The Effects of Dietary Dieldrin on Residues in Eggs and Tissues of Laying Hens and the Effects of Phenobarbital and Charcoal on these Residues

by DAVID L. MICK and KEITH R. LONG
Institute of Agricultural Medicine
College of Medicine
University of Iowa, Iowa City, Iowa 52240
and STAN M. ALDINGER
Director of Research
Yoder, Inc.
Kalona, Iowa 52247

Contamination of chickens, and their eggs, with dieldrin has occurred in Iowa over the past few years. Two questions are frequently asked in these situations: (1) How long will the chickens and eggs remain contaminated? (2) Is there anything that can be done to accelerate the elimination of the residue from the chickens?

The accumulation and depletion of dieldrin in eggs from hens fed dieldrin have been studied but generally at low levels of exposure (COOK AND WILSON 1970, CUETO AND HAYES 1965, CUMMINGS et al. 1966). The present study investigated higher levels of dieldrin exposure that would be created by a more gross exposure to dieldrin, perhaps as a result of misuse of the product.

The use of charcoal to adsorb pesticide residues from the digestive tract with subsequent elimination in the feces has been reported for animal species such as sheep, goats and cows (DAVIDSON AND SELL 1972, FOSTER et al. 1972, HERRICK et al. 1969).

Barbiturates, such as phenobarbital, decrease the storage of dieldrin in rats by inducing liver microsomal enzymes that are capable of metabolizing dieldrin (LAMB et al. 1970, SMALLEY et al. 1971). COOK AND WILSON (1970) used, in addition to the rat, the cow, calf, sheep and goat to show that phenobarbital was effective in inducing liver microsomal enzymes. These researchers felt that it was feasible to use phenobarbital as a means of accelerating the dieldrin removal from livestock.

It seemed logical, according to the foregoing information, that charcoal or phenobarbital could be used to increase the rate of excretion of dieldrin from laying hens. The present study examines this hypothesis.

Experimental Procedure

The laying hens used in this study were 16 month-old Hy-Lines that had been in normal production for 11 months. Each bird was housed individually in conventional wire cages. Laying diets and water, both free of aldrin and dieldrin, were fed _ad libitum_ throughout the duration of the experiment.

Bulletin of Environmental Contamination & Toxicology,
Vol. 9, No. 4,

The 64 chickens used in this experiment were divided into 16 groups of four. These groups were randomly assigned to four treatments, four groups to each treatment. Each of the 16 groups was treated as a single experimental unit and the eggs from a given group were pooled prior to residue analysis. Egg production records, chicken weights, and shell thickness were maintained on each bird.

Each chicken assigned to treatment 1 was administered orally a capsule containing 3 mg of dieldrin on alternate days until six doses had been given. Number 2 gelatin capsules were used that contained 0.3 ml of the following solution: 1 g of technical-grade dieldrin dissolved in 100 ml of corn oil. Each chicken assigned to treatment 2 received a 100 mg phenobarbital tablet in addition to the dieldrin dose. Chickens in treatment groups assigned to treatment 3 were fed charcoal in the laying ration ad libitum during the 11-day period of dieldrin dosage. The charcoal was mixed with the laying ration at the rate of 1 g of Norit-A per 1 lb of feed. Treatment 4 was a control.

Every third day for the first 12 days of the experiment and on days 19, 29, 83, and 105 one bird was chosen at random from each treatment and sacrificed. Liver, fat, and brain samples from these chickens were analyzed for dieldrin residues.

The eggs were analyzed according to the method prescribed by the Food and Drug Administration in their Pesticide Analytical Manual. The livers, fats, and brains were analyzed according to the Manual of Analytical Methods prepared by the Primate Research Laboratories, Environmental Protection Agency.

Egg production records were maintained on all birds until sacrificed or termination of the experiment. Eggshell thickness was measured using a micrometer at four locations at the mid-point of each egg around the longitudinal axis.

