ENVI III

The significance of pentachlorophenol-treated wood as a source of dioxin residues in United States beef.

G. F. Fries[1], V. J. Feil[2], and K. L. Davison[2]
U.S. Department of Agriculture, Agricultural Research Service
[1] Beltsville, MD 20705, U.S.A.
[2] Fargo, ND 58105, U.S.A.

1. Introduction

The U. S. Environmental Protection Agency reassessment of dioxins and related compounds indicated that animal products are important contributors to the human background exposure to these compounds.[1)] Exposure via beef is considered particularly important because of the potential animal exposure by deposition of combustion emissions on pasture and forage crops. Another point of entry of dioxins into the food chain was as contaminants in chlorophenol-based products. The manufacture and use of these products have been curtailed or restricted since 1980 and these sources are considered to be less important than previously.

Since the reassessment, a statistical survey of the United States beef supply, and a focused survey involving 12 institutional facilities in various geographical areas were carried out and reported.[2,3)] Profiles of the distribution of chlorinated dibenzo-p-dioxin (CDD) and dibenzofuran (CDF) congeners with the 2,3,7,8 chlorine substitution pattern were characterized. Congeners that occurred most frequently, and with the highest mean concentrations, were 1,2,3,6,7,8-CDD, 1,2,3,4,6,7,8-CDD, and 1,2,3,4,6,7,8,9-CDD. Distributions dominated by these congeners are typical of the contaminants of pentachlorophenol and other chlorophenol-based products.[4)] In contrast, residues of combustion, are dominated by CDFs.

Pentachlorophenol-treated wood was used extensively for animal housing and confinement facilities before its use was restricted after 1980.[5)] Follow-up observations were made to evaluate the presence of treated wood and other potential environmental sources of CDDs and CDFs at several locations identified as having higher than average residue concentrations in beef.

2. Results

The animal residues from three facilities in two States (Pennsylvania and Oregon) were described previously.[3)] A fourth facility at a third location involved the control animals in a feeding study described elsewhere in these proceedings.[6)] Environmental samples included wood from fences, buildings, and feed bunks; hay and pasture grass; soils; and road surface material. Analyses of the animal fat and environmental samples from the four locations are summarized in Tables 1-4. The samples were prioritized for analysis because limited resources precluded examination of all potential sources of animal exposure.

Location 1a was a research and teaching facility with many small pens. Tissue samples were from two 2-year old bulls. The wood samples were from fence posts and boards, and a feed bunk in the area where the bulls were confined before slaughter. Ash from a coal-fired power plant was used on road surfaces at the facility. Hay was the primary forage for the bulls.

Location 1b, part of the same institution Location 1a, was a cow and calf facility located approximately 10 km from the main facility. The animal residue was from a 5-yr old cull cow. The most prominent wood sources were the feed bunk and associated brace posts. Soil was sampled in a pasture where it was reported that large quantities of sewage sludge had been applied. Hay was not analyzed because it was assumed to be similar to the hay at Location 1a.

Location 2 was a research facility and the three animals were two 4-yr old cows and a 2-yr old bull. Environmental and feed samples were typical of those at other locations.

Location 3 differed in that it was not part of the original survey and the high tissue concentrations were identified in four animals from the untreated control group in a dioxin feeding study. Serum samples had been obtained before the animals were moved into the facility used for the study and residues were not detected. High concentrations in fat were obtained after 120 days in the facility (Table 4). Hay and corn, the major feeds, had only traces of 1,2,3,4,6,7,8-CDD, and 1,2,3,4,6,7,8,9-CDD that were insufficient to account for the residues in the animals. Fecal concentrations of CDDs and CDFs in one animal were much higher than in the feed, which also suggested non-feed sources of residues.

