LEVELS AND DIETARY INTAKES OF POLYBROMINATED DIPHENYL ETHERS AND HEXACHLOROBENZENE IN MEAT IN KOREA

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Introduction

Polybrominated diphenyl ethers (PBDEs) are flame retardants and ubiquitous residual contaminants in the environment and food chain. PBDE levels have been shown to be increasing in aquatic animals while PCDD/Fs are declining. PBDEs can cause liver, thyroid, and neurodevelopmental toxicity[1].

The International Agency for Research on Cancer (IRAC) has classified hexachlorobenzene (HCB) under group 2B. HCB was found in human milk in Japan, although it is not a registered product there[2]. Similarly, HCB is not registered for use as a pesticide in Korea. However, HCB is an industrial pollutant formed in high temperature processes in the presence of chloride and during waste incineration[3]. No monitoring of HCB in food of animal origin has been conducted in Korea before, but in light of the findings in Japan, we decided to monitor for HCB in Korea.

PBDEs and HCB bioaccumulate due to their lipid solubility and resistance to degradation. The greatest concern for human exposure for the contaminants is in foods of animal origin, and consequently animal feed as the likely source of animal exposure. It is difficult to protect food and feed from the sources of toxic chemicals. Continuous monitoring is one part of a convenient system to minimize health risks from dietary exposure. This paper presents the results of residual PBDEs and HCB in beef, pork, and chicken from nationwide monitoring in Korea.

Materials and Methods

In the case of cattle and pork, 94 samples each were collected from all 9 provinces, and 31 chicken samples were collected from 5 provinces at slaughtering facilities in Korea during 2006 and 2007. PBDEs and HCB were analyzed together in one analysis and different methods of calculation used. HCB was determined by the method of external calibration, and an isotope dilution method was used for the analysis of PBDEs based on US EPA Method 1614. Fat was rendered from the beef and pork at 80^{o}C and chicken at 50^{o}C before analysis. Extraction was carried out with methylene chloride. A clean-up was performed by a jumbo triphasic silica column and regular columns of silica, alumina, and carbon using a Power-Prep^{TM} (FMS Inc., USA) automated column clean-up system. The extract was analyzed by HR-GC/MS (Autospec Ultima, Micromass Co., UK) equipped with a DB-5MS (J&W Scientific, USA) capillary column (50 m x 0.25 mm I.D., 0.25 μm film thickness). The recoveries of ^{13}C-surrogates of PBDEs were from 70% to 129%, and of HCB recoveries ranged from 86% to 94%.

Results and Discussion

Table 1 presents the levels of PBDEs, HCB in beef, pork, and chicken. The levels of PBDEs in chicken were 5.6 times the levels in beef and 3.8 times that in pork. PBDEs were found in all of the beef, pork and chicken samples. The mean concentrations of PBDEs were 0.33, 0.49, and 1.86 ng/g fat in beef, pork, and chicken, respectively. The highest concentration of PBDEs from the all samples was 3.70 ng/g fat in a chicken sample. The minimum, maximum, mean, and median concentrations of PBDEs occurred in the order: chicken > pork > beef. Congener profiles of PBDEs in beef, pork, and chicken are shown in Fig. 1. BDE-47 and BDE 99 were the dominant congeners in beef, pork, and especially in chicken. The regional findings of PBDEs in beef, pork, and chicken are shown in Figs. 3-5, respectively. Chicken samples have been analyzed from 5 provinces so far. The mean contributions of BDE-47 were 51%, 42%, and 37% in beef, pork and chicken, respectively. The mean contributions of BDE-99 were 31%, 31%, and 38% in beef, pork, and chicken, respectively. The regional mean concentrations of PBDEs ranged from 0.21 to 2.03 ng/g fat for the 9 provinces.

HCB was found in all of the chicken samples compared to samples of beef and pork (Table 1). The mean concentration of HCB in chicken was twice as high as that in beef or pork. The minimum, maximum, mean, and median concentrations of HCB were in order of chicken > pork > beef as in the case of PBDEs. The levels of HCB were one third of the PBDE levels in beef and pork and in one sixth in chicken. However, a significant relationship did not occur between the samples and the analyte concentrations. The mean concentrations of HCB in beef, pork, and chicken from the 9 provinces are shown in Fig. 2. The total concentration for all the samples is presented on the bar on the far right side. In the provinces with high concentration of HCB also had high concentrations in chicken or pork, except Province I, which had the highest concentration of HCB in beef.

Table 2 presents the maximum concentrations and dietary intakes of PBDEs and HCB in beef, pork, and chicken. The maximum concentration of beef, pork, chicken, from all the samples was applied to calculate a dietary intake. The intake levels of PBDEs were 3.6, 24.2 and 6.4 ng/person/day from beef, pork, and chicken, respectively. The total intake of PBDEs through the meat was 34.1 ng/person/day and 0.57 ng/kg bw/day for a 60 kg adult. The intake levels of HCB were 0.75, 4.6 and 3.2 ng/person/day from beef, pork, and chicken, respectively. The total intake of HCB through meat was 8.5 ng/person/day and 0.14 ng/kg bw/day for a 60 kg adult. There is no established maximum total daily intake (TDI) level for PBDEs. In the case of HCB, the intake from dairy is about 5% of the TDI (170 ng/kg bw/day) established by WHO. The actual dietary intakes through beef, pork, and chicken will be lower than the value suggested in this study because the highest residual concentrations were applied. Different dietary patterns will reflect to the levels of exposure, however, seafood is also regarded as a major source for human exposure to HCB[4,5].

