Removal of Pesticide Residues from Dairy Cattle

R. M. COOK and K. A. WILSON
Dairy Department, Michigan State University
East Lansing 48823

Abstract

The contamination of livestock with chlorinated hydrocarbon pesticide is a serious problem in animal agriculture. Once animals become contaminated with these pesticides elimination from the body is a slow process. The research on methods to intentionally increase the elimination of pesticides from cattle was reviewed. Several compounds have been fed to animals contaminated with heptachlor, dieldrin, or DDT. These compounds were mineral oil, animal and vegetable fat, calcium salts, bentonite, ethoxyquin, thyroprotein and vitamins A, D and E. In addition, the effects of high energy or low energy rations on pesticide excretion have been studied. Some of these materials helped to remove pesticides but the effects were not dramatic. The method that is effective as an antidote for pesticide poisoning in cattle is a combination of activated carbon and phenobarbital feeding. This method proved successful in a large scale field trial involving 105 lactating Holstein cows that had been contaminated with aldrin.

Introduction

The contamination of cattle with chlorinated hydrocarbon pesticides such as dieldrin, heptachlor and DDT presents a serious problem in animal agriculture. Since these pesticides are fat soluble, they are stored in adipose tissue of the animal following ingestion or other exposure. Urinary excretion is insignificant, and elimination in feces is slow. The primary excretory route is in the milk of a lactating animal. In any case, elimination of pesticides from a contaminated animal is a slow process. This has been clearly demonstrated for the pesticides dieldrin, heptachlor and DDT (3, 5, 14, 15, 26, 27, 30, 35).

Cattle become contaminated with pesticides in various ways. The use of pesticide-treated feeds is a major source of contamination. Feed crops become contaminated either by direct application of a pesticide or by drift from the aerial or ground rig application of a pesticide and from residual pesticides in the soil. In the experience of the authors, accidental poisoning of cattle with pesticides is a very serious prob-

---

1 Published with the approval of the Director of the Michigan Agricultural Experiment Station as Journal Article 5125.
In some cases dairymen have mistakenly mixed a sack of dieldrin instead of mineral in dairy feeds. Cattle sometimes break into storage areas and eat pesticides. In some cases dairy cattle have been dusted with lindane instead of the recommended biodegradable pesticides. Of course, the spraying of beef cattle with DDT and lindane is still practiced in various parts of the country. We have recently learned that dairy concentrates may become contaminated from feed sacks that were used first for pesticide-treated seeds and then reused for livestock feeds.

Chlorinated hydrocarbon pesticides were used to control alfalfa weevil and were applied to other dairy feeds up until about 1964. Federal laws did not permit residues of these pesticides in milk, but in many cases the residues were not detected until the electron-capture gas chromatograph was employed by the Food and Drug Administration (FDA). This instrument was so sensitive that 10^{-12} grams of a pesticide could be measured. Consequently, the zero tolerance concept for pesticides was not practical. Therefore, tolerances for chlorinated hydrocarbon pesticides in meat and milk were established. In some states where milk is imported dairy feed crops may still be treated with chlorinated hydrocarbon pesticides. In these situations the residues in milk go unnoticed unless the State Agricultural Department has a strong regulatory and pesticide monitoring program.

As a result of the changes in federal pesticide laws applying to animal agriculture in the early 1960's, work was initiated by several investigators to study carefully the metabolism of chlorinated hydrocarbon pesticides in cattle. Much of this work was directed towards the objective of finding an antidote for chronic pesticide poisoning and acute pesticide poisoning in cattle. Excellent reviews on methods of removal of pesticides from plants and foods have appeared recently (1, 29, 33). Liska and Stadelman (28) have reviewed the research on accelerated removal of pesticides from poultry. Laben (26) and Fries (16) have carefully discussed the pesticide residue problem in the dairy industry. This paper will deal only with studies of antidotes for pesticide poisoning in dairy cattle and other animals.

