THE EFFECTS OF COOKING BY VARIOUS METHODS ON CONCENTRATIONS OF PCDDs AND PCDFs IN BOVINE MEAT

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Introduction

There is an extensive body of data in the literature on the concentrations of PCDD/Fs in raw, fatty foods such as meat, fish and dairy products.[1] However, information on the concentrations present in cooked foods is limited and even more so on the effects of cooking *per se*. Körner and Hagenmaier[2] determined PCDD/F levels in smoked, fried and broiled (grilled) meat and fish. Stachiw *et al*[3] monitored TCDD levels in fortified carp fillets cooked by a variety of methods. Zabik and Zabik investigated the effect of cooking on TCDD in Great Lakes fish.[4] Schecter *et al*[5] measured PCDD/F concentrations in raw ground beef and also analysed cooked hamburgers prepared from the same product. The decreases in concentration which they observed, on a whole weight basis after cooking, always appeared to be due solely to the weight changes associated with loss of water and loss of PCDD/Fs with the fat. However, the raw beef was purchased from a supermarket and concentrations in the original raw product were relatively low, thus small changes may not have been observed. A different study by Schecter *et al*[6] showed that the amount of dioxins, furans and coplanar PCBs in ground beef, catfish and bacon decreased by about a half when the food was broiled (grilled). Average congener concentration changes varied from an increase of 29 % in bacon to a decrease of 33 % in the catfish.

A study by Petroske *et al*,[7,8] investigated the effect of pan-frying beef patties formed from tissue from animals which had been dosed with a mixture of 12 different PCDD/F congeners and four control animals. It was shown that concentrations of PCDD/Fs in the patties reduced by about 40 % - 50 % after cooking. Most of the reduction was accounted for by the amount of each congener found in the fat which was liberated from the patties during the cooking process. There was nevertheless an overall deficit of between 6 % and 14 % for each congener. The authors attributed the losses to volatility, degradation and processing, but errors due to analytical imprecision, or loss of fat, which for example may have sputtered from the pan during cooking, were not considered by the authors, and no details of the precision of the analytical method was given in either report. The general physical characteristics of these compounds would suggest that volatility and degradation are unlikely reasons for the loss.

In this study, raw meat was obtained from cattle which had been fed daily, for one month, capsules containing five PCDD/F congeners. This meat contained moderately high concentrations of incurred residues and allowed changes due to cooking processes to be measured. Several different cooking methods were used and the concentrations of PCDD/Fs were determined in raw and cooked products.

Materials and Methods

A cow was dosed with capsules containing the following five PCDD/Fs: 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, 1,2,3,6,7,8-HxCDD, 2,3,4,7,8-PeCDF and 1,2,3,4,7,8-HxCDF. The animal received one capsule per day for 28 days, to give a total dose of 4.2 μg per congener. A large piece of meat taken was from the animal, and portions of this large sample were prepared for various cooking experiments, as indicated by the headings in Table 1.

The analytical method used was based on that developed by Nygren *et al.*[9] All reagents were analytical grade, and solvents were glass distilled grade. These and all glassware were verified as free from contamination by PCDD/Fs before they were used. All GC-MS results were scrutinised before acceptance.

Results and discussion

The amounts of the 5 dosed PCDD/Fs in the raw and cooked samples (plus any juices released as food was cooked) for burgers, roasts and stews are presented in Table 1. Each data point is the mean of singlet analyses of duplicate sub-samples.

Burgers

The concentrations of the five PCDD/Fs were determined in raw and cooked burgers and in the released juices (consisting predominantly of fat) after cooking. Table 1 shows that each congener could be completely accounted for on a mass balance basis (within the experimental variability of the method). There was no indication of either loss or formation of PCDD/Fs during the cooking process. The concentrations determined in raw and cooked burgers were very similar, although this appears to be largely coincidental - a decrease in the absolute amount present (contained in released fat) being almost exactly matched by an apparent gain in concentration caused through weight loss caused by this loss and evaporation of water. Results are similar for all three modes of preparation - fried, grilled and barbecued, with the largest losses seen in the latter case where it was not possible to collect or analyse the released juices.

Roasts

Concentrations on a whole product basis were slightly higher in the cooked products. This could again be accounted for by weight changes during cooking arising from losses of water and fat. The amount (in pg) of each congener present in the raw and cooked joints (both oven baked and microwaved) appeared largely unchanged within experimental error. A small decrease in the total amount present could be explained by the release of fat which was not collected or analysed. The quantity of fat released by either cooking method was small and any difference due to this may not be significant given the precision of the method.

