EXCRETION OF HEPTACHLOR EPOXIDE IN THE MILK OF DAIRY COWS FED HEPTACHLOR-SPRAYED FORAGE AND TECHNICAL HEPTACHLOR

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Heptachlor [1 (or 3a), 4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene] fed to dogs and rats has been shown to be metabolically altered and stored as the epoxide derivative in the fat of these animals (2, 4). The epoxide metabolite has also been found in the milk of a dairy cow fed heptachlor (3). Heptachlor has been found to be an effective insecticide for the control of such economically important insects attacking forage as the alfalfa weevil and the meadow spittlebug.

The objectives of this investigation were (a) to determine if heptachlor or its epoxide metabolite was excreted in the milk of dairy cows fed hay that had been previously sprayed in the field with heptachlor, and (b) to study the excretion of heptachlor or heptachlor epoxide in the milk of the same cows fed various intakes of technical heptachlor with untreated hay following the insecticide-treated hay feeding.

EXPERIMENTAL PROCEDURE

Two similar plots of alfalfa of approximately 4 acres each were sprayed with heptachlor emulsion at the rate of 3.8 and 8.0 oz. per acre on July 7, 1952. The insecticide was applied with a sprayer mounted on a small truck equipped with a specially designed speedometer to aid in securing uniform coverage. The sprayer delivered approximately 6 gal. per acre at a pressure of 40 p.s.i. The hay on both plots was cut 7 days after spraying and was field-cured, field-baled, and stored until fed.

Four normal, healthy milking cows (three Jersey, one Holstein) were fed ad libitum on the hay sprayed with 3.8 oz. of heptachlor per acre from Nov. 15, 1952, to Jan. 5, 1953. The hay sprayed with 8.0 oz. of heptachlor per acre was fed to the same cows from Jan. 6 to Feb. 27, 1953.

After the two hay-feeding periods the same cows were fed individual dosages of technical heptachlor dissolved in soybean oil for a 50-day feeding period. Each animal was then fed an increased intake of heptachlor in soybean oil for an additional 70-day feeding period. The heptachlor in soybean oil was administered

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by capsule twice daily, and a control hay containing no insecticide residue was fed. The sequence of the four feeding periods is outlined below.

Period I — 54 days — heptachlor-sprayed hay. (3.8 oz/acre)
Period II — 52 days — heptachlor-sprayed hay. (8.0 oz/acre)
Period III — 50 days — heptachlor in soybean oil.
Period IV\(^1\) — 70 days — heptachlor in soybean oil.

All animals were fed sufficient hay to satisfy their appetites and provide a 10 to 15% roughage refusal. Varying amounts of a milking herd grain ration were fed, depending upon the level of milk production. Individual daily records were kept of the amount of feed fed and refused and the amount of milk produced. Each animal was weighed on two successive days at 10-day intervals. Samples of hay were taken from several locations in each bale fed and were composited for analyses for each 10-day feeding period. An aliquot of the milk produced by each animal for 2 days during each 10-day period was used for insecticide and butterfat analyses. The butterfat was separated from the milk by the method of Sager and Sanders\(^5\). Heptachlor epoxide concentrations in the butterfat were determined by the method of Radomski and Davidow\(^4\). The results were calculated to the equivalent concentration of heptachlor epoxide in fat-corrected milk (FCM).

Heptachlor residues on the hay were calculated from the organic chlorine content (corrected for the organic chlorine content of control hay) determined by the method of Carter and Hubanks\(^1\).

RESULTS AND DISCUSSION

A summary of the results of feeding the two lots of heptachlor-sprayed alfalfa hay is presented in Table 1. The hays sprayed with 3.8 and 8.0 oz. of heptachlor per acre had average insecticide residues of 1.2 and 5.0 p.p.m., respectively. The average daily heptachlor intake was 0.03 mg. per kilogram of body weight or from 8.7 to 14.0 mg. when feeding the hay sprayed with 3.8 oz. of heptachlor per acre.

The average daily heptachlor intake of the animals fed the hay sprayed with 8.0 oz. of heptachlor per acre ranged from 0.10 to 0.13 mg. per kilogram of body weight or a total intake of from 31.9 to 57.7 mg. No heptachlor or heptachlor epoxide was found in the milk of these cows while feeding either of the insecticide-sprayed forages. Daily observations of the animals for hyperirritability, muscular twitching, inappetence, and decreased milk production were negative, indicating that there were no toxic effects on the animals from eating the heptachlor-sprayed hays.

A summary of the results of feeding various dosages of technical heptachlor in soybean oil is given in Table 2. Daily intakes ranging from 100 to 1,800 mg. were fed for 50 or 70 days. These intakes were equivalent to 8.7 to 125.0 p.p.m.