3. Conclusions

One or more wood samples that had high concentrations of CDDs compatible with pentachlorophenol contamination were identified at each location. The congener profiles in the beef fat samples were compatible with the profiles in wood samples adjusted for differential congener absorption by animals. Except at Location 1a, the concentrations are sufficient to explain the animal residues at wood ingestion rates less than 1 g/day. The three wood samples from Location 1a exhibit characteristic congener profiles, but the concentrations were low. It is possible that woods with higher concentrations were present, but not sampled. The soil concentration at Location 1b could be significant if the contaminated area is extensive and if animal contact time is sufficient. No feed sample contained sufficient residues to account for the animal residues. The frequent use of pentachlorophenol-treated wood, the propensity of animals to lick or chew wood, and the compatibility of congener profiles lead to the conclusion that pentachlorophenol-treated wood may be an important source of residues in animal products in the United States. More comprehensive studies will be required to evaluate the situation.

4. References

1) U. S. Environmental Protection Agency (1994): Estimating Exposure to Dioxin-like Compounds. Report No. EPA/600/6-88/005Ca-c, Office of Research and Development, Washington, DC.
2) Winters D., D. Cleverly, K. Maier, A. Dupuy, C. Byrne, C. Deyrup, R. Ellis, J. Ferrario, R. Harless, W. Leese, M. Lorber, D. McDaniel, J. Schaum and J. Walcott (1996): A statistical survey of dioxin-like compounds in United States beef: A progress report. Chemosphere 32, 469-478.
3) Feil V.J., K.L. Davison, G.L. Larsen and T.O. Tiernan (1995): A nationwide study of dioxin and furan residues in beef. Organohalogen Compounds 26, 117-120.
4) Hagenmaier H. and H. Brunner (1987): Isomer specific analysis of pentachlorophenol and sodium pentachlorophenate for 2,3,7,8-substituted PCDD and PCDF at sub-ppb levels. Chemosphere 16, 1759-1764.
5) Shull L.R., M. Foss, C.R. Anderson and K. Feighner (1981): Usage patterns of chemically treated wood on Michigan dairy farms. Bull. Environ. Contam. Toxicol. 26, 561-566.
6) Feil V.J., K.L. Davison, T.O. Tiernan and V.L. Anderson (1996): Distribution of polychlorinated dioxins and furans in beef. 16th International Symposium on Dioxin and Related Compounds, Amsterdam.

Table 1. Dioxin and furan residues in beef fat and environmental samples from Location 1a.

Congener	Animal Fat(n=2)	Hay	Feed bunk	Fence board	Fence post	Ash
	(pg/g)					
2378-CDD	0.6	(0.8)	(3.3)	(8)	(5)	(1.1)
12378-	18.3	(0.5)	(1.9)	(6)	(4)	(0.6)
123478-	8.6	(0.7)	(2.8)	(11)	12	(0.8)
123678-	47.9	(0.6)	(2.6)	(10)	20	(0.8)
123789-	18.7	(0.6)	(2.3)	(9)	(5)	(0.7)
1234678-	60.4	3.5	29.4	69	251	4.8
12346789-	40.2	38.7	273.0	580	1693	74.4
2378-CDF	(0.1)	(0.5)	(3.3)	50	(3)	(0.6)
12378-	(0.2)	(0.6)	(2.3)	(9)	(8)	(0.8)
23478-	4.5	(0.5)	(1.8)	(7)	(6)	(0.6)
123478-	4.0	(0.4)	(1.9)	(6)	8	(0.5)
123678-	19.5	(0.7)	(3.4)	(11)	13	(0.9)
234678-	7.5	(0.5)	(2.2)	(7)	(3)	(0.6)
123789-	(0.7)	(0.6)	(2.5)	(9)	(4)	(0.7)
1234678-	19.9	(0.7)	11.6	(14)	(11)	(0.8)
1234789-	(1.6)	(1.1)	(4.1)	(23)	(13)	(1.4)
12346789-	2.4	(1.2)	(6.6)	(29)	26	4.2

Values in parenthesis are half the detection limit for congeners that were not detected.

Table 2. Dioxin and furan residues in beef fat and environmental samples from Location 1b.

