Bull. Environm. Contam. Toxicol. 24,344-349 (1980)

Dioxin Levels in Raw and Cooked Liver, Loin Steaks, Round, and Patties from Beef Fed Technical Grade Pentachlorophenol[1]

Mary E. Zabik and Matthew J. Zabik[1]

Department of Food Science and Human Nutrition, [1]Pesticide Research Center, Michigan State University, East Lansing, MI 48824

Technical grade pentachlorophenol (penta) is a widely used pesticide and consists of chlorophenols, chlorinated dibenzodioxin and dibenzofurans. Penta-treated wood products have been used in livestock premises for many years. To determine whether a potential hazard to humans exists from cattle on dairy farms being exposed to substantial amounts of penta-treated wood, liver, longissimus dorsi (loin), semimembranosus (top round), biceps femoris (bottom round) stew, ground round and hamburger from four mature Holstein fed penta were analyzed for octa-, hepta- and hexachlorodibenzo-p-dioxins. The fate of these compounds during cooking were assessed.

EXPERIMENTAL

Liver, longissimus dorsi (loin steaks), semimembranosus (top round), biceps femoris (bottom round), stew meat (from quadraceps) ground round and hamburger samples were obtained from four mature female Holstein dairy cattle fed technical grade penta at a dose rate of 0.2 mg/kg body weight for 75 days followed by a dose rate of 2.0 mg/kg body weight for 60 days. All cattle were fed a complete feed ration composed of alfalfa haylage, corn silage, high moisture corn and a 38% protein supplement. The penta was added to a portion of concentrate and fed twice daily to control dosage. Ration composition, penta analyses and other details of the feeding experiments are summarized by KINZELL et al. (1979). Following slaughter, the carcass was held for 4-5 days at 40°C to allow the muscles to pass through rigor before samples were taken.

Consecutive slices of liver, steaks, and round from each animal were assigned to raw and cooked analyses. Composite samples of stew, ground round and hamburger from each animal were randomly assigned to raw and cooked treatments.

One-half inch liver slices were pan-fried to an internal temperature of 77°C as described by YADRICK et al. (1971). One-half inch semimembranosus and bicep femoris pieces were braised to 80°C (MAUL et al. 1971). One pound samples of one inch cubes of stew meat were pressure cooked as outlined by ZABIK (1974). One inch loin steaks were positioned inches from the heat source of an electric charbroiler to internal temperatures of 60 and 77°C.

---

1 Published as Michigan Agricultural Experiment Station Journal Article No. 9129.

0007-4861/80/0024-0344 $01.20

Ground round and hamburger patties (110g each) were charbroiled to 77°C as well as to a very well-done stage (5 min on each side past 77°C). Total cooking losses and time temperature relationships were obtained.

Percentage moisture and petroleum ether extractable fat were obtained using AOAC (1975) procedures. All analyses were run using the Dow Analytical Method (ML-AM 73-97) for dioxins in fish except that the samples were digested using concentrated HCl followed by hexane extraction instead of the concentrated base-hexane-benzene digestion-extraction system. The quantitation was by electron capture gas-chromatography. The limit of detection for all analysis was defined as 2.5 times the noise shown on the recorder chart just before and just after each dioxin peak. Gas chromatography conditions employed were 3% OV-1 on 100/120 mesh Chromsorb W HP 1.8 mm X 4 mm ID; injector temp. 250°, column temp 200°, detector temp. 300° and at a flow rate 40 mL/min. Whenever GC peaks were obtained for dioxins, the presense of dioxins was confirmed by monitoring M, M+2 and M+4 ions on a DuPont 321 GC-MS for one of the duplicate samples being analyzed.