Results and Discussion

Statistical Analysis - The dieldrin residue in the eggs increased for the first 20 days and by day 22 the values had begun to decrease (Fig. 1). Therefore, the data were analyzed separately for days 1-20 and days 22-115. The linear model (residue = a + bt) was fitted to the data for the periods of increasing residues using linear regression. An exponential model (residue = ae^{bt}) was fitted to the data for days 22-115 using linear regression on the logs of the residues. The fit was good in all cases ($0.73 \leq r^2 \leq 0.98$). Separate lines were fitted for each group within treatments 1, 2 and 3 and the slopes (b) and intercepts (a) were compared using appropriate ANOVA procedures. The control group values were usually 0 and never exceeded 5 ppb and, therefore, were not used in the analysis.

The peak dieldrin residue in the eggs was reached about 9 days after cessation of dieldrin dosage (Fig. 1). HERRICK et al. (1969) found that hens fed 0.114 ppm aldrin had the highest dieldrin residue in their eggs 9 days after the initiation of a 7-day feeding period. This was related to the fact that it takes the hen approximately 9 days to produce a mature yolk. Our results show that the maximum dieldrin residue was found in the eggs 9 days after termination of dosage rather than after initiation of dosage. It is unlikely that this difference in results can be attributed to HERRICK et al. (1969) feeding aldrin while we fed dieldrin to the hens. In fact, one would expect just the opposite to occur in that conversion from aldrin might delay slightly the appearance of the maximum dieldrin residue in the eggs when the hens were fed aldrin. Therefore, it may be that the later appearance of the dieldrin residue in the eggs of our experiment was involved with the greater amount of insecticide dosage. The egg producing system of the laying hens was probably at maximum dieldrin saturation at the time of termination of dieldrin dosage and the eggs produced 9 days thereafter were the ones containing the maximum residue.

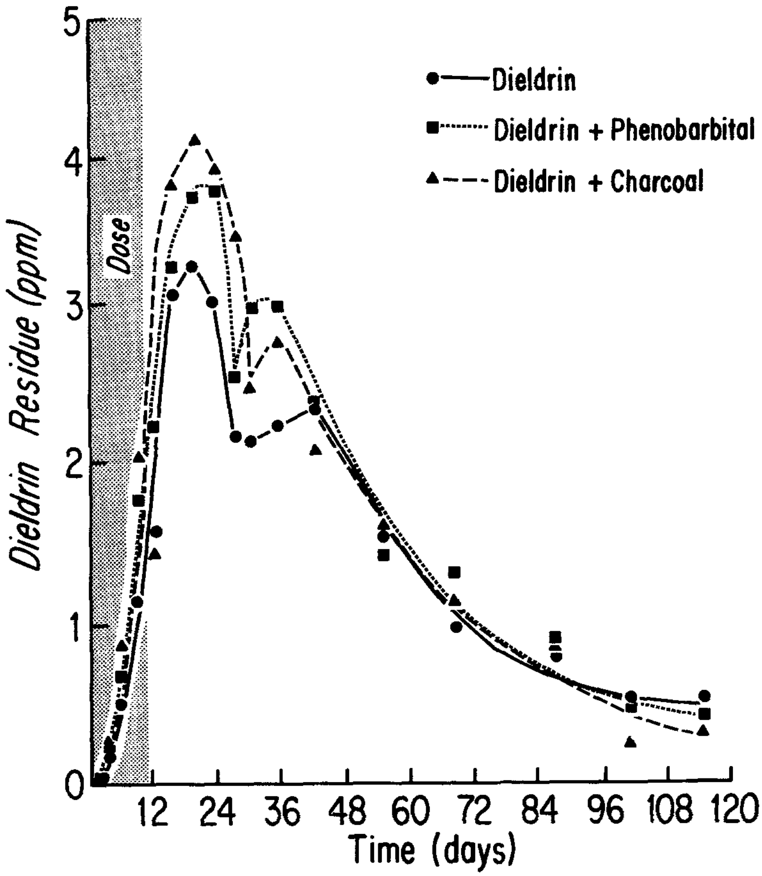

Fig. 1 Dieldrin Residue Levels in Eggs

There was an increase in the dieldrin residue in the eggs about 18 days after the maximum residue peak for all treatments except the control group. This second peak might be explained by the decrease in the fat reserves of dieldrin (Fig. 2) beginning to be reflected in the increased residue level in the eggs.

