tional 54% loss. Apparently ziram is not as stable in apricots during storage as maneb and zineb.

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Received for review May 24, 1971. Accepted August 23, 1971. Work conducted under contract No. 12-14-100-9513 (74) awarded to the National Canners Association Research Foundation by the Agricultural Research Service, U.S. Department of Agriculture. Presented before the Division of Agricultural and Food Chemistry, 161st Meeting, ACS, Los Angeles, California, March 1971.

Effects of Heating and Cooking Method on Chlorinated Hydrocarbon Residues in Chicken Tissues

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Lindane, endrin, heptachlor, dieldrin, and aldrin were fed at 10 ppm to broilers throughout an 8-week growing period. Tissues from these birds were cooked by baking, frying, or steaming and were heated in closed containers for 30–60 and 90 min. Residues, calculated on a dry matter basis, were lowered during cooking but the reduction in concentration was not significant in most cases. Lindane concentration was reduced considerably when tissues were heated in closed containers. Heptachlor epoxide was lowered during heating, but the amounts of endrin, dieldrin, and aldrin were not reduced. Losses of these residues occurred primarily by leaching with fat and water, although there was some destruction of lindane and heptachlor epoxide by heating.

Previous work from this laboratory (Ritchey *et al.*, 1967, 1969) has demonstrated that DDT was broken into its isomers during the heating or cooking of chicken tissues. However, the concentration of the total amount of residue varied with the particular method of cooking. Dy *et al.* (1970) have recently followed the deposition of DDT and its isomers from the hen through the egg and into products containing eggs. The concentrations of residue in cakes were related to the amount of DDT in the eggs. Variations in the amounts of DDT in different types of cakes were related to the part of the egg utilized in preparation and the content of residue in that part.

Although a large number of reports, including those of Draper *et al.* (1950), Ivey *et al.* (1961), Liska *et al.* (1964), and Naber and Ware (1961), have indicated deposition of pesticide residues into chicken tissues, relatively few reports have examined the fate of residues during the cooking or heating of foods. The work of Liska *et al.* (1965, 1967) and Carlin *et al.* (1966) and those noted above are examples of efforts to define the effects of processing and preparation methods upon pesticide residues deposited in a wide variety of foods.

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While DDT may represent the group of chlorinated hydrocarbons, the possibility that other residues of this general type may respond differently in the preparation of food seemed very good. Thus, the present report is concerned with the effects of cooking and heating on lindane, endrin, heptachlor, dieldrin, and aldrin present in chicken tissue.

EXPERIMENTAL PROCEDURE

Day-old Vantress AA male chicks were purchased from a commercial hatchery, housed in wire-screen batteries, and fed *ad libitum* commercial starter and grower rations to which had been added measured amounts of the pesticides. The only difference between groups of broilers was the pesticide added to the feed. Thirty chicks were randomly allotted to each treatment. They consumed feed containing the added pesticide throughout the 8-week growing period. Either lindane, heptachlor, endrin, dieldrin, or aldrin (10 ppm) was added to feed throughout the feeding period.

At the end of the growing period, birds were slaughtered, processed in the conventional manner, wrapped in freezer paper, and frozen at −20°F. The carcasses from each pesticide treatment were divided into equal numbers and were cooked or heated as described by Ritchey *et al.* (1969). Carcass weights of all birds were recorded and the amount of cooking loss was determined. The amounts of water and

Table I. Average Weights of Raw and Cooked Broiler Tissues, Cooking Losses, and Percentage of Dry Matter and Fat

