.	2.61	n.d.	6.3	301	87.71	n.d.	2.43	n.d.	4.8
2012	28	36	100.00	n.d.	0.86	n.d.	n.d.	82	100.00	n.d.	0.87	n.d.	n.d.
	52	36	100.00	n.d.	0.94	n.d.	n.d.	82	100.00	n.d.	0.96	n.d.	n.d.
	101	36	100.00	n.d.	0.67	n.d.	n.d.	82	100.00	n.d.	0.65	n.d.	n.d.
	138	36	63.89	n.d.	1.82	n.d.	5.0	82	78.05	n.d.	1.79	n.d.	2.1
	153	36	63.89	n.d.	1.89	n.d.	5.2	82	76.83	n.d.	1.94	n.d.	2.3
	180	36	69.44	n.d.	1.11	n.d.	3.0	82	89.02	n.d.	1.38	n.d.	2.0
2012*	28	13	100.00	n.d.	0.05	n.d.	n.d.	-	-	-	-	-	-
	52	13	100.00	n.d.	0.05	n.d.	n.d.	-	-	-	-	-	-
	101	13	100.00	n.d.	0.05	n.d.	n.d.	-	-	-	-	-	-
	138	13	100.00	n.d.	0.05	n.d.	n.d.	-	-	-	-	-	-
	153	13	92.31	n.d.	0.05	n.d.	n.d.	-	-	-	-	-	-
	180	13	100.00	n.d.	0.05	n.d.	n.d.	-	-	-	-	-	-

n = number; n.d. = not detected; \*) PCB in ng.g<sup>-1</sup> (meat with fat content < 2%);  $\bar{x}$  = arithmetic mean

roughly 84% of the results expressed for fat in the period 2009–2011 fell beneath the LOQ. In 2012, 80% of the results were beneath the LOQ. The average concentrations of sum PCBs (5.48–8.02 ng.g<sup>-1</sup> of fat) were beneath the ML (40 ng.g<sup>-1</sup>) for the entire period assessed.

Our results are not in disagreement with the results of tests by the European Food Safety Authority (EFSA) on a total of 11 214 foodstuffs sampled in the period 1995–2008 in 18 EU member states, Iceland and Norway analysed for the occurrence of six NDL PCB indicator congeners (PCBs 28, 52, 101, 138, 153 and 180).

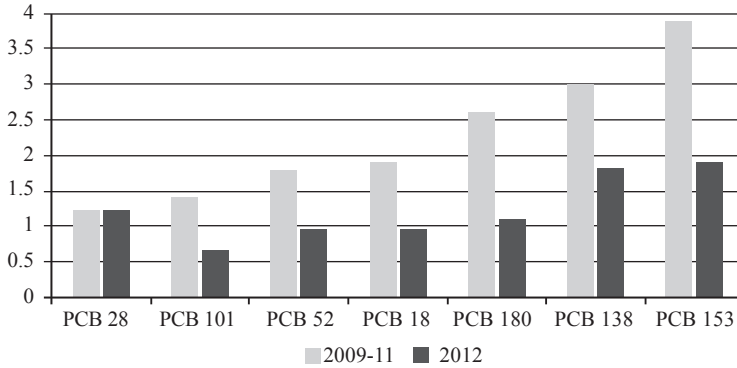


Fig. 1. Proportion of NDL PCB congeners in the meat of cattle in the Czech Republic in 2009–2011 and 2012 (ng.g<sup>-1</sup> fat)

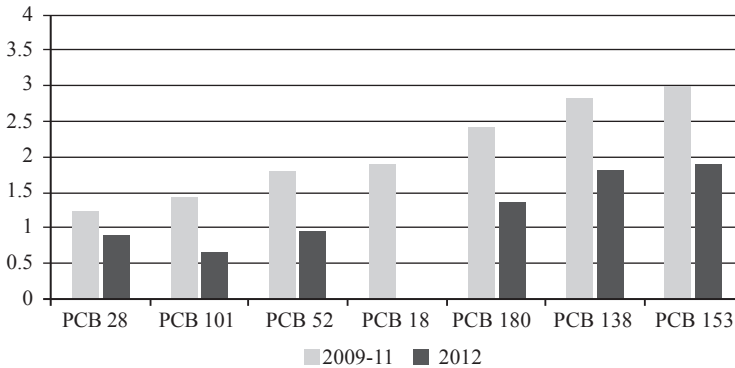


Fig. 2. Proportion of NDL PCB congeners in the meat of pigs in the Czech Republic in 2009–2011 and 2012 (ng.g<sup>-1</sup> fat)

The average 18.8% of the results for individual congeners were beneath the LOQ, though their distribution differed greatly between individual food groups. Congeners PCB-153 and PCB-138 were detected most frequently, followed by PCB-180, PCB-28, PCB-101 and PCB-52. PCB-153 and PCB-138 together accounted for at least 50% of the total sum of the six congeners in each group of foods. Meat and meat products from ruminants and pigs had an average NDL PCBs content of less than 5 ng.g<sup>-1</sup> fat (4.64 and 3.69 ng.g<sup>-1</sup> fat, respectively). Among animal fats, the greatest average level of contamination was discovered in the fat of ruminants (8.71 ng.g<sup>-1</sup> fat) (EFSA 2010). Andrée et al. (2010) reported an average content of the sum of PCB-6 indicator congeners in beef (5.33 ng.g<sup>-1</sup> fat) and pork (1.41 ng.g<sup>-1</sup> fat). In comparison with these average values for the sum concentration of PCBs and the values calculated from documentation on 18 EU member states, Iceland and Norway, the average NDL PCB concentrations we found were approximately twice higher in the meat of cattle and pigs.

## Conclusions

The average concentrations of NDL PCBs in the meat of cattle and pigs in 2009–2012 were beneath the ML valid from 2012. The concentrations of highly chlorinated PCBs in the order 153 > 138 > 180 were higher than those of congeners with a lower number of chlorine atoms (PCBs 118, 101, 52 and 28) throughout the entire period assessed. Their content was beneath the LOQ in almost all cases. Polychlorinated biphenyls, however, continue to represent a potential risk of contamination of livestock animals and, subsequently, foodstuffs of animal origin. Such contamination may occur during direct contact between animals and materials containing PCBs (old paintwork and building materials) in environments in which old farm buildings have not been completely decontaminated.

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