A Congener Specific Evaluation of Transfer of Chlorinated Dibenzo-*p*-dioxins and Dibenzofurans to Milk of Cows following Ingestion of Pentachlorophenol-Treated Wood

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Pentachlorophenol (PCP) treated wood has been hypothesized as an important source of dioxins in milk and beef. This phase of studies to evaluate the hypothesis involved the administration of PCP-treated wood to cows and measurement of the transfer of polychlorinated dibenzo-*p*-dioxins (PCDD) and dibenzofurans (PCDF) to milk. The 3 g/day dose of ground wood was administered to four cows for 56 days. This dose provided a PCP intake of 4.8 mg/day and PCDD/F intakes in the range of 0.3 μg/day for 2,3,7,8-TCDD to 17 000 μg/day for 1,2,3,4,6,7,8,9-OCDD. Steady state with respect to excretion in milk was reached because concentrations of PCDD/Fs in milk fat were reasonably constant from day 28 through day 56. The PCDFs without chlorine in the 4 and 6 positions were metabolized and not transported to milk. The other PCDFs and all PCDDs had intake adjusted concentrations in milk that were inverse to the number of chlorines. Variations among cows in concentrations of specific congeners were small and were not related to body weight, dry matter intake, or production of milk and milk fat. The transfer coefficients calculated for the PCDD/Fs in this study provide tools for reducing uncertainty in risk assessments.

Introduction

The background concentrations of polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in foods are considered to be the primary source responsible for producing mean body burdens of 28 pg/g TCDD toxic equivalents (TEQ) in adipose tissue of the general population of the United States (*1*). Meat and dairy products are thought to provide as much as 90% of human exposure from foods (*2, 3*). Forages and pastures contaminated by aerial deposition of PCDD/Fs from combustion sources are considered the major pathways of uptake in cattle. Papers and guidance documents for calculating estimated exposures by these pathways are available (*2, 4, 5*).

The most prevalent PCDD/Fs detected in surveys of the United States beef supply were 1,2,3,6,7,8-HxCDD, 1,2,3,4,6,7,8-HpCDD, 1,2,3,4,6,7,8-HpCDD, and OCDD (*6, 7*). High concentrations of PCDDs relative to PCDFs, and of 1,2,3,6,7,8-HxCDD relative to other HxCDDs, are typical of the contaminants of chlorophenol, whereas PCDFs are typically the dominant chemicals in combustion emissions (*8*). Animal confinement and housing facilities built before uses of pentachlorophenol (PCP) were restricted during the 1980s often contain PCP-treated wood (*9*). The importance of these facilities as reservoir sources of PCDD/Fs was suggested by finding PCP-treated wood in several facilities that produced beef with higher than average PCDD/F concentrations (*10*).

Reliable measurements of the transfer coefficients of PCDD/Fs from feed to milk and adipose tissue of cattle are required to produce dependable exposure assessments and to infer sources based on congener profiles found in meat and milk. Transfer of PCDD/Fs to milk and tissues of lactating cattle has been measured in studies that have one or more deficiencies (*11–16*). These deficiencies include inadequate replication, use of animals in nonrepresentative stages of lactation, failure to collect or report data on feed intake and production, and the failure to obtain data on the full range of toxic congeners.

This paper describes the first phase of studies designed to characterize the transport of PCDD/Fs to the milk and tissues of dairy cows that had been dosed with PCP-treated wood. An additional objective was to extend and improve the reliability of the database on the uptake and elimination of PCDD/Fs in milk and tissues. The transport of PCDD/Fs to milk is evaluated in this paper. Mass balance, depuration, tissue residues, and evaluation of the significance of PCP-treated wood as a PCDD/F source will be included in subsequent papers.

Materials and Methods

Four Holstein cows in mid to late lactation were used in the study (Table 1). The work, conducted at the Beltsville Agricultural Research Center (BARC), followed a protocol approved by the Beltsville Area Animal Use and Care Committee. The design and methods are described in more detail in the Supporting Information on the *ES&T* Web site.

