BIOACCUMULATION OF PCDD/Fs FROM SOIL BY FORAGING CHICKENS

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1. BACKGROUND

The uptake of PCDD/PCDF from contaminated soils has significant implications on human and animal health. Several studies have shown that food is the major source of human exposure, while other studies have shown that many animal species have body burdens of PCDD/PCDFs which reflect their environment. As a result, this laboratory undertook studies, using egg producing chickens as a model, to determine the rate of PCDD/PCDF uptake from soils, and the congener-specific, tissue-specific bioconcentration factors (BCFs). The information generated was intended to elucidate the relationship between soil PCDD/PCDFs and human foods. Under controlled laboratory conditions, chickens fed soil contaminated with ppt levels of PCDD/PCDFs showed elevated levels of PCDD/PCDFs in eggs and tissues[1,2]. The bioavailability of PCDD/PCDFs from the soil was congener-dependent, decreasing with increasing chlorination. Rates of uptake, as well as steady state tissue concentrations were tissue- and congener-dependent. BCFs were tissue- and congener-dependent, with the liver representing only a minor repository for PCDD/PCDFs[1,2]. To validate these findings two studies were undertaken. In the first, chickens were raised under field conditions and their eggs and tissues monitored over time. Males (caponized) were included to assess the effect of egg-laying on PCDD/PCDF elimination. In the second study, a cross-sectional survey of backyard chickens was conducted by analysing eggs and soils to determine BCFs.

2. METHODOLOGY

1. Longitudinal feeding study. White Leghorn chickens were brought to the field at 20 weeks of age, where they were randomly assigned to six groups: **Exposed** (males and females): allowed to forage inside the study enclosure and have free contact with soil and soil organisms; **Control** (males and females): kept individually caged above ground; and **Free ranging** (males and females): left free to roam on the farm with no attention given to them. 2. Cross-sectional survey. Communities near pentachlorophenol treatment facilities were targeted and candidate households (presence of chickens in the backyard and proximity to the facility) were contacted. Samples of eggs and soil were collected and a brief questionnaire was filled regarding the chicken rearing practices, breed, size of flock, etc.

Sample collection and handling

Soil Soil samples were collected from the top 1 cm of soil. Eggs Three eggs were randomly selected on a particular day (feeding study) or backyard (cross-sectional study). The 3 egg yolks were composited in all but one case (day 160). Tissues Following

euthanasia, whole body and liver weight were recorded. Adipose, liver and thigh samples were collected for analysis. Composites of three tissues were analysed in all but one case (study day 85).

Analytical Methods

Soil samples were homogenized, spiked with $^{13}C_{12}$ internal standards and Soxhlet extracted with toluene. Soil samples were cleaned up through basic and acidic silica gel followed by alumina and AX21 carbon, as per our in-house protocol.[3]

Tissue samples were analyzed by a modified Smith-Stalling procedure (homogenized, spiked with $^{13}C_{12}$ internal standards, extracted with 1:1 dichloromethane:cyclohexane, potassium silicate/silica column clean up, AX21 carbon column enrichment, potassium silicate/acid silica/alumina column purification)[3]. Egg yolks were mixed with sodium sulfate, homogenized, spiked with $^{13}C_{12}$ internal standards, extracted with 1:1 ether:hexane, cleaned up with silica gel, AX21 carbon, followed by chromatography column clean up using neutral/basic/acidic/neutral silica gel, and neutral alumina. Lipid content for all matrices was determined gravimetrically on an aliquot extracted with 1:1 hexane:acetone. All extracts were analyzed by HRGC-HRMS (Varian 3400, Finnigan MAT 90) with a 60m, 0.25mm ID, 0.25μm film thickness DB-5 column, using a temperature program (220°C for 2 min, then 5°C/min to 260°C, followed by 1°C/min to 300°C). The MS operated in the EI mode (50 eV) with a 0.5 mA emission current and a minimum resolution of 8000 amu.