1. Changes in PCDD/F content between raw and cooked food

	Beefburgers						Roast beef				Beef stew			
	Fry A	Fry B	Grill A	Grill B	BBQ A	BBQ B	Roast CA	Roast CB	Roast MA	Roast MB	Pres A	Pres B	Sim A	Sim B
of raw food, g	102.2	108.1	118.6	106.3	120.6	108.5	288.9	290.8	377.5	408.7	228.1	211.2	221.3	223.8
of cooked food, g	79.7	86.9	82.8	69.1	92.5	87.0	189.3	178.1	244.1	246.7	378.0	361.5	165.9	166.9
of collected juices, g	2.8	3.4	7.6	5.7	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ıange (%)*														
8-TCDD	-10	+9	+10	0	-17	-13	+3	-18	+3	-3	-5	-2	-25	-25
7,8-PeCDD	-1	+20	+18	+7	-23	-5	+9	-14	-10	-10	-44	-15	-38	-38
6,7,8-HxCDD	+26	+41	+44	+35	+6	-10	-13	-8	-3	-25	+10	-15	-25	-38
7,8-PeCDF	+2	+19	+7	+3	-23	-32	-42	-13	-3	-9	+10	+14	-13	-38
4,7,8-HxCDF	-15	-15	-14	-13	-30	-19	+44	+8	+13	-3	-16	-14	-7	-26

not possible to collect and/or analyse juices from these samples

net change is the percent change between the absolute amount in the raw food and the amount in the cooked food plus juices which exuded as the food was cooked (where these were collected and analysed).

whole product basis, concentrations are lower in pressure cooked stews compared with pan cooked stews. However, as with the cooking methods, these apparent differences are attributable to weight changes - stews cooked in an open pan lost considerably water than pressure cooked stews. The total amount of some congeners present was more constant for the pressure cooked There was an apparent decrease in the amount present in pan cooked stews. This could be because some of the food burnt to n during the cooking process and the burnt mass could not easily be removed from the pan for analysis. All results were within nge of experimental variability and further experiments would be required to verify any effect.

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Table 1. Changes in PCDD/F content between raw and cooked food

	Beefburgers						Roast beef				Beef stew			
	Fry A	Fry B	Grill A	Grill B	BBQ A	BBQ B	Roast CA	Roast CB	Roast MA	Roast MB	Pres A	Pres B	Sim A	Sim B
mass of raw food, g	102.2	108.1	118.6	106.3	120.6	108.5	288.9	290.8	377.5	408.7	228.1	211.2	221.3	223.8
mass of cooked food, g	79.7	86.9	82.8	69.1	92.5	87.0	189.3	178.1	244.1	246.7	378.0	361.5	165.9	166.9
mass of collected juices, g	2.8	3.4	7.6	5.7	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Net change (%)*														
2,3,7,8-TCDD	-10	+9	+10	0	-17	-13	+3	-18	+3	-3	-5	-2	-25	-25
1,2,3,7,8-PeCDD	-1	+20	+18	+7	-23	-5	+9	-14	-10	-10	-44	-15	-38	-38
1,2,3,6,7,8-HxCDD	+26	+41	+44	+35	+6	-10	-13	-8	-3	-25	+10	-15	-25	-38
2,3,4,7,8-PeCDF	+2	+19	+7	+3	-23	-32	-42	-13	-3	-9	+10	+14	-13	-38
1,2,3,4,7,8-HxCDF	-15	-15	-14	-13	-30	-19	+44	+8	+13	-3	-16	-14	-7	-26

n/a not possible to collect and/or analyse juices from these samples

* net change is the percent change between the absolute amount in the raw food and the amount in the cooked food plus juices which exuded as the food was cooked (where these were collected and analysed).

Stews
On a whole product basis, concentrations are lower in pressure cooked stews compared with pan cooked stews. However, as with the other cooking methods, these apparent differences are attributable to weight changes - stews cooked in an open pan lost considerably more water than pressure cooked stews. The total amount of some congeners present was more constant for the pressure cooked stews. There was an apparent decrease in the amount present in pan cooked stews. This could be because some of the food burnt to the pan during the cooking process and the burnt mass could not easily be removed from the pan for analysis. All results were within the range of experimental variability and further experiments would be required to verify any effect.

Quality control
The performance of the method was assessed by the agreement between duplicates of the analysis of a reference meat sample. Relative standard deviations for the replicates were in the range 10 - 33 %.

Acknowledgement
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