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Short Communication

Effect of alum (top-dressed and mixed) with rice hulls on pH and ammonia emissions from poultry houses

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The use of aluminum sulfate [alum; $Al_2(SO_3)_4 \cdot 14H_2O$] as top dressing to poultry litter has been proven in reducing ammonia (NH_3) volatilization under both laboratory and field tests; however, there has been no information of alum application in mixing methods from poultry litter or rice hulls. The aim of the experiment was to evaluate the effects of alum top dressed or mixed with rice hulls as litter management methods on pH and NH_3 emissions. A total of 180 broiler chickens were randomly allocated to 12 pens to a density of 0.07 m^2/bird for 5 weeks, creating 4 replicates of 3 experimental treatments with 15 birds per experimental unit as a completely randomized design. The treatments included an untreated control, 100 g of alum (top dressing) and 100 g of alum (mixed)/kg of rice hull. In addition, alum treatment was usually applied by top dressing onto the rice hulls or fully mixed with the rice hulls. During the experimental period, pH and NH_3 emissions were significantly reduced by the two different methods of alum amendments ($P < 0.05$) in the litter over time compared with the controls except for NH_3 emissions at 1 through 3 weeks. However, no significant differences ($P > 0.05$) in pH and NH_3 emission were observed between the two different methods with alum for 5 weeks. The reduction in NH_3 emission from 100 g of alum top-dressed and 100 g of alum fully mixed with kg of rice hull at 5 weeks was 50 and 51%, respectively. In summary, these results indicate that "mixing" methods of alum as well as top dressing would serve as a suitable method for decreasing NH_3 emission, which resulted in lower pH.

Key words: Alum, top dressing, mixing, pH, ammonia.

INTRODUCTION

Poultry litter contains large amounts of nitrogen (N). Much of the excreted N can quickly be converted into ammonia (NH_3), which may readily move into atmosphere via volatilization (Ritz et al., 2004). NH_3 losses from poultry facilities contribute to environmental degradation and health problems in both poultry and humans. Also, because birds are in continuous contact with litter, litter condition (wet litter) is the primary cause of NH_3 volatilization (Ritz et al., 2005). Therefore, concerns regarding the problems listed above have emphasized the need for research to find ways to improve poultry production and reduce NH_3 volatilization from poultry litter and facilities. An alternative for these criteria is to use litter amendments or treatment methods to determine which are most effective at reducing NH_3 volatilization and are also both practical and economically viable to poultry producers. Litter amendments can be defined as a substance that is applied to poultry litter with the intention of alleviating one or more of the problems previously mentioned (McCrory and Hobbs, 2001).

In the 1950's several attempts were made to use superphosphate, hydrated lime, and gypsum as litter amendment for inhibiting NH_3 release from litter (Cotterill and Winter, 1953). Since then, many different litter amendments have been studied to evaluate their

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effectiveness in decreasing NH_3 volatilization from poultry litter. According to McCrory and Hobbs (2001), numerous additives have been divided into five groups: digestive additives, chemical additives (ferrous sulfate and alum), adsorbents (clinoptilolite and peat), urease inhibitors (CHPT and NBPT) and saponins from Yucca. These additives are very effective, their use is often limited, primarily due to the high cost. Of all additives tested, several studies have shown that alum application (an acidifying agent) presents a potential technology transfer for use in the poultry industry (Moore et al., 2000; Sims and Luka-McCafferty, 2002; Ullman, 2005). In terms of treatment methods with poultry litter, a method of litter management that has been used in commercial production to extend the useful life of litter or delay a complete house clean out before replacing a new flock is top-dressing (Coufal et al., 2006). Likewise, adding alum to poultry litter was usually applied by top dressing onto the litter surface using hand or truck under a small pen trial and commercial tests. A novel approach to add these amendments to poultry litter is "mixing" methods that are thoroughly incorporated into the litter. However, no information of alum application in "mixing" methods from poultry litter or rice hull in comparison with top dressing has been tested.

Thus, the aim of the current study was to evaluate the effect of alum (aluminum sulfate) that was top-dressed and mixed with rice hulls on pH and NH_3 volatilization as a litter management technique.

