Degradation of 1,1,1-Trichloro-2,2-bis(*p*-chlorophenyl)ethane (DDT) in Beef by Canning and Cooking

Naturally contaminated beef samples containing 5 and 8 ppm of total DDT (DDE, DDD, and DDT) were processed and cooked by two different methods. Both processing methods (104 °C, 137 min; 126.7 °C, 66 min) reduced total DDT in the fat of beef. A mean loss of 20% occurred in fat below tolerance and a 10% loss in the fat above the tolerance level. Cooking by microwaves or in a conventional oven resulted in a 17% further loss.

Recent anti-pollution laws have prohibited the burning of gin trash at the site of ginning even in inverted cone type incinerators. Thus, feeding gin trash to cattle was considered as a means of disposal. Steers were fed diets consisting of approximately 25% gin trash and other feeds necessary to meet the nutrient requirements (National Research Council, 1970). The levels of chlorinated hydrocarbon insecticides remaining in the animal tissues could preclude usage unless some means of reducing the levels is ascertained.

Since 1943 DDT [1,1,1-trichloro-2,2-bis(*p*-chlorophenyl)ethane] has been used in vast quantities in the United States. As a result, its persistent residues are distributed in the atmosphere, soil, water, and in the fats of plants and animals. The seriousness of these residues has been recognized and the use of DDT has been banned except for certain uses specified by the Environmental Protection Agency. Nevertheless, the residues will remain in our environment for many years to come.

There have been a number of studies concerned with the fate of DDT added to feed for cattle (Fries and Kane, 1967; Rumsey et al., 1967; Whiting et al., 1968). The beef was not processed or cooked in these studies. Ritchey et al. (1967, 1969) and Liska et al. (1967) reported some loss of DDT in poultry during cooking. Carter et al. (1948) investigated the effects of various cooking methods on the DDT levels in beef, and reported that cooking beef did not cause material decomposition or loss of DDT. Improved methods of determining DDT, and the fact that the beef in this study was naturally contaminated by feeding steers cotton gin trash, would warrant further study on the beef as it would be consumed.

With this in mind the effects of two different processing methods on the level of DDT and its metabolites in ground beef have been investigated. The effects of further cooking on the pesticide level were also examined to determine the actual amount of DDT in the ground beef as it would be consumed.

MATERIALS AND METHODS

Eight steers were fed a ration containing gin trash contaminated with a mean level of 8.88 ppm of total DDT and its metabolites for a period of 216 days. The details of the feeding have been described previously (Martin et al., 1976). All eight steers were slaughtered in the Mississippi State University abattoir. Meat from two steers was selected for subsequent studies. The fat from one had levels of DDT, DDE, and DDD totaling 8 ppm (high residue), and the other had levels of 5 ppm (low residue). The current tolerance limit for fat of meat animals is 5 ppm of DDT as such, or any combination of isomers and degradation products DDD and DDE (Federal Register, 1974). The meat was ground and held in storage at −18 °C. Analysis at the time of the slaughter and at the time of canning revealed no change during storage (Martin, 1974).

Table I. DDT, DDE, and DDD in Beef Fat before and after Lyophilization

Sample	ppm			
	DDE	DDD	DDT	Total
Low residue[a]				
Before	3.18	0.28	1.55	5.02
After	3.26	0.25	1.54	5.05
High residue				
Before	5.56	0.74	1.81	8.11
After	5.76	0.78	1.59	8.13

[a] Low residue fat and high residue fat contained approximately 5 and 8 ppm of total DDT, DDE, and DDD, respectively.

The ground beef was processed in a steritort by two different processes, 104 °C for 137 min and 126.7 °C for 66 min. The ground beef was removed from the can, heated on a steam bath, and stirred to obtain a homogenous mixture. From this mixture a representative aliquant was taken and freeze-dried for 72 h. Quadruplicate assays were performed that revealed the freeze-drying process had little effect on DDT or its metabolites. The samples were ground immediately with sodium sulfate and the fat was extracted using a Soxhlet extractor. Three grams of fat from each sample was weighed into 10-ml graduated cylinders and brought to volume with petroleum ether. A microcolumn containing 5 g of aluminum oxide was washed with 15 ml of petroleum ether. A series of 1-ml eluate fractions was collected using a total volume of 15 ml of ether and this was subsequently concentrated using Kuderna-Danish concentrators and Snyder columns. The level of DDT and its metabolites was determined by gas–liquid chromatography. The instrument used was a Barber Coleman Pesticide Analyzer with an electron capture (^{63}Ni) detector. Glass columns were packed with equal portions of 10% DC-200 and 15% QF-1 coated on Gas-Chrom Q. A column temperature of 200 °C was used with optimum flow rate. The Mississippi State Chemical Laboratory has achieved 98% recovery of DDT in spiked meat samples with this method compared to 78% recovery when the FDA method was used.

