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Research article

Effects of Korean Red Ginseng marc with aluminum sulfate against pathogen populations in poultry litters

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ABSTRACT

Background: The aim of this study was to evaluate the effects of Korean Red Ginseng marc with aluminum sulfate as litter amendments on ammonia, soluble reactive phosphorus, and pathogen populations in poultry litters.

Methods: Increasing levels of Korean Red Ginseng marc with aluminum sulfate were applied onto the surface of rice hull as a top-dress application; untreated rice hulls served as controls.

Results: Treatment with Korean Red Ginseng marc with aluminum sulfate or aluminum sulfate alone resulted in lower litter pH ($p < 0.05$), as compared with that of the controls. There were some differences ($p < 0.05$) between treatments with Korean Red Ginseng marc with aluminum sulfate or aluminum sulfate alone and controls at 2–4 wk (not at 1 wk). Ammonia levels reduced on an average by 29%, 30%, and 32% for 10 g, 20 g Korean Red Ginseng marc with aluminum sulfate, and aluminum sulfate alone, respectively, as compared with controls at 4 wk. During the experiment, Korean Red Ginseng marc with aluminum sulfate or aluminum sulfate treatment had an effect ($p < 0.05$) on soluble reactive phosphorus content, as compared with the controls (not at 4 wk). A decrease in *Salmonella enterica* and *Escherichia coli* was observed ($p < 0.05$) in litter amended with both Korean Red Ginseng marc with aluminum sulfate and aluminum sulfate alone, as compared with the control, except at 1–3 wk for *Salmonella enterica* and 1 wk and 4 wk for Escherichia *coli,* respectively.

Conclusion: The results showed that using Korean Red Ginseng marc with aluminum sulfate (blends), which act as acidifying agents *by reducing the pH of the litter,* was equally effective as aluminum sulfate in reducing the environmental impact.

1. Introduction

Poultry litter is recognized as an excellent nutrient source and fertilizer in growing plants because of its high nitrogen and phosphorus (P) content. Compared with different types of animal manure, poultry litter that is a mixture of bedding material and manure, has high organic matter and macronutrient and micronutrient contents, leading to the formation and release of ammonia (NH_3) as volatile compounds [1,2]. In addition, poultry litter provides an ideal environment for microbial proliferation, which is effectively controlled by litter management practices. The major environmental problems of the intensive rearing conditions related to poultry production and the land application of poultry litter have become important concerns in recent years. There is direct evidence that air quality in poultry houses and agricultural fields can cause environmental change, which in some cases may adversely affect agriculture viability in the short term as well as the long term. Consequently, the main environmental impacts caused by improperly managed poultry litter can be broadly categorized as follows: (1) high levels of NH_3 emissions from poultry houses that

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affects poultry health and production or causes soil acidification; (2) environmental effects of over-application of P in aquatic systems that can lead to algal blooms and eutrophication; and (3) increased numbers of pathogenic organisms such as viruses, *Salmonella* and *Escherichia coli* [2–4].

In order to solve the above-mentioned problems in poultry litter management, alternative methods are needed to facilitate a reduction in the environmental impact of poultry houses. Currently, acidifying amendments, which are easily available for use in poultry houses, are one of the most commonly applied techniques to decrease NH_3, P, and potential pathogens in poultry litters. For example, aluminum sulfate is commonly applied to poultry houses to alleviate the negative environmental impact. Several benefits of aluminum sulfate application have been reported, including the following: improved animal production, reduction of NH_3 levels in the poultry house, pathogen populations in litter, soluble reactive P, and energy cost during the winter season [5]. Moore et al. [6] also reported a significant reduction in NH_3 fluxes (99%) from houses treated with aluminum sulfate, as compared with controls during the first 4 wk, which would result in a healthier environment for chickens. In another study of Moore and Edwards [7], aluminum in aluminum sulfate that binds with the P in litter showed an approximately 75% decrease in P runoff in pastures [7]. Line and Bailey [8] observed that increased level of litter treatment resulted in a slightly delay of *Campylobacter* colonization onset in broiler chicks.

Another alternative is the use of Korean Red Ginseng marc, a fibrous and insoluble byproduct of the Korean Red Ginseng extraction process. In general, Korean Red Ginseng is produced by repeatedly steaming the ginseng at 98–100°C for 2–3 h and drying it, which can increase the storage period and improve medicinal efficacy [9,10]. In South Korea, Korean Red Ginseng byproducts (Korean Red Ginseng marc) are rendered into poultry feed for poultry production purposes [11]. However, Korean Red Ginseng byproducts become environmental contaminants when disposed as waste in soil. To date, there are no studies or reports on the use of Korean Red Ginseng marc as a litter treatment in the poultry industry.