3. RESULTS AND DISCUSSION

Feeding study: The soil within the chicken enclosure had approximately 20 ppt I-TEQ, due predominantly to OCDD and HpCDD. PCDD/PCDF (I-TEQs) concentrations in eggs from the feeding study are shown in Fig. 1. Concentrations in eggs of exposed chickens were greater than those of controls. Even greater were concentrations in eggs of free ranging chickens. Eggs of commercial 'free ranging" chickens had PCDD/PCDFs similar to controls. Fig. 2 shows the concentrations of PCDD/PCDF (I-TEQs) in chicken adipose. Whereas caged chickens (both male and female) remained at low levels through out the study, exposed chickens showed increased PCDD/PCDF levels. Males had higher levels than females after 85 and 175 days of exposure. Free ranging chickens, and males in particular, had even higher levels, supporting a dose-response trend.

Cross-sectional study: BCFs were inversely related to the degree of chlorination.

4. CONCLUSIONS

The results of this set of field studies confirm the findings of the earlier[1,2] studies which had been conducted under controlled conditions: PCDD/PCDFs can be uptaken by animals grazing on soils contaminated at the low ppt level. In addition, PCDD/PCDF bioconcentrate less in females than in males, presumably because of the fat excretion mechanism of egg laying.

5. REFERENCES

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2 Stephens RD, MX Petreas, DG Hayward. "Biotransfer and bioaccumulation of dioxins and furans from soil: Chickens as a model for foraging animals". Sci of the Total Envir, 175 (3): 253-273, 1995

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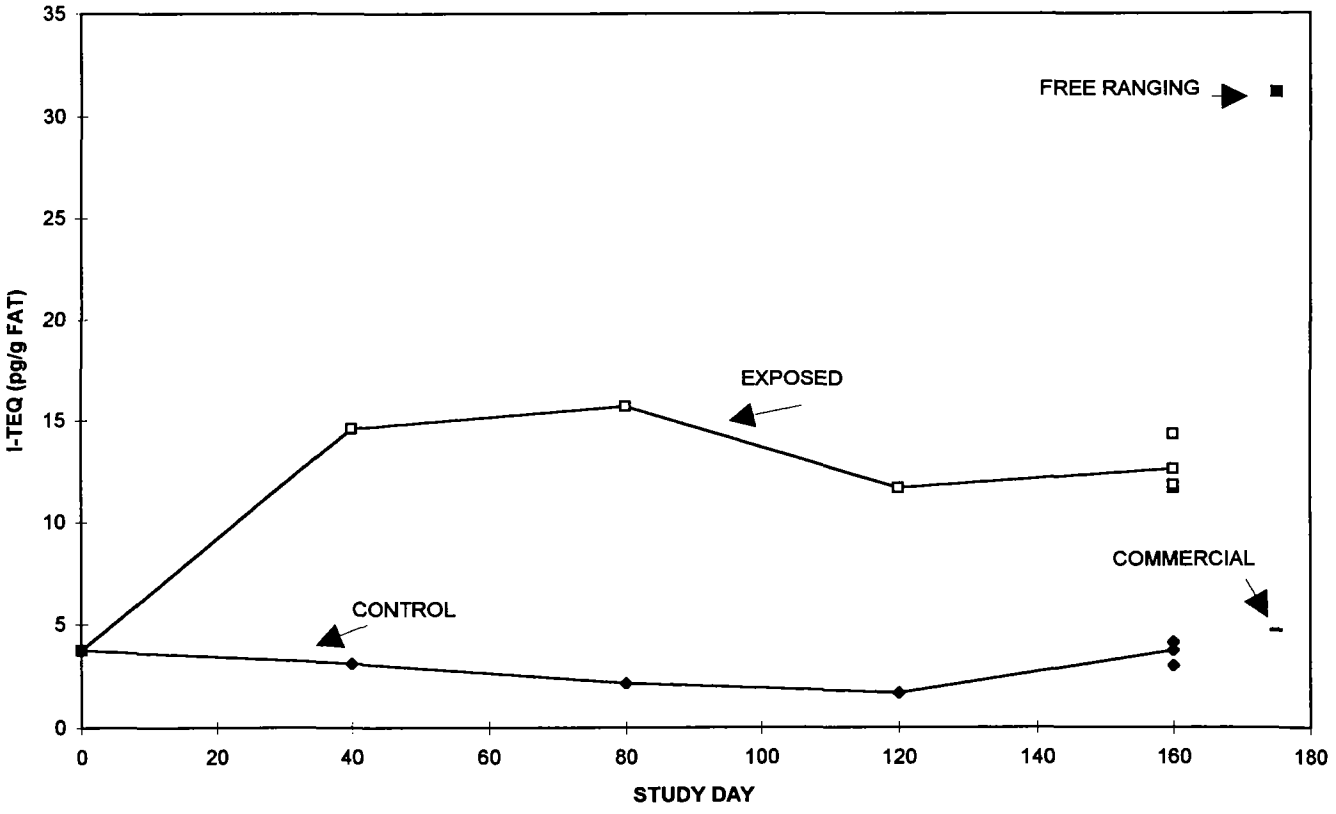
Fig. 1 PCDD/PCDFs IN EGGS OF EXPOSED AND CONTROL CHICKENS