RESULTS AND DISCUSSION

The fat, solids and total cooking losses of these beef cuts are presented in Table 1. As expected the percentage of solids increased significantly ($p < 0.001$) with cooking. Since the percentage of fat also increased significantly ($p < 0.001$) for all cuts but

TABLE 1. Solids and fat in raw and cooked beef cuts as well as total volatile and fat losses brought about by cooking.[a]

Cut	Solids		Fat		Total Cooking Losses
	Raw	Cooked	Raw	Cooked	
	%				
Liver	29.5	37.3	1.7	4.3	20.6
Longissimus dorsi	27.6	33.9[b]	3.2	4.2[b]	15.0[b]
	43.3[c]		5.2[c]		37.9[c]
Semimembranosus	26.9	38.4	2.1	4.1	33.0
Biceps femoris	27.0	37.0	3.1	5.6	27.8
Stew	26.3	41.1	2.0	2.6	44.2
Ground Round	27.4	41.8[c]	4.3	6.4[c]	40.1[c]
	50.1[d]			7.9[d]	50.1[d]
Hamburger	40.0	48.6[c]	21.8	19.7[c]	41.1[c]
	56.0[d]			19.6[d]	52.3[d]

a Mean of duplicate samples from four animals.
b Charbroiled to rare stage, 60°C.
c Charbroiled to well-done stage, 77°C.
d Charbroiled to very well done stage, 5 min/side beyond 77°C.

hamburger, a greater proportion of moisture loss than fat brought about the total cooking losses reported. This is typical of cooking data for lean cuts such as are obtained from mature Holstein cattle. When the cuts were cooked to higher internal temperature, i.e., longissimus dorsi, loin steaks, ground round and hamburger patties, cooking losses also increased. Levels of octa-, hepta- and hexachlorodibenzo-p-dioxins expressed as ppb of wet tissue are shown in Table 2. Most of the isomers showed a slight but non-significant

TABLE 2. Octa-, hepta- and hexachlorodibenzo-p-dioxin levels[a] expressed as ppb of wet tissue in raw and cooked beef

	Dioxin Isomers					
	Octa		Hepta		Hexa	
Cut	Raw	Cooked	Raw	Cooked	Raw	Cooked
	ppb					
Liver	183	187	18	20	3.2	3.8
Longissimus dorsi	0.5	1.3[b] 1.6[c]	n.d.	0.1[b] 0.3[c]	n.d.	0.1[b] 0.3[c]
Semimembanosus	1.3	2.1	n.d.	0.2	n.d.	n.d.
Biceps femoris	1.3	1.9	n.d.	n.d.	n.d.	n.d.
Stew	1.0	2.5	n.d.	n.d.	n.d.	n.d.
Ground Round	1.2	2.3[c] 2.0[d]	n.d.	n.d.[c] n.d.[d]	n.d.	n.d.[c] n.d.[d]
Hamburger	1.1	2.1[c] 2.0[d]	0.1	n.1[c] 0.3[d]	0.4	0.2[c] 0.5[d]

a Mean of duplicate samples from four animals.
b Charbroiled to rare stage, 60°C.
c Charbroiled to well done stage, 77°C.
d Charboiled to very well done stage, 5 min/side beyond 77°C.

increase upon cooking. Only the liver contained appreciable levels of these dioxin isomers with the octa isomer being present in ratios of 10 times the hepta and 30 times the hexachlorodibenzo-p-dioxin isomer.

In order to correct for changes in the percentages of solids and fats in the raw and cooked samples, the levels of dioxin isomers were expressed as both ppb of solids and fat basis. The significant difference that occurred among cuts in both cases was due to the fact that the levels in the liver were significantly higher than all other cuts. No significant differences in dioxin levels occurred in the other cuts. Cooking brought about a significant (p 0.001) decrease in the dioxin levels expressed both as a solids and fat basis. The levels of the octa, hepta, and hexachlorodibenzo-p-dioxins expressed on a fat basis are summarized in Table 3.

TABLE 3. Octa-, hepta- and hexachlorodibenzo-p-dioxin levels[a] expressed as ppb of the fat of raw and cooked beef

Cut	Dioxin Isomers					
	Octa		Hepta		Hexa	
	Raw	Cooked	Raw	Cooked	Raw	Cooked
				ppb		
Liver	11400	4700	1100	490	200	90
Longissimus dorsi	23	33[b] 32[c]	n.d.	2[b] 4[c]	n.d.	1[b] 5[c]
Semimembranosus	70	56	n.d.	n.d.	n.d.	n.d.
Biceps femoris	61	36	n.d.	4	n.d.	n.d.
Stew	46	99	n.d.	n.d.	n.d.	n.d.
Ground Round	36	36[c] 31[d]	n.d.	n.d.[c] n.d.[d]	n.d.	n.d.[c] n.d.[d]
Hamburger	5	12[c] 12[d]	0.3	n.d.[c] 2[d]	3	1[c] 3[d]

a Means of duplicate samples from four animals.
b Charbroiled to rare stage, 60°C.
c Charbroiled to well-done stage, 77°C.
d Charbroiled to very well done stage, 5 min/side beyond 77°C.