The housing facilities for the cows contained no PCP-treated wood, and the animals had no known past exposure to treated wood. The cows were offered a complete mixed diet that was typical of diets for lactating cows at BARC (Table S.1, Supporting Information section). Feed intake was measured from day 54 through day 58 of dosing. The PCDD/F analysis of the feed in shown in Table 2. Milk production was measured daily, and fat content was determined monthly as part of the routine record keeping at BARC.

A 3.0 g/day dose of ground PCP-treated wood was administered to each cow for 58 days. The treated wood was obtained from an unused structure at BARC. The date of treatment of the wood and the manufacturer of the PCP are not known. The analysis of a composite wood sample is shown in Table 2.

Milk samples for this phase of the study were collected from each cow at a single milking at 14-day intervals. Samples of the bulk milk from the BARC herd were obtained at the

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TABLE 1. Characteristics of the Cows at the Start and End of the 56-Day Period of Dosing with PCP-Wood

	cow			
	9405	9406	1047	9838
age at start, months	73	72	51	43
lactation	4th	4th	2nd	2nd
days in lactation at start	214	146	245	214
initial weight, kg	590	604	732	506
final weight, kg	596	600	784	543
feed intake (dry weight), kg/day	21.0	25.2	17.4	19.3
milk production, kg/day[a]				
start	31.1	37.2	12.1	25.2
end	27.9	34.1	9.1	22.9
fat production, kg/day[a]				
start	1.27	1.48	0.58	1.00
end	1.10	1.33	0.47	0.87

[a] The values were derived from statistically fitted lactation equations that utilized all of the daily milk production measurements rather than only the measurement on the specified date.

TABLE 2. Concentrations of PCDDs and PCDFs in the PCP-Treated Wood and the Complete Feed[a]

congener	wood, pg/g	feed, pg/g
2,3,7,8-CDD	45	(0.027)
1,2,3,7,8-CDD	1500	(0.047)
1,2,3,4,7,8-CDD	3900	0.044
1,2,3,6,7,8-CDD	38 000	0.14
1,2,3,7,8,9-CDD	8200	0.083
1,2,3,4,6,7,8,-CDD	1 100 000	4.1
1,2,3,4,6,7,8,9-CDD	5 500 000	46
2,3,7,8-CDF	26	0.072
1,2,3,7,8-CDF	260	0.063
2,3,4,7,8-CDF	340	0.051
1,2,3,4,7,8-CDF	3300	0.17
1,2,3,6,7,8-CDF	4000	0.079
2,3,4,6,7,8-CDF	3800	0.12
1,2,3,7,8,9-CDF	220	(0.022)
1,2,3,4,6,7,8-CDF	220 000	1.1
1,2,3,4,7,8,9-CDF	10 000	0.10
1,2,3,4,6,7,8,9-CDF	1 300 000	3.8

[a] Analysis in on a dry matter basis. Complete feed is the mixture listed in Table S.1 of the Supporting Information. Values in ( ) are detection limits for nondetected congeners.

same dates to serve as the untreated control. The extraction, cleanup, and quantitation of the PCDD/F homologues in milk and other samples was performed by Alta Analytical Laboratory (Eldorado Hills, CA) following standard methods (*17*). After cleanup, the extracts were analyzed using high-resolution gas chromatography/high-resolution mass spectrometry following the guidelines of EPA Method 1613A.

Results and Discussion

Concentrations in Milk Fat. The average concentrations of PCDD/Fs in control milk samples collected prior to, during, and following the dosing period were relatively stable, and no trends over time were apparent (Figure S.1 of the Supporting Information). The lack of a time trend is expected if the primary background sources of PCDD/Fs are the silage and hay components of the diet that were produced at BARC during a single crop year. All congeners except the three PCDFs without chlorine substitutions in the 4 and 6 positions were present at quantifiable concentrations. The average concentrations of individual PCDDs and PCDFs were approximately 30% and 70%, respectively, of the average concentrations found in a survey of United States milk (*18*).