In this study, we evaluated the effects of Korean Red Ginseng marc with aluminum sulfate as litter amendments on NH_3, soluble reactive phosphorus (SRP), and pathogen populations in poultry litters. The results of the study could be useful in determining the optimal levels to reduce the environmental impact of the poultry industry.

2. Materials and methods

2.1. Animals

All procedures of the present study were carried out in accordance with the guidelines of the animal policy at Yoosim Farms (Youngju, South Korea). The experiment was conducted on 160 male and 80 female chicks (1-d-old Arbor acres) obtained from a commercial hatchery for 28 d and randomly placed in 16 pens with a density of 0.07 m^2/bird. Each treatment had a randomized complete block design with four replicate pens of 15 birds (10 males and 5 females per pen). Chicks were raised on a depth of 5 cm with rice hulls as bedding materials. They were allowed *ad libitum* access to commercial diets and water through one tube feeder and an automatic bell drinker in each pen. The feeding program consisted of a commercial starter diet for the first 3 wk (0–21 d) and a finisher diet for the 4^{th} week (22–28 d). Temperature, lighting, and ventilation could be controlled to suit the chicks.

2.2. Treatments

The materials used in this experiment were Korean Red Ginseng marc (Yoosim, Youngju, South Korea) and aluminum sulfate, a form of dry acid salt that neutralizes alkalinity (Samchun Pure Chemical Corporation, Pyeongtaek, South Korea). These materials were applied onto the surface of the rice hull as a top-dress application. There were four treatment groups: CON, no treatment; T1, 10 g Korean Red Ginseng marc + 90 g aluminum sulfate per kg rice hulls; T2, 20 g Korean Red Ginseng marc + 80 g aluminum sulfate kg rice hulls; T3, 100 g aluminum sulfate per kg rice hulls.

2.3. Litter sampling and NH_3 gas measurements

Litter samples from each pen were collected weekly from four random locations for 4 wk and thoroughly mixed by hand. A subsample of 100 g was added to a plastic bag and maintained frozen until analysis. NH_3 emissions from rice hulls were taken weekly at four random locations in each pen and analyzed using the multigas analyzer (Yes Plus LGA, Critical Environment Technologies Canada Inc., Delta, Canada).

2.4. Chemical analysis

The pH and SRP content of the litter were determined with a 1:10 litter/water extract ratio, as described previously [12]. In brief, 10 g of poultry litter from each sample was weighed in a 200 mL polycarbonate centrifuge tube and diluted with 100 mL deionized water. The entire mixture was shaken using a mechanical shaker for 2 h and centrifuged at 6,000 rpm for 15 min. After that, pH measurements were made immediately in an unfiltered condition using a pH meter. SRP samples were filtered in the laboratory through a membrane filter of 0.45 μm to remove suspended solids. All filtered samples were acidified using hydrochloric acid of pH 2.0 and then frozen for analysis [12]. SRP analysis was estimated using the ascorbic acid technique with an auto-analyzer according to American Public Health Association method 424-G [13].

2.5. Microbial analysis

To determine *Salmonella enterica* and *E. coli*, samples (10 g) were prepared by adding 100 mL of phosphate-buffered saline buffer (pH 7.0) and mixed using a stomacher. Then, 0.1 mL of the litter suspension (10^0) was serially diluted from 10^1 to 10^7 dilutions. Serial dilutions were spread-plated on a sterile Petri plate with Difco TM SS agar (Becton, Dickinson and Company, Sparks, MD, USA) and Difco TM Violet Red Bile agar (Becton, Dickinson and Company, Sparks, MD, USA) for counting *Salmonella enterica* and *E. coli*, respectively. Plates were incubated at 37°C for 24 h, after which the colonies as average colony forming units (cfu)/g litter were counted at 1 wk through to 5 wk.

2.6. Statistical analysis

All data analyses were performed with analysis of variance using the general linear model of SAS (SAS Institute, 1990), with the pen as the experimental unit. Differences between means were compared using Tukey's honest significant difference test. Significance was set at $p < 0.05$.

3. Results and discussion

Effects of the addition of Korean Red Ginseng marc with aluminum sulfate to poultry litter on pH as a function of time were shown in Table 1. The litter pH showed statistically significant