**Types of Antidotes for Poisons**

There are three general types of antidotes for poisons. First, a mechanical antidote is one that binds a poison in the gut and prevents absorption of the poison. Second, a chemical antidote stimulates the body such that the poison is metabolized and detoxified at a faster rate. Third, a physiologic antidote counteracts the toxic effects of the poison. An example of a mechanical antidote is the so-called "Universal Antidote" which consists of 2 parts charcoal, 1 part magnesium oxide and 1 part tannic acid. Charcoal is an adsorbent, tannic acid is a precipitant for alkaloids, and magnesium oxide is both an adsorbent and an antacid. The barbiturate phenobarbital is an example of a chemical antidote. Phenobarbital very markedly increases the rate of metabolism of drugs and poisons such as zoxazolamine and Warfarin by the liver (7). Examples of physiologic antidotes are atropine and phenobarbital. Atropine is an antidote for poisons such as parathion that interfere with cholinesterases. In cases of acute poisoning with dieldrin or DDT phenobarbital is an effective antidote. Thus, phenobarbital can act both as a chemical antidote and a physiologic antidote. Physiologic antidotes are routinely used in veterinary and human medicine but mechanical and chemical antidotes are not used as extensively.

A comprehensive review of the literature on the use of activated carbon as an emergency antidote for treatment of ingested poisons was presented in 1963 by Holt and Holtz (21). These authors demonstrated that activated carbon is an excellent adsorbent for many poisons. For example, 1 g of carbon would adsorb 1.8 g of mercuric chloride or 1.0 g of sulfanilamide. Weber and Gould (36) and Decker et al. (13) have clearly shown that activated carbon adsorbs pesticides and other xenobiotics. Holt and Holtz (21) pointed out that the value of replacing half of the activated charcoal in "Universal Antidote" with tannic acid and magnesium oxide have never been demonstrated and there was evidence that magnesium interfered with the adsorptive capacity of charcoal. In 1966 Picchioni et al. (32) experimented with rats and clearly demonstrated that activated carbon alone is more effective as an antidote for several different poisons than an equivalent amount of activated carbon in "Universal Antidote." They reported that tannic acid or magnesium oxide, or both, interfered with the adsorptive capacity of activated carbon and they recommended that activated carbon replace "Universal Antidote" in the treatment of poisoning. Holt and Holtz (21) recommended that for treatment of poisoning in humans, activated carbon should be administered as a fine powder. The carbon can be stirred into water to make the consistency of a thick soup and then drunk.

It was discovered during the 1950's that phenobarbital markedly induces the activity of
drug-metabolizing enzymes in liver microsomes. These enzymes are generally referred to as mixed-function oxidases and they are responsible for metabolizing and detoxifying foreign compounds such as drugs and poisons which enter the body. It is now known that the activity of these enzymes is increased by many foreign compounds and this is the basis for the development of resistance to drugs and poisons. In 1965 Cueto and Hayes (11) showed that phenobarbital will decrease the storage of dieldrin in fat. Although at that time the mechanism by which phenobarbital brought about a reduction in dieldrin storage was not clear, it is now generally recognized that the barbiturate induces the activity of liver microsomal enzymes that metabolize dieldrin.

Antidotes for Pesticide Contamination in Cattle

Some of the first attempts to intentionally increase the rate of excretion of pesticides from ruminants were experiments initiated by King (22, 23) at the University of Maryland, Brown (3, 4, 5) at Michigan State University, Miller (30) of New Mexico State University and Stull and coworkers (35) at the University of Arizona. King (22) fed as mechanical antidotes mineral oil, animal and vegetable fat, calcium salts or bentonite along with hay contaminated with heptachlor to lactating cows. The mineral oil and fat treatments slightly decreased heptachlor in milk fat and increased heptachlor in feces. Calcium salts and bentonite did not affect heptachlor excretion. Also, King (22) found that neither DDT nor ethoxyquin increased the rate of clearance of heptachlor from lactating cows. These compounds can act as chemical antidotes. Braund et al. (3) found that neither thyroprotein feeding, fat depressing rations or variable energy intake affected the rate of dieldrin clearance from lactating cows. King (22) found that these treatments did not affect the rate of heptachlor clearance from lactating cows. Miller has found that a low-energy ration increased the clearance of DDT from lactating cows (30). In an interesting study conducted by Hironaka (20) he found that injecting vitamins A, D, and E into steers and heifers contaminated with dieldrin reduced the residue half-concentration time. The half-concentration time for untreated steers was 245.6 and 146.3 days for vitamin-treated steers. However, for heifers the control half-concentration time was 85.7 days and the treated value was 38.5 days. The heifers excreted the residue faster than the steers. There was no increase in dieldrin elimination when body fat was reduced by restrict-

![Graph](image)

**Fig. 1.** Concentration of HEOD in blood, parotid saliva, rumen fluid and bile and pancreatic juice after injecting 20 mg of HEOD into the jugular vein of a goat.