Residue	Method or time of cooking	Carcass wt, g	Cooked wt, g	Cooking loss, %	D.M., %	Fat, %
Lindane	Raw	1301 ± 83[a]	...	...	31.3 ± 1.6	41.6 ± 5.0
	Baked	1268 ± 140	1028 ± 148	19.3 ± 3.8	34.7 ± 1.6	31.4 ± 2.8
	Fried	1299 ± 165	814 ± 108	37.4 ± 1.5	41.8 ± 1.2	28.8 ± 1.2
	Steamed	1331 ± 154	922 ± 123	30.9 ± 1.9	37.4 ± 1.6	29.4 ± 3.5
Endrin	Raw	1050 ± 49	...	...	33.9 ± 0.5	42.3 ± 2.6
	Baked	1064 ± 38	807 ± 38	24.8 ± 0.9	37.2 ± 0.8	28.8 ± 2.4
	Fried	1003 ± 93	664 ± 81	34.1 ± 2.4	42.8 ± 1.0	28.2 ± 0.2
	Steamed	1026 ± 172	729 ± 38	28.9 ± 1.2	37.6 ± 0.9	30.2 ± 3.4
Heptachlor	Raw	1218 ± 123	...	...	30.7 ± 1.7	36.4 ± 4.7
	Baked	1137 ± 38	881 ± 54	22.6 ± 2.8	37.1 ± 1.7	31.6 ± 4.4
	Fried	1249 ± 172	827 ± 80	33.3 ± 5.6	41.8 ± 1.3	29.6 ± 4.4
	Steamed	1202 ± 122	851 ± 100	29.3 ± 1.6	37.2 ± 1.1	29.2 ± 2.6
Dieldrin	Raw	1241 ± 86	...	...	30.6 ± 1.4	37.9 ± 5.5
	Baked	1182 ± 133	914 ± 132	22.8 ± 4.4	36.2 ± 1.9	29.9 ± 7.7
	Fried	1258 ± 95	819 ± 79	35.0 ± 1.7	42.2 ± 1.8	30.6 ± 2.7
	Steamed	1193 ± 214	862 ± 119	27.1 ± 1.5	38.4 ± 2.1	30.3 ± 4.4
Aldrin	Raw	1179 ± 90	...	...	28.9 ± 1.9	33.8 ± 5.9
	Baked	1173 ± 91	896 ± 84	23.6 ± 2.8	31.2 ± 1.0	29.1 ± 5.6
	Fried	1136 ± 153	733 ± 91	35.3 ± 3.2	41.4 ± 2.2	29.6 ± 0.6
	Steamed	1190 ± 160	853 ± 135	28.5 ± 1.8	38.2 ± 2.3	30.3 ± 0.8

[a] Mean ± SD; six birds per group except endrin, in which there were four birds.

Table II. Percentages of Dry Matter and Fat in Chicken Tissue Heated for Various Times

	30 min[a]		60 min		90 min	
	D.M., %	Fat, %	D.M., %	Fat, %	D.M., %	Fat, %
Lindane	32.6 ± 1.3[b]	40.0 ± 2.8	34.8 ± 1.7	40.6 ± 4.0	37.3 ± 1.6	40.1 ± 3.1
Endrin	39.0 ± 4.9	42.0 ± 2.3	38.5 ± 2.5	41.4 ± 3.3	47.9 ± 4.0	41.5 ± 1.7
Heptachlor	31.9 ± 1.3	35.6 ± 4.8	34.6 ± 2.1	35.9 ± 5.1	35.6 ± 2.9	37.3 ± 3.4
Dieldrin	32.5 ± 2.8	35.9 ± 4.5	35.2 ± 1.4	37.6 ± 5.4	37.3 ± 1.3	37.9 ± 5.3
Aldrin	34.4 ± 3.9	35.1 ± 5.8	33.8 ± 4.0	34.0 ± 6.1	37.6 ± 2.2	34.0 ± 5.0

[a] Tissues heated in closed containers @ 350°F for various times. [b] Mean ± SD.

Table III. Amount of Residue in Chicken Tissue after Being Cooked by Different Methods and Heated for Varying Lengths of Time

	ppm in dry tissue						
	Methods of cooking				Minutes of heating[b]		
	Raw	Baked	Fried	Steamed	30	60	90
Lindane	7.3 ± 3.4[a]	9.0 ± 2.1	5.5 ± 2.2	3.9 ± 2.7	5.2 ± 2.4	5.9 ± 2.4	1.5 ± 0.4
Endrin	28.2 ± 3.2	20.8 ± 0.8	22.7 ± 1.3	19.4 ± 0.9	31.5 ± 5.8	35.3 ± 7.1	31.5 ± 2.4
Heptachlor	28.1 ± 7.3	22.5 ± 2.0	30.6 ± 11.8	22.1 ± 2.6	16.0 ± 5.6	19.5 ± 2.5	18.2 ± 5.9
Dieldrin	49.7 ± 7.4	38.8 ± 2.4	28.7 ± 2.9	31.2 ± 4.9	40.7 ± 7.1	46.1 ± 2.3	43.2 ± 2.2
Aldrin	49.1 ± 8.3	37.3 ± 2.0	34.3 ± 2.0	38.5 ± 2.8	39.1 ± 8.1	50.8 ± 6.3	44.4 ± 3.5

[a] Mean ± SD. [b] Tissues heated in closed containers @ 350°F for varying times.

fat were determined by methods of the A.O.A.C. (1960). The residues were determined by the method reported previously (Ritchey *et al.*, 1967). Residues were calculated on a dry matter basis.

