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Case Report - Phosphine Gas Detected in the Rumen Content of Dead Calves

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Abstract

One hundred and fifty-eight calves were fed whole corn containing aluminum phosphide tablets added to it the previous day. Twenty-four hours later, 4 calves were found dead at the feed trough and 15-20 others were sick. The only significant findings at necropsy were lung lesions caused by previously diagnosed pneumonia. A strong odor resembling garlic or rotten fish was noted in the rumen of all dead calves. The owners indicated that they noticed the same odor when they fed the corn. Rumen content was placed in bags inside a sealed glass jar and sent to the Oklahoma Animal Disease Diagnostic Laboratory for analysis. Toxic phosphine gas was detected in the rumen content of necropsied cattle.

Introduction

Aluminum phosphide (AlP) and zinc phosphide (ZP) are used as pesticides and rodenticides. Poisoning with these compounds peaked during the war years 1939-45 when red squill (the most frequently used rodenticide until that time) was in short supply and the effort to control rat populations was intensified.[3] Zinc phosphide is a grayish-black crystalline powder while aluminum phosphide is a greenish-gray powder. These powders were soaked in baits of bread, grains, sausage rusks or sugar. More recently they have been produced in pellet or tablet form, which is stable for long periods of time when dry. Both of these compounds react with moisture to produce toxic phosphine gas (PH_3), which has been reported to smell like acetylene, garlic or rotten fish.[7] Acidic conditions increase the rate of gas release.

Zinc phosphide is more often used as a rodenticide. Aluminum phosphide degrades more readily than ZP, making it more useful as a grain fumigant in ships and grain elevators. Phosphine gas is released from the aluminum phosphide from the natural moisture in the grain over a long period of time. Being heavier than air, it permeates into the grain, giving continued protection during shipment.[2]

Many nontarget animals and humans have been poisoned. Suicide attempts with aluminum phosphide tablets are common in India.[4,5] Animals have been poisoned directly by eating the bait or indirectly by feeding on carcasses of poisoned rodents. Massive poisoning of birds and rabbits has occurred in Holland and Britian.[11] Poisoning from these compounds is less frequent since other rodenticides have become more commonly used.

History and Clinical Findings

Weevils were observed in whole corn at a local grain elevator during the morning of October 08. While loading corn into the farmer's truck mounted bulk feeder, an elevator employee placed an unknown number of aluminum phosphide[a] tablets into the elevator's corn bin to control the weevils. The corn was left on the truck overnight and was fed at approximately 8 AM the next morning to 158 calves. The farmer noticed an unusual odor to the grain during feeding, but consumption by the calves appeared normal. The calves were not observed again until the following day.

The calves had been purchased several weeks earlier and were being held for future wheat pasture grazing. The diet consisted of free choice prairie hay and

[a]Fumitoxin, Pestcon Systems, Inc., Raleigh, N.C.

limit-fed whole corn. Water was supplied by a pond. Forty percent had been treated for respiratory disease.

At 10 AM on October 10, the farmer found 4 dead calves near the feed trough. Fifteen-twenty others were found near the pond, separated from the rest of the herd. These calves were markedly depressed; lowered heads, drooped ears and arched backs. The local veterinarian was contacted and arrived at the farm about two hours later. By then, the group of calves which had appeared sick had joined the remainder of the herd and appeared normal.

Necropsy Findings

Upon necropsy examination, bronchopneumonia lesions were found in the lungs of all four calves. No other gross lesions were noted. The attending veterinarian felt that the lesions were not severe enough to have been the cause of death. A peculiar garlic/rotten fish odor was noted when the rumens were opened. The owners indicated it was the same odor they detected in the corn fed the previous day. Rumen samples and fresh liver, kidney and lung were taken for laboratory submission.

Laboratory Data

Following consultation with a toxicologist at the Oklahoma Animal Disease Diagnostic Laboratory (OADDL), the rumen content collected in plastic sleeves was placed in a sealed glass jar and shipped on ice to the OADDL. The samples arrived at the laboratory on October 12.

Dräger Detector Tubes®[b] are used to measure various types of gases. In this case, the Dräger Detector Tube CH 31101, specific for measuring phosphine gas, was used.[c] The presence of phosphine gas was confirmed by the change of color in the tube from white to gray-violet at a rate of 2 ppm at 30 minutes. The presence of phosphine gas supported the diagnosis of aluminum phosphide poisoning.

The other tissue samples were not analyzed once the phosphine gas was detected.

Discussion

Fumigants are routinely used in the grain industry. The release of toxic gas is an effective way to rid grain of weevils and other pests. Aluminum phosphide is a highly toxic substance. The tablets, formulated with 55% aluminum phosphide and ammonium carbamate, are sealed until ready for use. When opened, they react with moist air, water, acids and other liquids to produce toxic and flammable hydrogen phosphide gas (phosphine, PH_3) and ammonia.[7] This is ideal for an enclosed area like a grain bin, providing label instructions and safety recommendations are followed.