The residue level in the eggs continued to decline after the second peak was reached and were in 0.5 ppm range at the termination of the experiment. The residue values were beginning to level off which would indicate that a further decline in the residue level below 0.5 ppm would be at a rate considerably slower than the rate of decline to 0.5 ppm.

There were no statistical differences among the treatments either in the increasing or decreasing phases of the dieldrin residue in the eggs. Therefore, the phenobarbital and charcoal were not effective in decreasing the dieldrin residue in the eggs. However, the intercepts of the decreasing lines were significantly different at the 95% level. This significance occurred because the eggs of the dieldrin plus charcoal treatment reached a significantly higher maximum residue level than the eggs of the dieldrin treated birds ($p < 0.05$ by Tukey's test). This is contrary to what was expected if the charcoal had been affective in reducing the dieldrin residue. FOSTER et al. (1972) found that charcoal did not reduce the level of pesticides in eggs from hens fed pesticides.

LAMB et al. (1970), using pheasants fed a single dose of 1.4 mg dieldrin, found that the number of eggs produced was an important consideration in determining the amount of residue in the eggs. It would appear that this was not an influential factor in the level of dieldrin residue in the eggs of the chicken study. The dieldrin plus phenobarbital treatment group had an 85% decrease in egg production from days 5 to 16 but, as previously noted, the dieldrin residue level in the eggs was not significantly different from the other treatments where normal production was maintained. However, during the period of decreased egg production of the dieldrin plus phenobarbital treatment, the fat accumulated more dieldrin residue than the other treatments (Fig. 2). The accumulation of dieldrin in the fat increased when elimination of dieldrin via the eggs decreased. Egg production gradually returned to normal from days 16 to 33 for the dieldrin plus phenobarbital treatment and the fat residue levels concomitantly decreased.

The dieldrin level in the fat was from 10-15 times greater than that found in the eggs (Fig. 2). The highest dieldrin residue level in the fat was reached on or after day 12 but before day 19 of the experiment while the maximum residue in the eggs occurred at about day 20 of the experiment.

Livers and brains were analyzed on the same schedule as the fats. The dieldrin residue in the livers was detected only in the first 12 days of the experiment, which was essentially the period of dieldrin dosage (Table 1). The quantity of dieldrin found in the livers was considerably less than that found in either the eggs or fat. The chickens fed the dieldrin plus charcoal had the least dieldrin residue in their livers. If charcoal was responsible for this residue reduction, the same effect was not found for the eggs and fat. No dieldrin residue was found in the brains.