Congener	Animal Fat(n=1)	Feed bunk	Feed bunk brace	Pasture soil
	(pg/g)			
2378-CDD	(0.3)	(2)	(62)	(2)
12378-	5.0	10	(32)	(1)
123478-	(0.3)	16	389	(2)
123678-	27.0	29	1,226	13
123789-	7.1	31	1,245	9
1234678-	36.4	794	69,006	298
12346789-	19.8	8,672	555,176	5,677
2378-CDF	(0.2)	(2)	(34)	17
12378-	(0.2)	(2)	(47)	(1)
23478-	1.3	(2)	(37)	(2)
123478-	1.8	5	(33)	5
123678-	3.0	11	(59)	(2)
234678-	(0.4)	6	(38)	2
123789-	(0.2)	(2)	(44)	(1)
1234678-	3.8	117	1,876	48
1234789-	(0.4)	10	313	6
12346789-	(0.6)	303	12,761	116

Values in parenthesis are half the detection limit for congeners that were not detected.

Table 3. Dioxin and furan residues in beef fat and environmental samples from Location 2.

Congener	Animal fat(n=3)	Hay	Shed wall	Feed bunk soil	Pasture soil
	(pg/g)				
2378-CDD	0.4	(0.5)	(7)	(4)	(0.8)
12378-	1.3	(0.2)	37	13	(0.4)
123478-	1.0	(0.3)	92	33	(0.5)
123678-	11.9	(0.3)	413	127	(0.5)
123789-	(0.6)	(0.2)	187	59	(0.4)
1234678-	17.4	2.8	10,531	1,990	9.1
12346789-	53.0	30.8	37,318	18,210	86.4
2378-CDF	(0.1)	(0.3)	(11)	(2)	(0.5)
12378-	(0.1)	(0.3)	52	28	(0.5)
23478-	0.5	(0.2)	39	15	(0.4)
123478-	1.5	(0.2)	55	45	(0.4)
123678-	2.4	(0.3)	149	95	(0.7)
234678-	1.0	(0.2)	71	25	(0.5)
123789-	(0.2)	(0.3)	(4)	(3)	(0.5)
1234678-	3.3	(0.3)	788	786	(1.1)
1234789-	(0.3)	(0.6)	46	50	(1.6)
12346789-	(0.6)	(0.8)	467	1,990	(0.3)

Values in parenthesis are half the detection limit for congeners that were not detected.

Table 4. Dioxin and furan residues in beef fat and environmental samples from Location 3.

Congener	Animal Fat(n=4)	Hay(n=2)	Corn	Fence Posts	Shed wall	Fence boards
	(pg/g)					
2378-CDD	0.8	(0.13)	(0.05)	60	1,530	(8)
12378-	7.4	(0.15)	(0.07)	560	25,300	(10)
123478-	14.3	(0.29)	(0.13)	1,579	23,900	(28)
123678-	168.5	(0.27)	(0.12)	3,659	92,000	153
123789-	23.6	(0.23)	(0.11)	3,384	53,500	91
1234678-	471.3	0.73	(0.20)	34,001	1,723,000	2,970
12346789-	697.5	6.22	3.01	151,476	15,322,000	25,000
2378-CDF	(0.1)	(0.06)	(0.04)	23	188	(5)
12378-	(0.1)	(0.21)	(0.12)	99	1,610	(8)
23478-	3.6	(0.08)	(0.09)	69	3,280	(6)
123478-	16.5	(0.19)	(0.08)	1181	14,500	(14)
123678-	20.8	(0.30)	(0.13)	3044	22,600	(25)
234678-	(0.2)	(0.20)	(0.09)	1516	(6,300)	(16)
123789-	10.2	(0.24)	(0.10)	(112)	(4,130)	(19)
1234678-	90.3	(0.31)	0.62	19,424	356,000	657
1234789-	7.7	(0.45)	(0.31)	1,672	(44,200)	(34)
12346789-	21.0	1.82	2.50	26,591	1,123,000	924

Values in parenthesis are half the detection limit for congeners that were not detected.