Concentrations of the PCDD/Fs in milk fat of the treated cows are presented in Figures 1 and 2. The concentrations of PCDD/Fs in the milk of the cows at day 0 were essentially the same as the concentrations in the control milk. The dose of PCP-treated wood was set at an amount projected to produce concentrations of hexa-, hepta-, and octacongeners in milk fat at least 10-fold greater than background in order to minimize the influence of variations in background intake. The concentrations of these congeners detected in milk fat were in the projected range.

The concentrations of the TCDD/Fs and PeCDD/Fs were relatively low in the treated wood, and the concentrations of the 2,3,7,8-TCCD and 1,2,3,7,8-PeCDD were below the detection limits in feed (Table 2). Thus, caution must be exercised in drawing inferences concerning rates of transport of tetra- and penta-congeners to milk because the large relative variation in analyses of samples with concentrations near the detection limit could introduce large variations in a calculated transport coefficients. The primary objective of this study was to characterize the transport of PCDD/Fs in PCP. Thus, it was not a high priority to provide optimum concentrations for analysis of the congeners that occur at low concentrations in PCP. In addition, the existing database on TCDD is more extensive than other congeners, and high intakes of PCDD/Fs can lead to abnormal tissue distributions in some species (*19*).

The 2,3,7,8-TCDF, 1,2,3,7,8-PeCDF, and 1,2,3,7,8,9-HxCDF congeners are not shown in Figure 2, because the concentrations did not consistently exceed the detection limits and the pattern of occurrence of samples with detectable concentrations was inconsistent. Low rates of transport of one or more of these congeners to milk has been found by others (*14, 15*). The findings suggest that PCDFs without chlorines in the 4 and 6 positions are more metabolically labile than PCDDs and other PCDFs; a conclusion that is supported by results of metabolic studies in laboratory animals (*19*).

All PCDD/Fs attained stable concentrations in milk within 28 days of the initiation of dosing (Figures 1 and 2). Data for the individual congeners were examined in a 3 × 4 analysis of variance with cows and sampling dates as the variables. The differences in concentrations among sampling dates were not significant with any compound. Although the concentrations in milk fat were stable from 28 to 56 days, this observation does not necessarily mean the cows were in equilibrium with their intake. Concentrations of halogenated hydrocarbons in body fat require longer to attain equilibrium than concentrations in milk fat due to the poor perfusion of deep fat reservoirs (*20*).

The average concentrations of many congeners at day 28 were greater than at the other dates (Figures 1 and 2). The elevated concentrations were due primarily to one animal that was recovering from a mammary gland infection that was treated 3 days prior to sample collection. The apparent effect of the infection on concentrations of several representative PCDD/Fs is shown in Figure S.1 of the Supporting Information. The enhanced concentrations of the highly chlorinated PCDD/Fs in the milk of the infected animal are likely due to an alteration of mammary gland membrane structure, which in some cases can be so severe that the milk may contain red blood cells (*21*).

Measures of Biotransfer. The literature contains several terms that have been used to quantitatively characterize the biotransfer of chemicals from the diet of cows to milk and milk fat. The terms encountered most frequently include Bioconcentration Factors (BCF), Biotransfer Factors (BTF), and Carry-over Rates (CR) (*4, 14, 20, 22, 23*). The terms are defined by the following equations in which the units have been modified to fit the concentrations usually encountered in work with PCDD/Fs