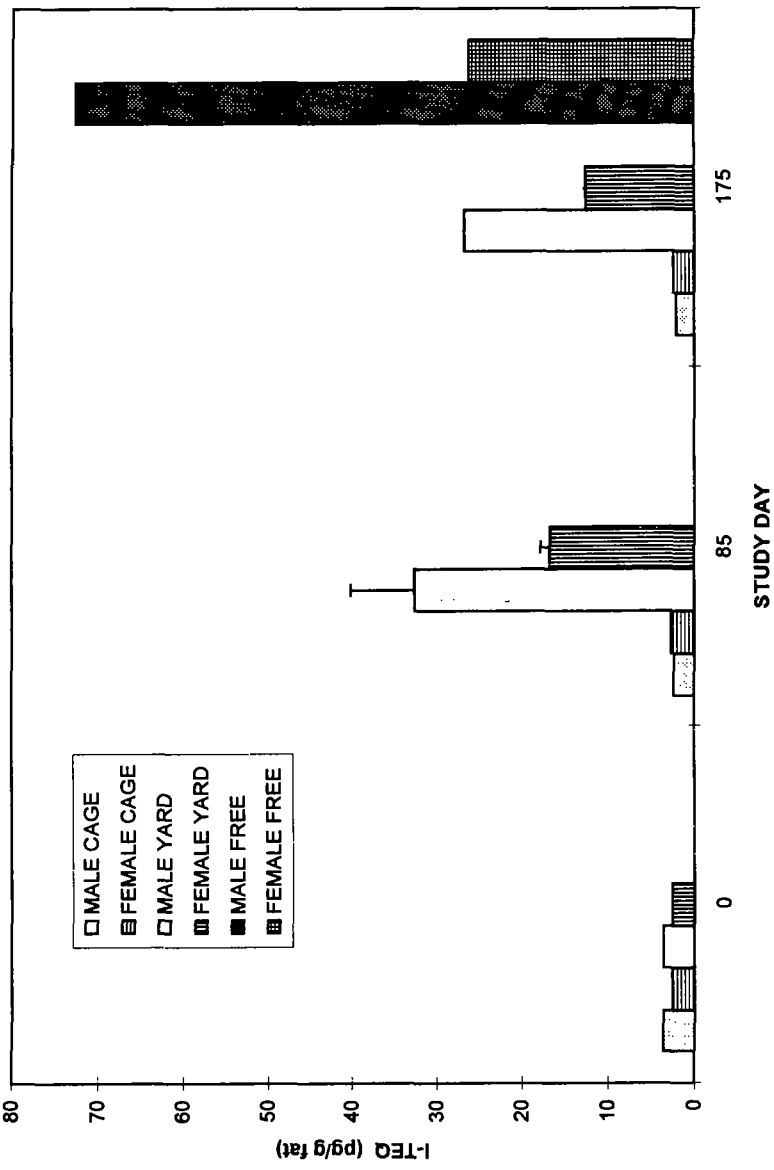


Fig. 2 PCDD/PCDFs IN CHICKEN ADIPOSE