MATERIALS AND METHODS

Animals and treatments

A trial was performed in an experimental poultry farm located in Gunwi (South Korea). One hundred and eighty (1-day-old) broiler chicks (Arbor Acres) were obtained from a local commercial hatchery. Chicks were randomly allocated to 12 pens to a density of 0.07 m^2/bird for 5 weeks, creating 4 replicates of 3 experimental treatments with 15 birds per experimental unit as a completely randomized design. Chicks were reared in a house with automatically controlled light, temperature and ventilation system, and about 7 cm of clean rice hulls as bedding materials was placed on the floor. Chicks were fed with starter diets during first three weeks (0 to 21 days) and finish diets during second two weeks (22 to 35 days). Feed and water were supplied *ad libitum* with an automatic bell drinker and one suspended tube feeder per pen throughout the study. The treatments included (1) control (normal rice hulls), (2) 100 g of alum (top dressing)/kg of rice hull and (3) 100 g of alum (mixed)/kg of rice hull. Alum addition was usually applied by top dressing onto the rice hulls or fully mixed with the rice hulls. The levels of alum in rice hulls were determined as recommended by Moore et al. (1995). Al^+Clear Alum (Poultry Grade Alum) used in this study is the form of dry acid salt that neutralizes alkalinity (General Chemical Corporation, Parsippany, NJ).

NH_3 measurements, litter sampling and analysis

NH_3 measurements from rice hulls were done weekly with gas analyzer (Yes Plus LGA**,** Critical Environment Technologies Canada Inc., Delta, Canada) attached to a small chamber that was equipped with a battery-operated fan to stir the air at 4 random locations within each pen. Fresh litter from each pen was thoroughly mixed, and a 100 g of litter (20% moisture) was placed in a plastic bag and kept frozen until analyzed. To obtain aliquots for pH, 20 g of rice hulls (contained poultry litter) from each sample was weighed in a 250 ml polycarbonate centrifuge tube, then extracted with 200 ml of deionized water for 2 h on a mechanical shaker and centrifuged at 6,000 rpm for 15 min, as described by Moore et al. (1995, 1996). At this time, unfiltered samples for pH were measured immediately.

Statistical analysis

All data were analyzed using the General Linear model (GLM) procedure of SAS (2002). Statistical differences among means as Duncan's multiple range test were determined at $P < 0.05$.

RESULTS AND DISCUSSION

The effects of alum (top-dressed and mixed) with the rice hulls on pH and NH_3 are reported in Figures 1 and 2. In Figure 1, pH was significantly reduced by the two different methods of alum amendment in the litter with time when compared with the controls ($P < 0.05$). For controls, pH was greatest immediately after 2 weeks and increased with time (from 6.23 at time zero to 7.90 at 5 weeks). During the experimental periods, rice hull pH from the two different treatments with alum varied from 3.73 at time zero to 7.62 at 5 weeks and showed similar trends with time ($P > 0.05$, Figure 1). As shown in Figure 2, alum treatment that was top dressed and mixed with rice hulls was not significantly different from the control at the beginning (at 1 through 3 weeks; $P > 0.05$) with respect to NH_3 emission, but showed variable responses thereafter (at 4 and 5 weeks; $P < 0.05$). Also, no significant differences in NH_3 emission were observed ($P > 0.05$) between two different methods for alum application for 5 weeks. These results are not surprising because the use of litter amendments is known to reduce litter or rice hull pH. Moore et al. (1995) also reported that the mechanisms for pH reduction with alum treated litter are that if the litter has been treated with alum, then the pH will start out low 5 or 6 and increase with time as the acidity from alum reacts with NH_3 (base). Eventually, all of the acidity will be consumed, causing the pH to increase to over 7 after 5 weeks (Figure 1)

In the present study (Figure 2), the lowest NH_3 emissions in all treatments were noted for alum treatments top-dressed or mixed (from 0 at time zero to 22 ppm at 5 weeks), whereas the highest NH_3 emissions were observed with the controls (from 0 at time zero to 36 ppm at 5 weeks). In addition, as time increased, NH_3 emissions in alum treatments mixed followed a similar tendency to alum treatments top-dressed. This study clearly demonstrated that there are two possibilities in the effectiveness of alum: (1) a reduction in NH_3 emission from poultry litter is highly related to lower pH from the two different methods of alum amendments and (2) when