$$BCF = C_{MF}/C_{diet} \tag{1}$$

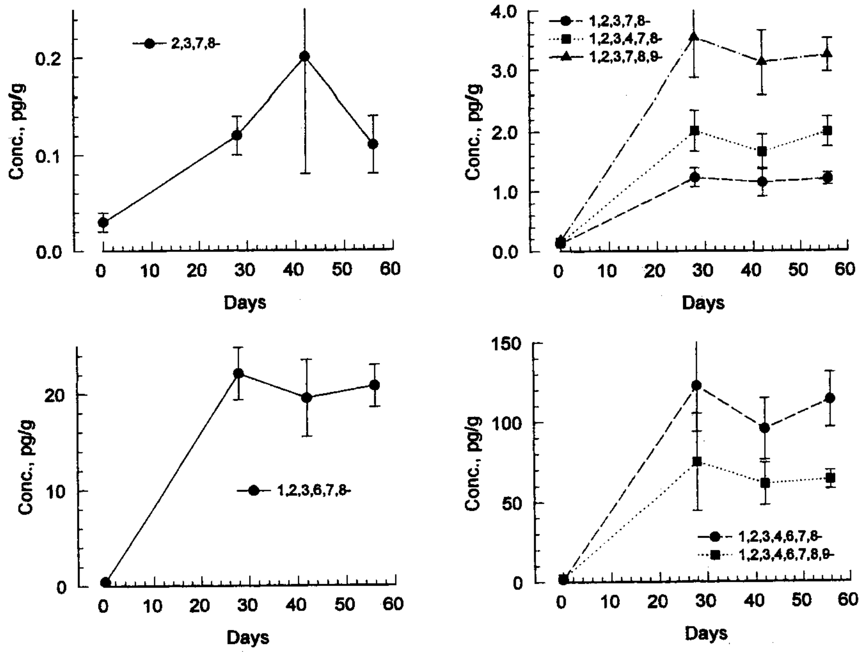

FIGURE 1. Concentrations of 2,3,7,8-substituted dioxins in the milk fat of cows administered 3 g/day pentachlorophenol-treated wood for 58 days. Each point is the mean and standard deviation of four cows.

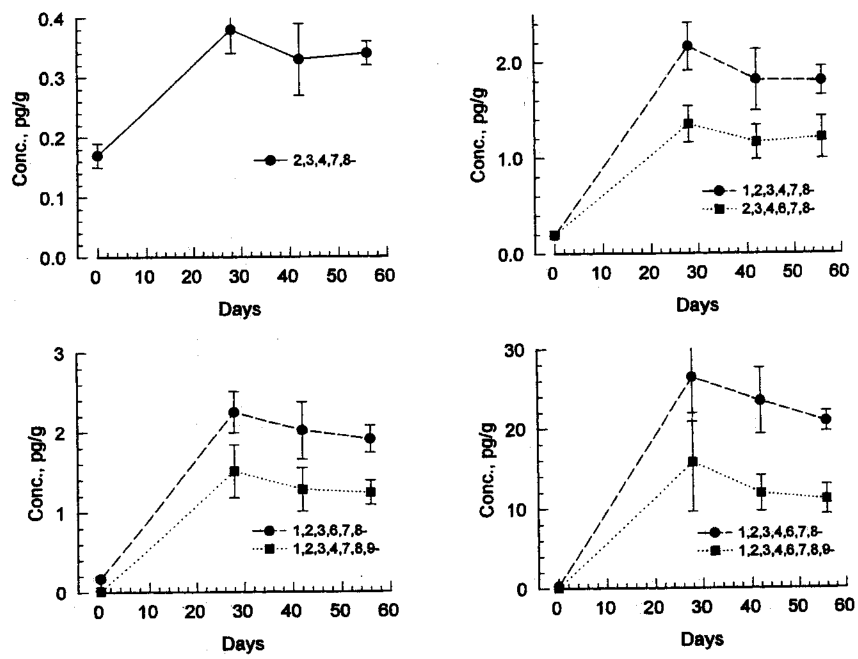

FIGURE 2. Concentrations of 2,3,7,8-substituted furans in the milk fat of cows administered 3 g/day pentachlorophenol-treated wood for 58 days. Each point is the mean and standard deviation of four cows. The 2,3,7,8-TCDF, 1,2,3,7,8-PeCDF, and 1,2,3,7,8,9-HxCDF congeners are not shown because occurrence of residues at concentrations greater than the 0.01 to 0.02 pg/g detection limits were inconsistent.