The significant loss of dioxin during cooking was associated with the liver. The values of the isomers in the other cuts fluctuated slightly but for the octachlorodibenzo-p-dioxin, the levels decreased slightly for braised round (semimembranosus and biceps femoris) but increased slightly for charbroiled loin steaks (longissimus dorsi), ground beef and hamburger patties as well as for the pressure cooked stew meat.

To further study the fate of the dioxin isomers during cooking, the total micrograms of each dioxin isomer in each raw and cooked cut were calculated. Cooking resulted in a slight but significant (p 0.05) overall decrease of 18% in the overall levels of the octachlorodibenzo-p-dioxin levels. The overall decrease in hepta and hexachlorodibenzo-p-dioxin levels was 8% but this loss was not significant. The percentage changes are reported in Table 4.

As can be seen in Table 4, only the liver lost a portion of the octa, hepta and hexachlorodibenzo-p-dioxins. The other cuts generally showed an increase in the octa isomers and for some cuts the hepta and hexa isomers also increased. The Dow Chemical study reported that dioxins appear to be formed during the broiling of New York Strip steaks charcoal broiled to a very well done stage and attributed this to the general phenomenon that small levels of dioxins are formed during any intensive heat combustion. Since this

TABLE 4. Percentage change[a] in the micrograms of dioxin isomers during cooking

	Chlorodibenzo-p-dioxin Isomer		
	Octa	Hepta	Hexa
Liver	-20%	-11%	- 8%
Longissimus dorsi	+77%[b]	---	---
	+63%[c]	---	---
Semimembranosus	+ 7%	---	---
Biceps femoris	0	---	---
Stew	+43%	---	---
Ground round	+15%[c]	---	---
	-10%[d]	---	---
Hamburger	+14%[c]	---	+32%[c]
	-10%[d]	---	+68%[d]

[a] Mean of duplicate samples from four animals.

[b] Charbroiled to rare stage, 60°C.

[c] Charbroiled to well-done stage, 77°C.

[d] Charbroiled to very well done stage, 5 min/side beyond 77°C.

raw meat had dioxin accumulation from feeding the pentachlorophenol, loss of dioxins during cooking of the liver may have masked small levels of dioxin formation while the increases in many of the other cuts may be due to dioxin formation. Although duplicate analyses on the same tissue gave fairly consistent analytical results, there was animal to animal and sample to sample variation so sample variance was quite high. Thus it is not possible from this study to conclude whether or not dioxins are formed during cooking.

Most tissues analyzed from these mature Holsteins had dioxin isomers in their tissues. All muscle cuts were low ranging from n.d. to 4 ppb with an average of 1 ppb on a wet tissue basis for the octachlorodibenzo-p-dioxin. Levels of hepta- and hexachlorodibenzo-p-dioxin were even lower. The liver accumulated much higher levels of all isomers and clearly would be a public health hazard if dairy cattle are allowed access to pentachlorophenol treated wood.

ACKNOWLEDGMENT

The authors thank Dr. Lee Shull and the Dairy Science Department of Michigan State University for supplying the meat.

REFERENCES

AMERICAN ASSOCIATION OF ANALYTICAL CHEMISTS: Washington, D.C. (1975).

KINZELL, J. H., L. R. SHULL AND R. M. McKENZIE: Manuscript in preparation (1979).

MAUL, R.E., K. FUNK, M. E. ZABIK, and M. J. ZABIK: J. Am. Dietet. Assoc. 59, 481 (1971).

YADRICK, M. K., K. FUNK, and M. E. ZABIK: J. Agric. Fd. Chem. 19, 491 (1971).

ZABIK, M. E: Poultry Sci. 53, 1785 (1974).