MIGRATION OF TCDD/TCDF FROM PAPER BASED FOOD PACKAGING AND FOOD CONTACT PRODUCTS

L. LaPleur*, T. Bousquet, K. Ramage, T. Davis, H. Mark, D. Lorusso, D. Woodrow, T. Saldana

National Council of the Paper Industry for Air and Stream Improvement, (NCASI)
P.O. Box 458, Corvallis, Or. USA

ABSTRACT

The measurement of the migration from selected paper based food packaging and food contact products are presented. Products were selected for study due to perceived high potential for migration. Generally, a small percentage of the TCDD/TCDF was found to migrate. Migration for fatty foods were generally higher than for non-fatty foods.

INTRODUCTION

The estimate of potential human exposure to TCDD/TCDF due to normal use of paper based products requires the measurement of the migration of the compounds from the product into the food. For the purpose of the present study, it was decided to study the food packaging or contact applications which presented the highest perceived potential for migration. The factors which were considered important were (a) length of contact (b) temperature of contact (c) presence or absence of a barrier and (d) contact with fatty foods. These factors were considered by the US FDA and the paper industry and it was decided that the products listed in Table 1 would be selected for the determination of potential migration.

Table 1. Products Selected for Migration Testing

Food Contact	Food Packaging
Hot Beverage Cups	Dairy Product Cartons
Dual Ovenable Board	Orange Juice Cartons
Paper Plates	
Coffee Filters	
Microwave Popcorn	

EXPERIMENTAL PROCEDURES

Paper Product Exposures

The exposure conditions selected for each product were selected to exemplify normal product use. However, within the range of normal uses of any given product, the uses which represented the worst case potential for exposure were selected for the study. The exposure conditions are described below for each product. Where possible, the actual food products were used for the migration testing. In some instances such as dual ovenable board and paper plates, the actual food packaging and contact applications are highly variable. Therefore, corned beef hash was used as a representative fatty food to simulate the worst case exposure conditions.

Hot Beverage Cups Polyethylene coated cups designed for hot beverage use were used for the study. Separate exposures were conducted for coffee and chicken broth. The beverage was heated to 95°C and transferred to the paper cup. Aluminum foil was placed on the top of the cup to simulate a lid. After filling, the cup was allowed to stand for 30 minutes prior to being removed for analysis.

Dual Ovenable Board Polyester terephthalate coated dual ovenable trays were used for the study. A measured weight of corned beef hash was transferred to each tray and was cooked, uncovered, in a conventional oven for 30 minutes at 350°F. Since most of these convenience foods are consumed in the tray, the corned beef hash was then allowed to stand at room temperature in the tray for an additional 30 minutes. The exposed corned beef hash was then transferred to sample bottles prior to analysis.

Paper Plates A measured weight of corned beef hash, was pre-heated in a covered petri dish in a conventional oven for 30 minutes at 350°F. The heated dish of corned beef hash was then inverted onto a paper plate and allowed to stand at room temperature for 30 minutes to mimic the time it would normally take to consume food served on a paper plate. The exposed corned beef hash was then transferred to sample bottles prior to analysis.

Microwave Popcorn Microwave popcorn was popped in the bag for 3.25 minutes and allowed to stand at room temperature for 30 minutes to simulate typical cooking and consumption. The contents of four bags were then ground and combined in a sample bottle prior to analysis.

Coffee Filters The exposure conditions were described previously (NCASI, 1988, Sullivan et al., 1989).

Dairy Cartons (Half and Half Exposure) The exposure conditions and polyethylene coated pint cartons were identical to those used in a previous study (LaFleur et al., 1990).

Orange Juice Cartons One quart juice cartons coated with an ethylene vinyl alcohol barrier were used for the study. Canned orange juice was transferred into the cartons and exposed at 4°C for three days, one week, two week, four week and eight week time intervals. A single carton of juice was used for each sample prior to being removed for analysis.

In most cases, paper products were analyzed for background TCDD/TCDF levels. From these, the samples with the highest detectable levels from two different suppliers were exposed and migration rates determined. This was necessary to facilitate the experiment. Each exposure was conducted in triplicate.

Analytical Procedures

Paper product analyses were performed as described in NCASI Technical Bulletin No. 551 (NCASI, 1989). The extraction and cleanup procedures used for the fatty foods were described previously (LaFleur, et al., 1990). The coffee analysis procedure was an adaptation of a procedure described previously (NCASI, 1988, Sullivan et al., 1989).