where C_{MF} is the concentration in milk fat (pg/g) and C_{diet} is the concentration in dry matter of the diet (pg/g)

$$BTF = C_{milk}/I \qquad (2)$$

where C_{milk} is the concentration in whole milk (pg/kg) and I is the intake (ng/day), and

$$CR = 100*A_{milk}/I \qquad (3)$$

where CR is expressed as percent (%), A_{milk} is amount excreted in milk (pg/day), and I is intake (pg/day).

The three transport coefficients were calculated using data from all sampling times during the dosing period. Feed intake was measured only during the 5-day period beginning on day 54, but daily dry matter intake for cows such as those in this study would vary less than 5% over the period from day 28 to day 56 (*24*). Therefore, it is reasonable to use the intake measured from day 54 to day 58 as the value for dry matter intake at days 28 and 42 when calculating total congener intake and the apparent concentrations in the total diet.

The average values of the transfer coefficients are presented in Table 3. The concentrations of 2,3,7,8-TCDD and 1,2,3,7,8-PeCDD in feed were below the detection limits. Concentrations of half the detection limits were used for feed when calculating the coefficients listed for these PCDDs.

TABLE 3. Mean Bioconcentration Factors (BCFs), Biotransfer Factors (BTFs), and Carry-Over Rates (CR) of PCDD and PCDF Congeners of Four Cows Dosed with PCP-Treated Wood[a]

congener	BCF mean ± SD	BCF CV	BTF, (pg/kg)/(ng/d) mean ± SD	BTF CV	CR, % mean ± SD	CR CV
PCDDs						
2,3,7,8-	7.1 ± 4.2	58	14 ± 7.5	52	35 ± 25	73
1,2,3,7,8-	5.0 ± 1.2	24	10 ± 1.0	10	24 ± 10	42
1,2,3,4,7,8-	3.1 ± 0.8	26	6.2 ± 0.8	13	15 ± 6	42
1,2,3,6,7,8-	3.7 ± 0.9	24	7.4 ± 0.8	10	18 ± 7	41
1,2,3,7,8,9-	2.6 ± 0.7	26	5.2 ± 0.6	11	13 ± 6	43
1,2,3,4,6,7,8-	0.68 ± 0.22	32	1.4 ± 0.3	18	3.3 ± 1.6	45
1,2,3,4,6,7,8,9-	0.08 ± 0.03	40	0.16 ± 0.04	27	0.39 ± 0.22	57
PCDFs						
2,3,7,8-	<0.01		<0.1		<0.1	
1,2,3,7,8-	<0.01		<0.1		<0.1	
2,3,4,7,8-	3.5 ± 0.7	19	7.2 ± 1.1	15	17 ± 6	37
1,2,3,4,7,8-	3.0 ± 0.7	23	6.0 ± 0.7	12	14 ± 6	41
1,2,3,6,7,8-	3.1 ± 0.8	24	6.3 ± 0.7	10	15 ± 6	42
2,3,4,6,7,8-	1.9 ± 0.5	26	3.7 ± 0.5	13	8.9 ± 3.9	43
1,2,3,7,8,9-	<0.01		<0.10		<0.1	
1,2,3,4,6,7,8-	0.72 ± 0.21	30	1.4 ± 0.2	16	3.5 ± 1.7	47
1,2,3,4,7,8,9-	0.87 ± 0.27	31	1.7 ± 0.3	16	4.3 ± 2.1	48
1,2,3,4,6,7,8,9-	0.07 ± 0.03	35	0.14 ± 0.04	31	0.33 ± 0.21	63

[a] Values are the mean ± standard deviation (SD) of 12 observations involving four cows at three times. CV is the coefficient of variation (%). Concentrations of 2,3,7,8- and 1,2,3,7,8-CDD in feed were below the limit of quantitation, and half of the detection limit was used in calculations for these congeners. Detection of 2,3,7,8-, 1,2,3,7,8-, and 1,2,3,7,8,9-CDF was inconsistent, and only the nominal upper limits based on the detection limits are shown.