RESULTS AND DISCUSSION

Information is given about the birds (Table I), including average carcass weights, cooked weights, percentage of cooking loss, percentage of dry matter, and percentage of fat (dry matter basis). Differences in carcass weights (raw) were due to rates at which the birds grew (treatment differences) or the random selection of carcasses for control or cooked groups within a given pesticide treatment. Weights of birds receiving endrin and aldrin were somewhat lower than the other groups. Several birds died in the endrin group, indicating that the level of endrin fed was near the maximum amount of residue which could be tolerated by the bird. The cooked weights and percent cooking loss are indicative of relative differences of cooking methods.

Since there was good evidence that major losses of DDT occurred through leaching of fat and water (Ritchey *et al.*, 1969), chicken tissues were heated in closed containers to prevent the leaching and to provide information about the breakdown of the residue during heating. Dry matter and fat (dry matter basis) are summarized (Table II) for each of

the heating times. Differences in fat and dry matter were minute since losses were prevented except for small amounts through refrigeration. The major difference may be noted in the group of birds fed endrin; these differences no doubt reflect the slower growth of these chickens.

Residues formed in the controls (raw), and in the cooked and heated tissues are summarized in Table III. All data were calculated on a dry matter basis to provide a base of comparison. While variation between birds was large, certain trends seem apparent. There was some reduction in residue concentration in most of the cooked samples, but reduction below the raw tissue was not significant in most cases. Lindane was lowered considerably in the steamed tissues, but reductions were minor when the tissues were either baked or fried. The amounts of endrin in the cooked samples were below the raw controls, but there were no differences between methods of cooking. Heptachlor, determined as heptachlor epoxide, was reduced slightly in the baked and steamed samples, but the concentration in the fried samples was similar to the control. The amounts of dieldrin and aldrin were reduced by cooking, but there were no differences in the cooking methods.

When samples of chicken containing the residue were heated for 30, 60, and 90 min in closed containers, residues of lindane and heptachlor epoxide were reduced. Lindane was reduced from 7.3 to 1.5 ppm in the tissue heated for 90 min. Heptachlor epoxide was reduced from 28.1 to 18.2 ppm at 90 min, but this level was the same at 30 and 60 min. Any reduction of heptachlor epoxide occurred in the initial 30 min with no further loss of the residue. However, endrin, dieldrin, and aldrin were not reduced significantly below the raw control. Heating had no effect on these latter three pesticides and any loss which occurred in the cooked samples was apparently through leaching of fat and water. Losses of lindane and heptachlor occurred by both leaching and destruction by heat.

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Received for review August 11, 1971. Accepted October 21, 1971.

Influence of Sequential Herbicide Applications on Cottonseed Oil Composition

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Influence on cottonseed oil quality of four sequential herbicide applications selected from the compounds trifluralin, chlorpropham, fluometuron, DCPA, norea, diuron, MSMA, linuron, and prometryne was measured by gas–liquid chromatography. The sequential herbicide treatments did not greatly influence the fatty acid composition of cottonseed oil which consisted of myristic (1.0%), palmitic (23.1%), palmitoleic (0.6%), stearic (2.6%), oleic (18.5%), linoleic (53.7%), linolenic (0.2%), and arachidic (0.3%) acids.

Herbicides are requisite tools in current cotton (*Gossypium hirsutum* L.) production practices, and since herbicides alter plant metabolic processes, quality of food produced from herbicide-treated cotton has been an area of increasing concern. Approximately 568 million kg of cottonseed oil was used in the United States for human food in 1966 (Fats and Oils Situation, 1967). In that year herbicides were applied to 3,017,000 ha of cotton (Quantities of Pesticides Used by Farmers in 1966, 1970) from a total 3,867,000 ha of cotton harvested (Supplement to Statistical Bulletin, 1969). Thus, 78% of the shortening, margarine, or salad and cooking oils prepared in the United States from cottonseed oil grown in 1966 came from herbicide-treated plants.

Numerous studies have been reported on the influence of herbicides on seed germination, plant emergence, growth, and development, photosynthesis, respiration, and yield of various crops. Wilkinson and Hardcastle (1971) demonstrated that individual applications of several herbicides did influence the fatty acid content of cottonseed oil less than seasonal fluctuation, soil fertility, or soil type. However, current agronomic practices utilize several sequential herbicide applications at various growth stages of the cotton crop. The possibility of synergistic reactions from sequential herbicide applications presently needed for effective cropping remains a problem of concern for which data have not been reported. Therefore, samples of seed from field grown cotton treated with sequential herbicide applications were collected. Gas–liquid chromatographic analyses of the cottonseed oil quality are reported herein.

METHODS AND MATERIALS

Cotton (cv. Atlas 67) was grown in 1969 according to accepted agronomic practices with uniform fertilization of the Cecil fine sandy loam in the entire field area as recommended by soil testing. Insecticides [*i.e.*, dichlorodi-