QA/QC Procedures

All exposures were carried out in triplicate. Analytical procedures were validated by, at a minimum, analyzing triplicate spikes at three concentration levels near the levels of the analytes detected in exposed samples. With the exception of coffee, all food products contained measurable levels of one or more of the analytes prior to exposure, thus triplicate un-exposed controls were prepared and analyzed for each experiment. In most cases, a multi-ion, independent laboratory validation analysis was conducted as described previously (LaFleur et al., 1990).

RESULTS AND DISCUSSION

The results for the migration tests for products where only a single exposure time interval was tested are summarized in Table 2.

Table 2. Summary of Migration Rates

	Percent Migration			
	TCDD		TCDF	
Hot Beverage Cups - Coffee	Mean	Range	Mean	Range
Supplier A	0.22	0.20-0.24	0.15	0.14-0.15
Supplier B	0.29	0.25-0.35	0.39	0.34-0.43
Hot Beverage Cups - Broth				
Supplier A	6.0	4.9-6.7	10	8.6-11
Supplier B	4.8	4.6-4.9	5.9	5.5-6.3
Dual Ovenable Board				
Supplier A	16	7.4-27.3	8.5	5.2-18.3
Supplier B	4.2	3.0-5.7	6.1	4.9-7.3
Paper Plates				
Supplier A	NA[a]		2.6	
Supplier B	13	9.8-15	18	12-24
Microwave Popcorn[b]	1.9	1.7-2.2	1.3	1.1-1.4

[a]Percent migration calculation not applicable. Levels of 2378-TCDD in exposed sample not significantly greater than controls.
[b]Additional microwave popcorn experiments in progress

With the exception of coffee, all controls showed detectable levels of one or both of the analytes. Thus, in each experiment, corrections for background were required. Reviewing the hot beverage cup data, the overall migration was small as was the difference between suppliers. It was apparent that the migration from fatty food products was higher than for coffee. There were greater differences between suppliers for the dual ovenable board migration rates; particularly for TCDD. Overall, dual ovenable board migration was quite similar to the hot beverage cup chicken broth migration. There were large differences in the migration measured for paper plates with some of the measurements for the non-clay coated plate actually indicating a decrease in the concentration in the corned beef hash. This is probably due to the plate absorbing corned beef hash fat which contained measurable levels of TCDD prior to exposure thus resulting in a lowering of the corned beef hash TCDD concentration. Microwave popcorn migration rates were found to be uniformly low for both TCDD and TCDF.

There was no detectable migration of TCDD from the orange juice containers for exposure times of up to 8 weeks. The TCDF concentration increased from a level of 0.7 ppq in the unexposed control to a maximum of 1.8 ppq after 8 weeks of exposure. This corresponded to a maximum migration rate of 0.17%.

A migration rate study was conducted as described previously (LaFleur, et al., 1990) using the same cartons only half and half was used rather than whole milk. Similar to the whole milk study, the half and half migration was found to be essentially linear with the square root of time. The results are summarized in Table 3.

Table 3. Summary of Half-And-Half Migration Study Results

	Percent Migration			
Exposure Time Interval	2,3,7,8-TCDD		2,3,7,8-TCDF	
	Mean	Range	Mean	Range
24 Hour	1.2	1.0-1.4	3.7	3.0-4.4
48 Hour	2.7	1.3-5.4	5.9	4.8-6.6
120 Hour	2.0	1.4-2.6	10.3	10.2-10.5
288 Hour	8.1	7.4-8.4	16.1	15.8-16.6

The coffee migration results, expressed in a percent migration vs. liters brewed per weight of aggressively wetted filter basis, were found to differ from the results reported in an earlier study (NCASI, 1988, Sullivan et al., 1989). Thus, since the previous relationship was found to not be representative of a broader range of filters, an alternative means of expressing the data was explored. It was found that a much better relationship existed between the percent migration and the liters brewed per total weight of filter. Using all data from both the previous study and the present study, the linear regression correlation coefficients were 0.74 and 0.71 for TCDD and TCDF respectively. The linear regression equations describing the coffee filter migration rates are:

$$\text{Percent TCDD Migration} = 10.3\ WF + 7.0$$

$$\text{Percent TCDF Migration} = 16.3\ WF + 7.9.$$

where WF = total weight of coffee filter (g) per liter of coffee brewed

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