This assumption is not serious in the case of 1,2,3,7,8-PeCDD because approximately 95% of the estimated intake was from PCP-treated wood. In the case of 2,3,7,8-TCDD, however, less than 50% of the estimated intake was from wood and the coefficients could be in serious error if the actual concentration in feed was markedly above or below half the detection limit.

The differences in transfer coefficients among the three sampling periods were not significant. The greatest source of variation among the transfer coefficients for individual congeners was attributed to differences among cows. The coefficients of variation (CVs) were calculated to determine which of the methods of expressing transfer provided the least variation among animals. The BTFs, which essentially are PCDD/F concentrations in whole milk normalized to a unit of intake (eq 2), had lower CVs than other measures of biotransfer. The biological basis for this finding is not clear. The PCDD/Fs are fat soluble and are transported through biological compartments by processes dependent on concentration gradients in the lipid fractions. Thus, the comparability of the concentrations in whole milk, which is largely water, is somewhat unexpected. On the other hand, the low variation in BTFs may be an artifact related to the small variation in the fat concentrations in the milk (Table 1).

The carry-over rates were the most variable of the coefficients (Table 3). The large variations in CRs mainly reflect the 3-fold variation in milk production among the cows (Table 1). Because of the influence of the amount of milk and fat produced on CRs, the use of CRs in exposure assessments requires adjustment for any differences in milk production between the experimental cows used to determine the CRs and cow population in the field situation. The greater variability of BCFs than BTFs was related to the differences in dry matter intake (Table 1). Intake of PCDD/Fs was essentially the same for all cows with the result that calculated concentrations in the diet were inverse to dry matter intake.

Transfer Rates at Background Intake. Concentrations of PCDD/Fs in milk fat reached a stable level within 28 days of the initiation of dosing, but it cannot be inferred that body burdens were at steady state. Longer times would be required to perfuse PCDD/Fs to deep fat stores than the time required to reach stable concentrations in milk fat (*20*). The fortuitous finding that background concentrations in milk fat were relatively stable (Figure S.1 of the Supporting Information) suggested a stable background concentration in feed and that the cows at day 0 were probably near steady state with their environment. Because changes in daily dry matter intake over a 56-day period would not be great (*24*), it is reasonable to calculate the transfer coefficients for day 0 using the intake and analyses values from day 56 (Tables 1 and 2).

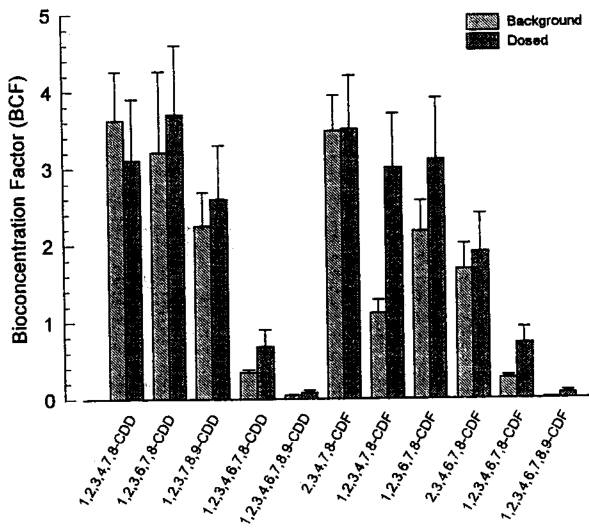

FIGURE 3. Comparison of bioconcentration factors calculated using data from cows exposed to background PCDD/F sources only (day 0) and with the same cows dosed with PCP-treated wood (days 28, 42, and 56). Only the congeners consistently occurring at concentrations above background are shown. Error bars represent the standard deviations.