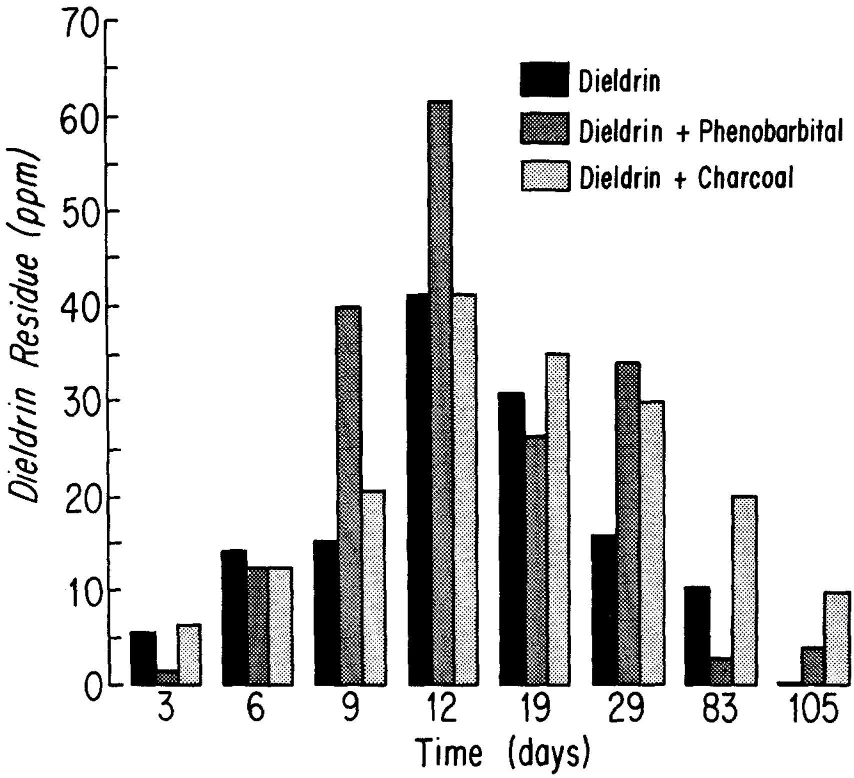

Fig. 2 Dieldrin Residue Levels in Chicken Fat

TABLE 1

Dieldrin Residue in Chicken Liver (ppb)

Time (Days)	Treatment			
	Dieldrin	Dieldrin + Phenobarbital	Dieldrin + Charcoal	Control
3	14	0	2	5
6	102	21	0	0
9	2	0	2	3
12	0	228	0	0
19	0	0	0	0
29	0	0	0	0
83	0	0	0	4
105	0	0	0	0

No statistical differences existed among treatments for eggshell thickness and weights of the chickens. Other researchers have also reported no change in eggshell thickness as a result of feeding dieldrin to chickens (DAVIDSON and SELL 1972).

Summary

Laying hens were fed a total of 18 mg of dieldrin over an 11-day period. Some of these were fed charcoal and others received phenobarbital during the 11-day period. Neither treatment affected the amount of dieldrin residue in the eggs. The maximum dieldrin residue in the eggs was about 4 ppm and occurred about 20 days after the initial dosage or about 9 days after cessation of dosage. The dieldrin residue levels in the livers ranged from 0 to 228 ppb and the brains contained no dieldrin residue. No change in shell thickness of the eggs or weights of the chickens was noted.

Acknowledgements

This research was supported under contract by the Pesticide Community Studies Division, Pesticides Office, Environmental Protection Agency through the University of Iowa.

References

1. COOK, R.M. and K.A. WILSON: J. Agr. Food Chem. 18, 441 (1970).

2. CUETO, C. Jr. and W.J. HAYES: Toxicol. Appl. Pharmacol. 7, 481 (1965).

3. CUMMINGS, J.G., K.T. ZEE, V. TURNER, and F. QUINN: J. Assoc. Offic. Anal. Chemists 49, 354 (1966).

4. DAVIDSON, K.L. and J.L. SELL: Bull. Environ. Contam. Toxicol. 7, 9 (1972).

5. FOSTER, T.S., H.V. MORLEY, R. PURKAYASTHA, R. GREENHALGH, and J.R. HUNT: J. Econ. Entomol. 65, 982 (1972).

6. HERRICK, G.M., J.L. FRY, W.G. FONG, AND D.C. GOLDEN: J. Agr. Food Chem. 17, 291 (1969).

7. LAMB, D.W., Y.A. GREICHUS, AND R.L. LINDER: J. Agr. Food Chem. 18, 168 (1970).

8. SMALLEY, H.E., H.R. CROOKSHANK, AND R.D. RADELEFF: J. Agr. Food Chem. 19, 331 (1971).

9. STADELMAN, W.J., B.J. LISKE, B.E. LANGOLIS, G.C. MOSTERT, and A.R. STEMP: Poultry Sci. 44, 435 (1965).

10. STREET, J.C., M. WANG, and A.D. BLAU: Bull. Environ. Contam. Toxicol. 1, 6 (1969).

11. WILSON, K.A. and R.M. COOK: J. Agr. Food Chem. 18, 437 (1970).

12. WILSON, K.A., R.M. COOK, and R.S. EMERY: Fed. Proc. 27, 558 (1968).