\(^1\) Three additional cows (N191, N193, N194) that had not previously received heptachlor were fed heptachlor in soybean oil at a later date and included in this group.
TABLE 1

Summary of heptachlor-sprayed hay feeding experiment

<table>
<thead>
<tr>
<th>Animal</th>
<th>Feeding period</th>
<th>Av. daily hay consumed</th>
<th>Heptachlor on hay</th>
<th>Av. daily Heptachlor epoxide in FCM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(days)</td>
<td>(lb.)</td>
<td>(p.p.m.)</td>
<td>(mg/kg)</td>
</tr>
<tr>
<td>N638</td>
<td>54</td>
<td>20.4</td>
<td>1.2</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11.1</td>
</tr>
<tr>
<td>N680</td>
<td>54</td>
<td>16.0</td>
<td>1.2</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.7</td>
</tr>
<tr>
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<td>54</td>
<td>17.8</td>
<td>1.2</td>
<td>0.03</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>9.7</td>
</tr>
<tr>
<td>N805</td>
<td>54</td>
<td>25.8</td>
<td>1.2</td>
<td>0.03</td>
</tr>
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<td></td>
<td></td>
<td>14.0</td>
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<tr>
<td>N638b</td>
<td>20</td>
<td>18.9</td>
<td>5.0</td>
<td>0.11</td>
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<td></td>
<td></td>
<td></td>
<td>43.2</td>
</tr>
<tr>
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<td>13.5</td>
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<td>0.11</td>
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<td></td>
<td></td>
<td></td>
<td>32.0</td>
</tr>
<tr>
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<td>52</td>
<td>14.0</td>
<td>5.0</td>
<td>0.10</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>31.9</td>
</tr>
<tr>
<td>N805</td>
<td>52</td>
<td>23.3</td>
<td>5.0</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>57.7</td>
</tr>
<tr>
<td>N667</td>
<td>30</td>
<td>16.5</td>
<td>5.0</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>37.6</td>
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</table>

* Milligrams of heptachlor daily per kilogram of body weight.

b N638 was replaced by N667 after 20 days of feeding in Period II.

of the ration (hay plus grain), and to 0.30 to 3.78 mg. per kilogram of body weight.

No heptachlor or heptachlor epoxide was detected in the milk of cows fed less than 500 mg. of heptachlor daily. Increasing concentrations of heptachlor epoxide in the milk were observed when heptachlor intakes of more than 1.6 mg. per kilogram of body weight were fed. When approximately 3.0 mg. of heptachlor daily per kilogram of body weight was fed, the concentration of heptachlor epoxide in the milk was approximately the same as found by Davidow et al. (3) when feeding a comparable intake.

When daily intakes of heptachlor were high enough to detect heptachlor epoxide in the milk of cows fed technical heptachlor, they excreted from 0.3 to 2.8% of the heptachlor fed as the epoxide metabolite. No symptoms of toxicity were observed in any of the animals fed technical heptachlor in soybean oil in this experiment.

The results of this experiment indicate that forage harvested at least 1 week

### TABLE 2

The excretion of heptachlor epoxide in the milk of cows fed heptachlor in soybean oil

<table>
<thead>
<tr>
<th>Animal</th>
<th>Feeding period</th>
<th>Heptachlor fed daily</th>
<th>Av. daily FCM</th>
<th>Heptachlor epoxide in FCM</th>
<th>Dose excreted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(days)</td>
<td>(mg.)</td>
<td>(p.p.m.)</td>
<td>(mg/kg)</td>
<td>(lb.)</td>
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<tr>
<td>N667</td>
<td>50</td>
<td>100</td>
<td>28.7</td>
<td>0.30</td>
<td>26.6</td>
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<tr>
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<td>50</td>
<td>200</td>
<td>29.6</td>
<td>0.66</td>
<td>17.4</td>
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<td>300</td>
<td>20.2</td>
<td>0.60</td>
<td>24.9</td>
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<td>500</td>
<td>55.6</td>
<td>1.60</td>
<td>15.5</td>
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<td>70</td>
<td>600</td>
<td>44.6</td>
<td>1.30</td>
<td>29.8</td>
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<td>800</td>
<td>71.4</td>
<td>2.34</td>
<td>21.7</td>
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<tr>
<td>N194</td>
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<td>900</td>
<td>53.0</td>
<td>1.95</td>
<td>34.6</td>
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<td>70</td>
<td>900</td>
<td>91.4</td>
<td>2.93</td>
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<td>70</td>
<td>1,000</td>
<td>110.5</td>
<td>3.17</td>
<td>12.9</td>
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<tr>
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<td>50</td>
<td>1,000</td>
<td>66.2</td>
<td>2.12</td>
<td>24.7</td>
</tr>
<tr>
<td>N805</td>
<td>70</td>
<td>1,800</td>
<td>125.0</td>
<td>3.78</td>
<td>17.5</td>
</tr>
</tbody>
</table>

* Heptachlor intake calculated as p.p.m. of the feed consumed.

b Milligrams of heptachlor fed per kilogram of body weight.
after spraying with as high as 8.0 oz. of heptachlor per acre is safe for feeding livestock. This dosage is higher than normally recommended for the control of insects attacking the forage of crops that are cut for hay. Other conditions affecting the heptachlor residue on the forage would, of course, alter the margin of safety. The animals fed the hay sprayed with 8.0 oz. of heptachlor per acre had daily intakes of heptachlor that were approximately one-tenth the amounts required for the detection of heptachlor epoxide in the milk under the conditions of this experiment.

SUMMARY

No heptachlor or heptachlor epoxide was detected in the milk of cows fed hay made from forage sprayed with 3.8 to 8.0 oz. of heptachlor per acre and harvested 7 days after spraying. Heptachlor epoxide was detected in the milk of a cow fed 1.3 mg. of heptachlor per kilogram of body weight. Cows fed increasing amounts of heptachlor (up to 3.78 mg. per kilogram of body weight) had concentrations of heptachlor epoxide in the FCM as high as 5.7 p.p.m.

From 0.3 to 2.8% of the heptachlor fed was excreted in the milk as the epoxide metabolite.

ACKNOWLEDGMENT

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REFERENCES