Active Carbon Studies in Ruminants

We conducted studies using activated carbon to treat pesticide poisoning in ruminants in 1967. At that time we had found that dieldrin is recycled from the blood to the gastrointestinal tract in ruminants (9). The results from a typical experiment are shown in Figure 1. That dieldrin is recycled to the gut immediately suggested to us that a mechanical antidote could be effective in increasing dieldrin clearance when administered several hours or even several days after the animals were contaminated. We studied several materials to determine their effectiveness as an adsorbent of HEOD (the major component of dieldrin). These materials included pectin, lignin, liquid-phase activated carbon, and diatomaceous earths. Of these materials lignin and activated carbon were good adsorbents for HEOD. Activated carbon was chosen for feeding trials because it is inert and also adsorbed HEOD better than did lignin. The details of this work have been published (38). The data from typical experiments are in Figures 2, 3 and 4. Activated carbon markedly increased the rate of HEOD elimina-
tion in the feces. Also, activated carbon prevented the normal appearance of HEOD in the blood. This demonstrates that the carbon adsorbed HEOD in the gut. These studies have been conducted with goats, sheep and Jersey heifers.

**Phenobarbital Studies in Ruminants**

Cueto and Hayes (11), Street et al. (34) and Braund et al. (4) have shown that barbiturates decrease the storage of HEOD in body fat of rats. Of course, this discovery immediately suggests that barbiturates might be used to increase pesticide clearance from ruminants. To provide a basis for a trial to test this hypothesis we believed it was necessary to first establish whether or not ruminants respond to phenobarbital by induction of drug-metabolizing enzymes similar to the response found in the rat. Subsequent experiments clearly demonstrated that phenobarbital induces drug-
metabolizing enzymes in the cow, calf, goat, sheep and pig (10). These experiments are summarized in Figure 5. Next, trials were conducted in which HEOD and phenobarbital were fed to lactating Holstein cows (37). Phenobarbital decreased the storage of HEOD in the body fat and decreased the level in the milk fat. This work clearly demonstrated that it is feasible to treat cattle with phenobarbital to increase HEOD clearance.

**Other Studies with Activated Carbon and Drugs**

A well controlled field trial was conducted by Dr. Braund in 1969 to test the effectiveness of our method for increasing the rate of HEOD clearance from lactating cows (6). One hundred and five lactating cows which had been previously contaminated with aldrin were divided into two groups. One group served as controls and one group was fed Darco S-51 powdered activated carbon at 0.9 kg per head per day and phenobarbital at 10 mg per kilogram body weight per day. Pesticide levels in milk from the treated group were below tolerance (0.3 ppm in the fat) after 21 days while the pesticide level in milk from the controls was still well above the tolerance level. This large scale field trial clearly demonstrated the effectiveness of our method for clearing pesticides from cattle.

It is recognized that activated carbon is most effective as an antidote for pesticide poisoning when administered immediately after poisoning occurs. However, we recommend the use of carbon along with phenobarbital regardless of time of exposure to the pesticide for two reasons. First, pesticides are excreted in the bile, pancreatic juice and saliva and most probably in all the digestive juices (9). Also, Miller et al. (31) have shown that drugs enter the rumen after systemic administration. Secondly, it is well established that phenobarbital markedly stimulates the bile flow in rats (24, 25). Also, in rats it has been shown that a major route for excretion of pesticides is in the bile (19). Therefore, in ruminants phenobarbital no doubt increases the rate of recycling of pesticides back to the gut by way of the bile. Activated carbon feeding in conjunction with phenobarbital would then increase pesticide clearance long after exposure of the animals. Also, pesticide metabolites are excreted in the bile (19). Thus, the binding by activated carbon of pesticide metabolites in the gut is probably of equal importance.