The BCFs calculated for day 0 and those calculated for the dosing periods are compared in Figure 3. The BCFs were comparable for many congeners, but the background values were lower in the case of several PCDFs. The differences were relatively large for 1,2,3,4,7,8-HxCDF and 1,2,3,4,6,7,8-HxCDF and somewhat smaller for 1,2,3,6,7,8-HxCDF. The

TABLE 4. Comparison of Carry-Over Rates (%) Reported in This Study and in Previous Studies[h]

congener	Fries[a]	wood[b]	McL[c]	Olling[d]	Slob[e]	Tuins[f]	Fires[g]
milk, kg/day	26	25	28		28	23	14
milk fat, kg/day	1.1	1.0	1.4		1.0	1.2	0.5
2,3,7,8-CDD		35	35	30	15	34	
1,2,3,7,8-CDD		24	33	28	10	55	
1,2,3,4,7,8-CDD	18	15	17		5.6	28	
1,2,3,6,7,8-CDD	16	18	14	27	6.4	37	16
1,2,3,7,8,9-CDD	12	13	18		3.1	12	
1,2,3,4,6,7,8-CDD	1.8	3.3	3	1.6	0.6	2.5	1.7
1,2,3,4,6,7,8,9-CDD	0.3	0.4	4		0.1	0.6	0.3
2,3,4,7,8-CDF	18	17	25	36	12	24	
1,2,3,4,7,8-CDF	5.7	14		18	4.3	26	
1,2,3,6,7,8-CDF	11	15	16		3.6	30	
2,3,4,6,7,8-CDF	8.4	9.0	14		4.2	25	
1,2,3,4,6,7,8-CDF	1.4	3.5	3	1.7	0.4	1.9	
1,2,3,6,7,8,9-CDF		4.3	8		0.5		
1,2,3,4,6,7,8,9-CDF	0.1	0.3	1				0.1

[a] This study. The value is based on the mean of four cows. Intake of PCDD/Fs was from background sources in feed. Production of milk and milk fat and concentrations of PCDD/Fs were measured. [b] This study. Mean of three estimates on each of four cows made after dosing for 28, 42, and 56 days. Intake of PCDD/Fs primarily from PCP-treated wood, but background sources from feed also were included. Production of milk and milk fat and concentrations of PCDD/Fs were measured. [c] McLachlan et al. (*14*). Values were obtained from the original paper. Values were obtained during mass balance measurements in a single cow in midlactation with all PCDD/F input from normal environmental sources. [d] Olling et al. (*15*). Values were obtained from the original paper. No data on milk and fat production was provided. Four cows were given a single ^{13}C-labeled dose of PCDD/Fs. Carry-over was estimated as the percent of dose excreted in milk over an infinite time period. [e] Slob et al. (*25*). Values were calculated from data presented in the original paper. Data were derived by measuring environmental concentrations of PCDD/Fs in feed and composite milk fat on two farms. Intake of 16 kg/day dry matter and fat production of 1.03 kg/ were assumed. Fat content of 3.6% was assumed to derive milk production value in this table. [f] Tuinstra et al. (*16*) and Roos et al. (*26*). Values were calculated from data in the original papers. These data were based on measurement in one cow that was dosed during the dry period with concentrations in milk fat measured for 100 days post-calving. For this table, carry-over was estimated as the percent of dose excreted in milk over an infinite time period. [g] Firestone et al. (*12*). Values were calculated from data in the original paper. Values are an average of three cows that were dosed with technical-grade pentachlorophenol. Input, concentrations of PCDD/Fs in milk fat, and milk production are from that paper. Fat content of milk was assumed to be 3.6% when calculating carry-over. [h] The congeners 2,3,7,8-, 1,2,3,7,8-, and 1,2,3,7,8,9-CDF are not included because most values are below the limit of detection.

data are insufficient to provide an explanation for the differences, but it should be noted that the contribution of the PCDFs to the United States milk and beef supply is small (*7, 18*). Comparisons of the BTFs and CRs are not shown, but the conclusions would have been the same as for the BCFs.

