DOES DIATOMACEOUS EARTH HAVE A ROLE IN WORM CONTROL?

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Introduction

Diatomaceous earth (DE) consists of the fossilized, skeletal remains of single celled aquatic (usually marine) organisms called phytoplaktons, algae, or diatoms. Found in the earth in large quantities, DE is also known as diatomite. The product is composed primarily of hydrated silica (silicon dioxide), with 10-16% other minerals, depending upon the source (Martinovic et al., 2008). Harvested through mining, DE is approximately 50% moisture upon extraction, so it is dried and ground into a powder to create a useable product. The DE powder has a complex structure with a large surface area due to a large number of pores, channels and cavities (Figure 1), so it has a large absorption capacity and is used widely in filters for many purposes. It is used in concrete, ceramics and bricks. It is also used as fillers, coating agents, carriers and thickening agents for paints, fertilizers, pesticides, and ointments, as abrasives and protectants against pests in stored grain (reviewed in Stathers et al., 2008). Successful use of DE has been found in drug delivery systems (Aw et al., 2012), possibly as porous silicon anode material for batteries (Shen et al., 2012) and for DNA purification in laboratories (Sermwittayawong et al., 2013).

The U.S. Food and Drug Administration lists DE as GRAS (generally recognized as safe) when used as an inert carrier or anti-caking agent in animal feeds when it has a maximum of 15 ppm lead, 20 ppm arsenic and 600 ppm fluorine and is used at no more than 2% of the ration (FDA, 2014). It has also been listed as GRAS for food/water filtration. However, as a feed or food supplement, the product is not regulated by the FDA in the same manner as conventional food ingredients or drug products (FDA, 2015), so care should be taken when using those types of products.

Figure 1. Scanning electron microscope view of diatomaceous earth (modified; Mclean et al., 2005).

The structure and usefulness of DE can be be modified based on processing after mining, and can vary not only among the fields being mined but even among layers within a field (Elden, 2010). There may also be differences between DE from fresh and salt water diatoms, though differences in efficacy, at least when used with insect control, are thought to be primarily due to variation in physical and morphological characteristics of the product (Korunic, 1998). Because of this, and due to the fact that no real regulations are in place for quality control of the product, consistency is likely a major problem with DE. Although there is no doubt about that DE has an effect on crop pests and possibly on animal ectoparasites, variability in research results has been shown with DE for these uses (Korunic, 1998, Faulde et al., 2006, Athanassiou et al., 2011).

Review of Research

Research involving use of DE for endoparsites in small ruminants is difficult to find and often published only in abstract or proceedings form. Because of unconvincing and/or variable results, many scientists have not widely published their results. This review paper will present the information about research in ruminants, focusing on sheep and goats, available to the author at the time of submission.

Iowa State University conducted two studies using weanling lambs in the mid-1990s in which six animals each were group-fed 0.5 kg of a pelleted concentrate diet with or without 5% DE while being housed on pasture for up to 117 days (Osweiler and Carson, 1995). No significant differences were found for weight gain or fecal egg counts in Year 1, or abomasal worm counts in Year 2 in which the amount of DE was increased to 10% of the concentrate ration (Osweiler and Carson, 1995). However, the authors' report of visual/numerical differences encouraged interest in the product, in spite of their statement that DE alone was not an effective parasite control agent.

During the same time period, with similar results, research compared 12 sheep each of anthelmintic treated (every 4 weeks), athelmintic treated (every 8 weeks) with DE fed free choice and non-treated, DE fed free choice (Moore et al., 1995). The study lasted approximately 4 months during which fecal egg counts in all animals increased, with those fed DE and not treated increasing the most rapidly. Both groups fed DE required additional anthelmintic treatments and had severely depressed weight gains compared to the regularly treated sheep, prompting the authors to indicate that not only did DE not provide control of gastrointestinal nematodes but could be detrimental to the animal if intake is not controlled (Moore et al., 1995).

In a laboratory-based study, ovine feces was cultured with no additive, or 5% sand or boric acid or DE or 2% or 10% DE and larvae were harvested and counted (Hilson and Zajac, 2012). An effect was found for boric acid and 10% DE, but the DE level would be equivalent to a much higher level than would be fed (Hilson and Zajac, 2012).

Also supporting no positive effect of DE, research conducted with feedlot steers in 1996 used 11 anthelminitic-treated animals, and 9 each of DE fed and untreated animals (Fernandez et al., 1998). Steers fed DE were provided 0.3 kg of the product mixed daily with animal feed for 46 days. Fecal samples were collected on day 1, 15 and 28 and then every 28 days after that for fecal egg counting until slaughter. At the first and second months after treatment, untreated and DE steers had higher parasite egg counts than treated animals, then levels decreased and were similar for the rest of the study, in addition, DE fed calves had to be fed longer to finish out than treated animals (Fernandez et al., 1998).