To determine the effects of further heat treatment, 1 lb of ground beef from each process and 1 lb of ground beef that had not been canned was combined with 1 egg, 0.5 cup of reconstituted dry milk, 0.75 cup of bread crumbs, 1.5 tsp of salt, and 0.25 tsp of pepper. The mixture was spooned into muffin pan cups or glass custard cups and baked in a conventional oven at 350 °F for 30 min or 11 min in a microwave oven.

RESULTS AND DISCUSSION

In order to remove excess water before analysis the samples of ground beef were lyophilized for 72 h. Freeze-drying appeared to have little if any effect on the pesticide levels (Table I).

Table II. Pesticide Levels of Beef Fat after Two Methods of Processing

Processing	Pesticide fraction, ppm DDE	DDD	DDT	Total	% loss
Not processed	3.21	0.27	1.54	5.03	
104 °C, 137 min	3.00	0.96	0.09	4.05	19
126.7 °C, 66 min	3.09	0.60	0.46	4.15	21
Not processed	5.56	0.74	1.81	8.11	
104 °C, 137 min	5.43	1.29	0.66	7.39	8
126.7 °C, 66 min	4.92	1.27	0.91	7.10	12

Table III. Effects Due to Processing on DDT, DDD, and DDE in Beef Fat after Cooking in a Conventional or Microwave Oven

Process	DDT, ppm Low residue[a]	High residue	DDD, ppm	DDE, ppm
104 °C, 137 min	0.00a[b]	0.59a	0.95b	3.35a
126.7 °C, 66 min	0.29b	0.59a	0.81a	3.47b

[a] A significant ($P < 0.01$) interaction made presentation of means for each meat for each process necessary for DDT. [b] Means followed by the same letter in a column are not different ($P < 0.01$) for DDT and DDD, $P < 0.05$ for DDE.

Both processing methods (104 °C, 137 min, and 126.7 °C, 66 min) appeared to reduce the total level of combined DDT, DDD, and DDE in the beef fat, but the meat that was above tolerance, 8.11 ppm, still remained above the accepted level. The major losses occurred in the DDT fraction with very little change in the DDE and an increase in the DDD portion (Table II). This agrees with findings of Lamb et al. (1968) and Farrow et al. (1966) who studied canned spinach and suggested transformation of DDT to DDD during processing. Ralls and Cortez (1972) studied reactions of DDT with amino acids and peptides at 100 °C and found a higher level of conversion of DDT to DDD in the presence of glutathione and cysteine. They suggested that sulfhydryl hydrogens could participate in the hydrogenolysis involved in the conversion of DDT to DDD. Beef contains many sulfhydryl hydrogens. The data on the meat after preparation for consumption further substantiate these findings. Nevertheless, glass cups were used for microwave cooking and muffin tins for baking in the conventional oven. There was no difference in DDT due to the method of cooking (microwave vs. conventional), but the difference due to processing still remained (Table III). The fat from the cooked meat with the lower pesticide level which had been processed at 104 °C for 137 min contained no detectable DDT while that processed at 126.7 °C for 66 min contained 0.29 ppm of DDT. There was no difference due to processing in the DDT levels for the fat initially containing the higher level of pesticide. Statistical analyses revealed that even after cooking DDD was significantly greater ($P < 0.01$) in the product processed at 104 °C than in the one processed at 126.7 °C, but there was more ($P < 0.05$) DDE in the product processed at 126.7 °C (Table III). For DDD and DDE there was no significant interaction between processing methods and original pesticide levels. This indicated that the difference was in the same direction and of the same magnitude for each process regardless of initial pesticide level; thus the means are reported together.

Cooking in a conventional oven or by microwaves further reduced the total DDD, DDE, and DDT in the fat, with a mean loss of 17% (Table IV). Nevertheless, the high residue fat was still above the amount allowed (Federal Register, 1974).

Table IV. Total DDT in Canned Beef Fat after Cooking in Conventional or Microwave Oven

Process	Oven	DDT, DDE, DDD in canned product, ppm	DDT, DDE, DDD in cooked product, ppm	Loss, %
104 °C, 137 min	Conventional	4.05	3.29	19
104 °C, 137 min	Microwave	4.05	3.36	17
126.7 °C, 66 min	Conventional	4.15	3.55	14
126.7 °C, 66 min	Microwave	4.15	3.54	15
104 °C, 137 min	Conventional	7.39	6.04	18
104 °C, 137 min	Microwave	7.39	5.71	23
126.7 °C, 66 min	Conventional	7.10	5.75	19
126.7 °C, 66 min	Microwave	7.10	6.09	14
				Mean loss 17

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