References

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Table 1. Concentrations of PBDEs and HCB in beef, pork, and chicken (ng/g fat)

	Beef			Pork			Chicken		
	Mean	median	range	mean	median	range	mean	median	range
PBDEs	0.33	0.25	0.04 ~ 2.16	0.49	0.38	0.14 ~ 2.86	1.86	1.56	1.01 ~ 3.70
HCB	0.11	0.04	nd ~ 0.45	0.15	0.12	nd ~ 0.54	0.31	0.24	0.04 ~ 1.83

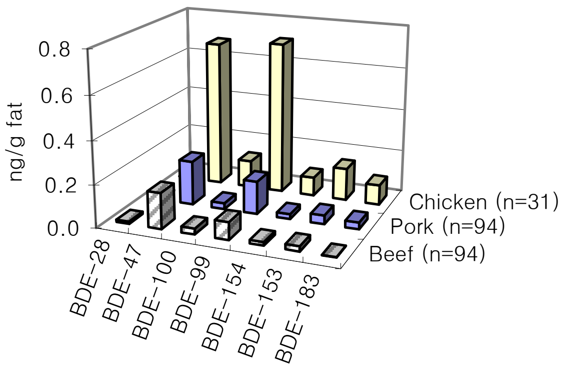

Figure 1. Congener profiles of PBDEs in beef, pork, and chicken.

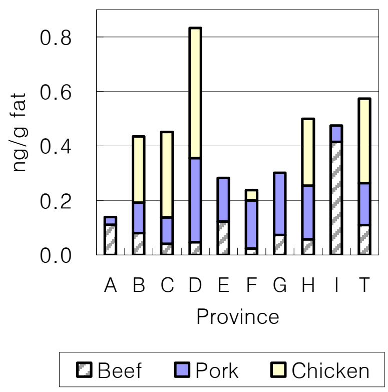

Figure 2. Concentration of HCB in beef, pork, and chicken.

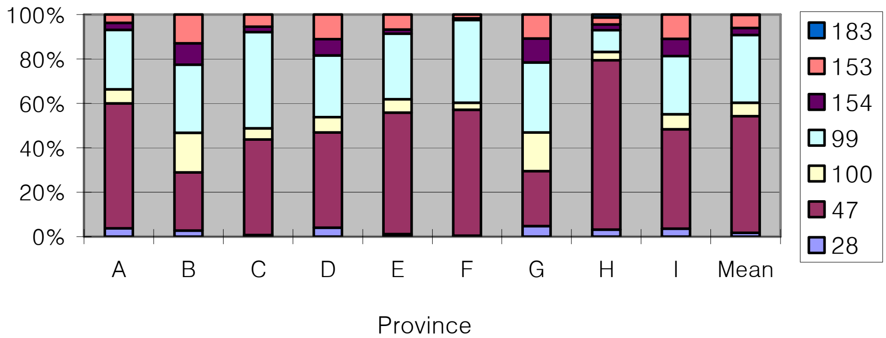

Figure 3. Contributions of PBDEs in beef from the 9 provinces in Korea.

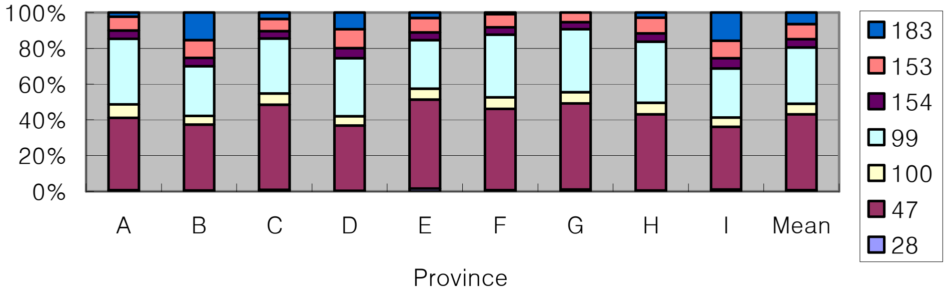

Figure 4. Contributions of PBDEs in pork from the 9 provinces in Korea.

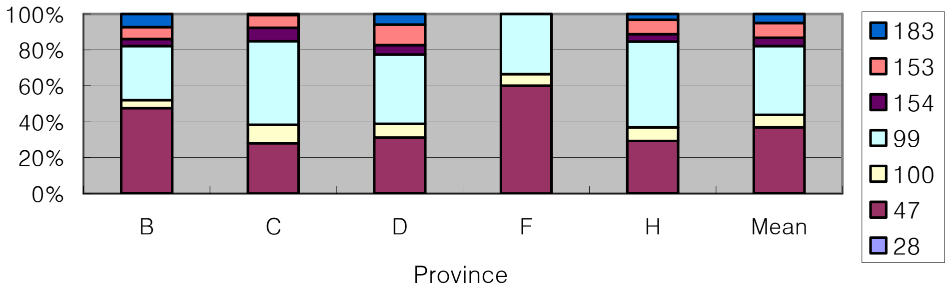

Figure 5. Contributions of PBDEs in chicken from 5 provinces in Korea.

Table 2. Maximum concentrations and calculated dietary intakes of PBDEs and HCB in beef, pork, and chicken

Ingestion rate* (person/day)	PBDEs		HCB	
	Max. level (ng/g fat)	Intake level (ng/person/day)	Max. level (ng/g fat)	Intake level (ng/person/day)
Beef 18.1 g (1.66 g fat)	2.16	3.6	0.45	0.75
Pork 48.1 g (8.45 g fat)	2.86	24.2	0.54	4.6
Chicken 17.2 g (1.72 g fat)	3.70	6.4	1.8	3.2
Sum 83.5 g (11.8 g fat)		34.1 (0.57 ng/kg b.w.)		8.5 (0.14 ng/kg b.w.)

* Korea Rural Economic Institute, Korean Food Balance Sheet 2006.