Comparisons with Other Studies. Five studies in the literature provide transport coefficients for PCDD/Fs or data from which the transport coefficients can be derived. Three of the five studies included estimates of CRs or the equivalent with different terminology (*14, 15, 25*). Two other studies provided sufficient information to allow estimation of CRs (*12, 16*). The results of these studies and the two sets of CRs from this study are presented in Table 4. The three PCDFs that rarely occurred at concentrations greater than the detection limit in this study are not included.

Levels of milk and fat production by cows in all studies, except Firestone et al. (*12*), were in a fairly narrow range. The CRs reported by Slob et al. (*31*) are consistently lower, and those derived from Tuinstra et al. (*16*) are consistently higher than the CRs in the other studies. Slob et al. (*31*) measured concentrations in feed and milk but used assumed values for feed intake and milk production. Thus, systematic errors may have been introduced if either assumed value deviated from the real value. Similarly, a systematic bias may have been introduced by the method used to estimate excretion in milk when deriving values from the data of Tuinstra et al. (*16*).

The CRs for PCDDs from the remaining three studies, and both the dosing and background exposure phases of this study, are in good agreement. This is somewhat surprising because of the significant improvements in analytical methodology over time, and because more comprehensive feed intake and production information was gathered in this study than in work published previously. In addition, differences in milk production among cows were large in some cases, and methods of animal exposure included utilization of environmental background level, continuous dosing with PCP or PCP-treated wood, and single doses of labeled congeners. Two studies did not provide much information on PCDFs (*12, 15*), and agreement among PCDFs in the other studies is less consistent than for the PCDDs.

All studies are consistent in demonstrating that transport PCDD/Fs to milk decreases with increasing chlorination and that some PCDFs appear not to be transported from diet to milk due to metabolism. It is noteworthy that the toxicity of PCDD/Fs also decline with increasing chlorination. Therefore, it is important when conducting exposure assessments to evaluate transport of each congener in the mixture and that TEQ approach not be used until the point of human ingestion is reached.

Physical parameters such as log K_{OW} are related to bioaccumulation of organic compounds. In animals a negative relationship has often been observed when the log K_{OW} exceeds 6.5 (*22*). All of the PCDD/Fs included in this study have log K_{OW}'s that exceed 6.5 (*27, 28*), and, as shown in Figure S.3 in the Supporting Information, there is a clear negative relationship between log K_{OW}s and BCFs. Log K_{OW}s are related to the degree of chlorination. When BCFs were plotted against the number of chlorines, the negative relationship was as strong as that observed for the log K_{OW}s (Figure S.3). Neither parameter, however, will predict metabolism as exemplified by the PCDFs that lack chlorines in the 4 and 6 positions.

This work greatly expands the database concerning the transfer of PCDD/Fs to the milk of cows. Interestingly, our results agree most closely with those of McLachlan et al. (*14*), which was the most comprehensive database available for calculating transport coefficients in the U.S. Environmental Protection Agency reassessment of dioxins (*2*). Thus, the results of this work do not indicate that important changes in the published transfer coefficients are needed. There should, however, be greater confidence in these various coefficients as a result of this study, because we used more animals and more observations on each animal than that reported in previous studies.

Supporting Information Available

Animal facilities and care, analytical methods, table of daily feed allowances for each cow, and figures of background concentrations of dioxin and furan congeners, effect of mammary gland infection on the concentrations of selected PCDD/Fs in the milk fat of a cow, and relationship of bioconcentration factors to log K_{ow} values and the degree of chlorination. This material is available free of charge via the Internet at http://pubs.acs.org.

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