Animals and humans are exposed to the toxin through inhalation and ingestion. In this case, we believe that some of the tablets placed in the grain bin went directly into the bulk feeder on the truck, which was enclosed. The calves subsequently ingested an unknown amount of aluminum phosphide, followed by liberation of phosphine gas (PH_3) in the alimentary tract. Calves with lung lesions resulting from pneumonia, resulting in an impaired respiratory system, could be more susceptible to inhalation toxicosis, however, these calves were fed outdoors in open troughs, decreasing the likelihood of inhaling toxic gas. The presence of phosphine gas in the rumen suggests that ingestion was more likely the route of exposure.

Reported lethal doses in cattle, sheep, pigs, goats, dogs, and cats are between 9.1-22.7 mg/lb (20-50 mg/kg).[1] Poultry are most often affected.[3] When the rumen or stomach pH is low, the animal is more likely to be poisoned. A dog with an empty stomach is more resistant to poisoning. Zinc or aluminum phosphide generally stimulates emesis, which is somewhat protective for nontarget monogastric animals, but cattle and horses cannot vomit.

In this case, the ingestion of contaminated grain and mixing with rumen fluid likely facilitated the formation of toxic phosphine gas. The following reaction occurs when aluminum phosphide comes into contact with water:

$$AlP + 3\ H_2O \rightarrow PH_3 + Al\ (OH)_3$$

Both phosphine and intact phosphide are absorbed from the GI tract. Most vital organs in the body are affected producing a variety of clinical manifestations. The onset of clinical signs is rapid, usually within 15 minutes to 4 hours following ingestion. Death from large doses usually occurs within 3 to 5 hours. Phosphine is believed to cause the majority of acute signs, while the intact phosphide may later cause hepatic and renal damage.

Phosphine poisoning in humans is characterized by vomiting, retrosternal and abdominal pain, profuse watery diarrhea, cardiac arrhythmia, peripheral vascular failure and altered consciousness.[4] The initial signs in animals are anorexia and lethargy, followed by rapid deep respiration that may be accompanied by wheezing sounds. Abdominal pain, colic in horses and rumen tympany in cattle have been reported. Animals then become ataxic, weak and recumbent while gasping for breath. A colt which died from ZP poisoning 5 hours after the onset of clinical signs did not exhibit signs of colic, but did try to vomit.[12] Gastrointestinal

[b]Dräger Detector Tubes®, Drägerwerk Aktiengesellschaft Lübeck, Federal Republic of Germany.
[c]Specific instructions on how to use the Dräger Detection Tubes® are enclosed with each kit.

bleeding, centrilobular liver necrosis, renal congestion, myocardial injury and pulmonary edema are common, although nonspecific, findings during gross postmortem and histopathological examination.[5,6] Hyperesthesia or convulsions may resemble strychnine poisoning in dogs and cats.[10]

Phosphide or phosphine toxicity can be tentatively diagnosed based on the history, clinical signs and the strong acetylene, garlic or rotten fish odor from the stomach content of animals or crop content of birds. If possible, unopened carcasses should be sent to the diagnostic laboratory, otherwise airtight containers should be used to store and ship GI content.

Treatment can be risky if caregivers are not in a well-ventilated area, however, the phosphine released in the stomach is quickly absorbed from the GI tract. There is no antidote for ZP or AlP poisoning. Humans have been decontaminated by gastric lavage with potassium permanganate to remove and oxidize the unabsorbed poison and bicarbonate to neutralize the acid. Supportive therapy with corticosteroids is recommended.[5] We were unable to find any successful treatment programs for cattle in the literature.

The prognosis for AlP poisoning is poor. Mortality can reach 100%. Determining factors would include the amount of toxin ingested, the ability to vomit or timing of gastric lavage, and complicating factors. Since cardiac arrhythmias, respiratory and renal complications are responsible for a large number of deaths in humans, it is likely that chances of survival for cattle would be even less.

In this case, the feed company offered to compensate the farmer for the dead calves, but refused to assume liability for the other calves, stating that there was no proof of ingestion or inhalation.

Carcasses of dead calves should be disposed in a manner to prevent ingestion by scavengers. Relay toxicosis can occur when animals that die of aluminum or zinc phosphide poisoning are ingested by other animals.

Conclusion

The history, clinical findings, necropsy examination, and the presence of phosphine gas in the rumen of the dead calves strongly support the diagnosis of phosphide/phosphine toxicity. When acute cattle deaths occur, phosphide/phosphine toxicity should be strongly considered when rumen content smells like acetylene, garlic or rotten fish. Proper handling and preservation of samples are vital to finding phosphine gas in the laboratory.

AlP is very useful as a grain fumigant. This case clearly illustrates the importance of following label instructions. When misused, serious threat to both animal and human health can result.

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