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Research with DE in sheep and cattle was presented at the First Scientific Conference of the International Society of Organic Agriculture Research in Australia. In these studies, a very specific type of DE with an exceptional high surface area and oil absorption capacity was used, and the chemical/trace mineral analysis for the product was also reported (Mclean et al., 2005). Pregnant ewes were used with 15 animals per group with groups consisting of untreated animals, animals drenched with chemical anthelmintic when turned out with lambs after giving birth or ewes treated with diatomaceous earth after lambing. All animals received a rolled barley feed supplement daily and were weighed and fecal samples for fecal egg counting for at least six weeks after lambing; lambs were also weighed at birth and 4, 8 and 10 (shearing) weeks of age. Although the dose was not stated, the author used 2% of the ration as the DE dose for the cattle study, so that may have also been the dose for the sheep study. Fecal egg counts were not impacted by treatment, and although body weights for lambs from DE fed ewes were higher than drenched lambs at 10 weeks of age, they were similar to that of lambs from untreated ewes. With similar treatment groups, yearling Welsh black heifers also showed no overall benefit of DE administration over a 10 week period (Mclean et al., 2005). This project overall supports previous study results of no realistic effect of DE when used in sheep or cattle.

In a more recent study, 9-18 month old mixed-sex sheep were individually fed diets with or without 2% DE and fecal egg counts, larvae cultured per gram of feces and larval development were determined on samples collected on days 0, 2, 4 and 7 of the 7-day study (Ahmed et al., 2013). Compared to untreated animals, there was no effect on fecal egg counts, and although the author reported differences in treatments for larve per gram of feces, those differences were also apparent at the sample taken on Day 0 (Ahmed et al., 2013), generally collected right before treatment begins, so any convincing effect of treatment is unclear.

In contrast to these controlled studies, a farmer report of DE use in Minnesota indicated mixed results with sheep according to the farmer who provided DE as free choice supplement one year (with heifers as well), mixed as 1/3 DE and 2/3 salt the next (free choice for heifers and dairy cows) and as 1/3 DE and 2/3 salt-mineral mix the last year in lambs (Deutschlander, 1995). His observations seemed to support positive effects the first two years with lambs and heifers, but felt he should have used anthelmintics with the DE the last year; his observations with cattle supported the use of DE (Deutschlander, 1995). There was no data collected or analyzed that would support his observations, and, in general, most farmers have indicated varying results with the use of DE (Duval, 2002).

In a small undergraduate student honors' project, a commercial product containing DE and other possible natural anthelmintics was conducted using 5 lambs and 5 ewes with no control animals (Bowie, 2014). Using linear regression, the authors reported that fecal egg counts decreased with time for 11 days after treatment for lambs, but was not significant for ewes (Bowie, 2014). For this study, not only are the results equivocal, but the product contained more than DE, the design was not a controlled study and there were few animal numbers.

Although there is a lack of convincing evidence for positive effects of DE for sheep or cattle, there have been reports of vague positive effects of DE in goats, though the researchers noted in personal communication the certain failure of the product to influence internal parasites in previous studies (unpublished). For one study, 79 pregnant and lactating does were assigned to 4 groups on separate pastures, untreated does, does treated three times with ivermectin, those reated once with ivermectin and given DE at 2.5% of the diet and those given just DE at 2.5% of the diet (Nuti et al., 2000). All animals received a concentrate supplement at 1.36 kg/head/day.

Animals were treated with anthelmintic at packed red cell volume of less than 20% or eggs per gram of feces of greater than 4,000 and were considered ‘non-survivors’. Because ivermectin was only found to be marginally effecitve, there were no differences among treatment groups for fecal egg counts or packed cell volume, but estimated survival was significantly lower for untreated than for treated animals (Nuti et al., 2000).

In another study by the same group of researchers, pen-fed does artificially-infected with *Haemonchus contortus* were provided with DE at 5% of the concentrate ration or were untreated; DE treated animals had lower fecal egg counts compared to the untreated does (El Gayar et al., 2002). However, number of does used, total length of the trail, timing of treatment relative to infection and initial level of fecal egg counts was not provided or was not clear, so the results remain open to question.

In contrast, in a study using five goats per group, DE was administered to 40 kg naturally parasite infected Spanish and Spanish/Boer crossbred goats as a drench at 50, 100, or 150 µg/kg body weight or were given a similar amount of distilled water over an 8-day period (Bernard et al., 2009). Animals were sampled (feces, blood) and weighed weekly for six weeks. No effect was noted on fecal egg counts, body weight or indicators of anemia (Bernard et al., 2009).

Diatomaceous earth does contain trace minerals (Mclean et al., 2005) that may be of use to animals with deficienies as a supplement, though that has not been proven with research. However, this may be the reason many users feel there is a visual health benefit of using DE and could explain the continued popularity of this product.

Summary

Although diatomaceous earth has been shown with certainty to have insecticidal properties, information about the use of this product for gastrointestinal nematode control is sparse and unconvincing. The majority of controlled studies with published results including sheep, goats and cattle have noted no significant impact of diatomaceous earth products on gastrotintestinal nematode infection indicators.

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