Fries et al. (17) have recently found that activated carbon feeding lowers the body load of DDT when activated carbon and DDT are fed simultaneously to cows. Activated carbon did not lower DDT in the milk when fed after the cows were contaminated. These workers have not tested the combination of activated carbon and phenobarbital (17). In line with results obtained by others, they have shown that phenobarbital decreases the storage of chlordrin in rats (18). However, they failed to show that phenobarbital decreased DDT storage in rats.

There are other drugs that may be useful in increasing clearance of pesticides from cattle. Bradley (2) has recently reported that aminopyrine decreased pesticide storage in lactating cows and goats. Davies et al. (12) reported that phenobarbital or dilantin or both decreased blood levels of DDT residues in humans by as much as 80%. These workers found that dilantin decreases DDT storage in the body fat of rats. The effects of this drug on pesticide storage in large animals should be studied thoroughly.

**Other General Considerations**

The aforementioned work discussed formed the basis for the recommendation in our Extension Bulletin for pesticide removal from dairy cows (8). It provides the farmer with an antidote for acute pesticide poisoning in cattle as well as a means for speeding up the removal of pesticides from cattle that may have been contaminated several months before the pesticides were detected in the milk. One of the major problems in using this antidote is that activated carbon is not readily available to the farmer. Activated carbon is used primarily in the dry cleaning industry and the sugar refining industry. It is not available to farmers through the feed dealers. Activated carbon is sold under the trade name Norite for human consumption. Phenobarbital or other barbiturates are prescribed as a sedative for humans and are still used occasionally as an anesthetic. However, neither activated carbon nor phenobarbital are approved by the FDA for treating cattle for pesticide poisoning. Each individual case of pesticide contamination must be considered separately. For this antidote to be useful to the animal husbandryman activated carbon must be readily available in the feed store or from some other local business. In many cases where cattle have been in convulsions from acute pesticide poisoning immediate treatment with activated carbon would trap the pesticides in the gut, prevent death and greatly reduce the time required to decontaminate the animals.

There is a concern about long-term feeding of activated carbon on the health of the animal.
Specific Treatment for Pesticide Poisoning

When cows become contaminated with chlorinated hydrocarbon pesticides such as dieldrin it is recommended that the following steps be taken:

1. Check feed, water and insecticide sprays to determine the source of contamination. Then discontinue use of contaminating materials.

2. In cases of acute pesticide poisoning cows should be drenched with 2 to 2.5 kg of activated carbon. The drench can be a slurry made of 2 to 3 parts water and 1 part activated carbon. Activated carbon is difficult to find. Darco S-51 activated carbon is difficult to find. Darco S-51 activated carbon is manufactured by Atlas Chemical Company, Wilmington, Delaware.

3. If cows are in convulsions, the veterinarian may also treat them with intravenous injections of phenobarbital. When intravenous injections cease, phenobarbital should be fed at a rate of 10 mg per kilogram body weight per day. This amounts to about 5 g (one tablespoon) daily. Treatment should be continued for 6 weeks or until milk tests show that the pesticides are below tolerance levels. Phenobarbital can be added to the diet 2 hours before feeding. Phenobarbital may be trapped in the gut by activated carbon. It is probably best to feed phenobarbital about 2 hours before feeding activated carbon. The level of phenobarbital administered may not be reduced if the drug was given by intramuscular injections.

In summary, it is possible to accelerate the removal of chlorinated pesticides from livestock. At present, the combination of activated carbon and phenobarbital is the most effective treatment. The concern about pesticides in meat and milk and the development of this antidote should serve to stimulate continuing research on this problem. No doubt, more effective and less costly antidotes for pesticide poisoning in cattle can be developed.

References

(12) Davies, J. E., W. F. Edmundson, C. H.


(22) King, R. L. 1968. Investigations to determine the factors affecting the rate of absorption and excretion of heptachlor and heptachlor epoxide in the milk of dairy cows. Final report of research conducted under Contract 12-14-100-8144(44) with the Agricultural Research Service, U.S. Department of Agriculture.