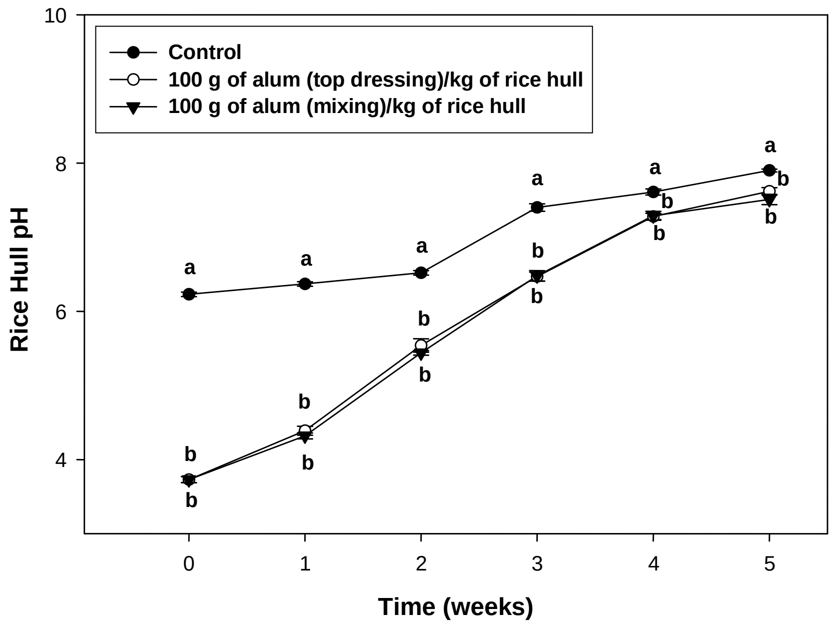

Figure 1. Effect of alum top-dressed and mixed with rice hulls on pH. [a–b]Bars with same letters are not significantly different at $P < 0.05$.

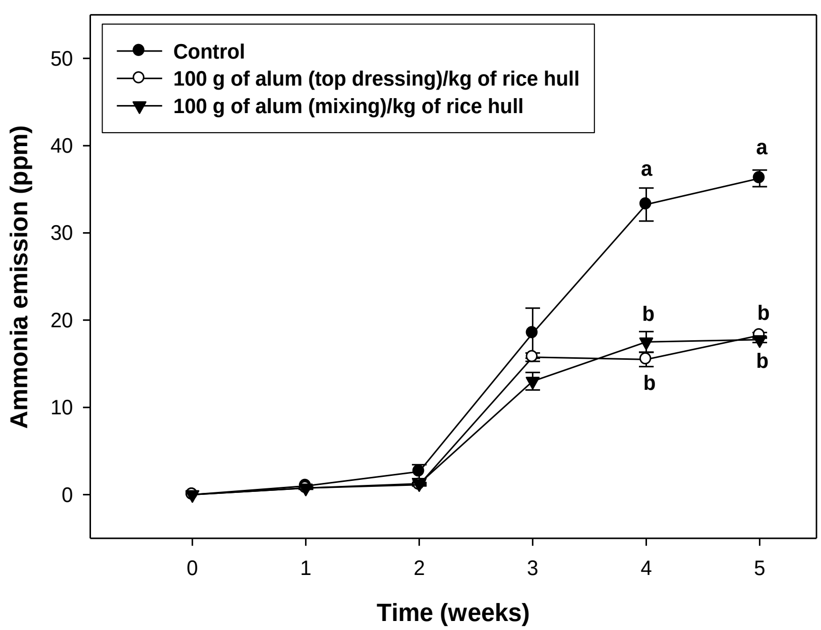

Figure 2. Effect of alum top-dressed and mixed with rice hulls on ammonia emission. [a–b]Bars with same letters are not significantly different at $P < 0.05$.

compared with top dressing (50% at 5 weeks), "mixing" methods of alum in poultry litter as a litter management may serve as a means to help the reduction (51% at 5 weeks) in NH_3 volatilization. These results supported the findings of Smith et al. (2004) and Choi and Moore (2008a), who indicated that the addition of dry $AlCl_3$ and liquid $AlCl_3$ to swine manure or poultry litter as top dressing or spraying reduces NH_3 volatilization."

Moore et al. (2000) observed that during the first three weeks NH_3 concentration in the alum-treated houses was 6 to 20 ppm, compared with 28 to 43 ppm in the control houses.

Laboratory studies were conducted by Choi and Moore (2008b) using dry alum, liquid alum, and A7 (high acid alum) which are acidifying agents. These treatments when added to poultry litter for 42 days reduced NH_3 volatilization, with reductions ranging from 77 to 96% for two experiments. Likewise, the differences in reduced rate of NH_3 emission by litter amendment between our results and other published data could have contributed to the lower rate of alum that were top-dressed or incorporated with rice hulls.

Conclusion

The results from this study suggest that a reduction in NH_3 emissions resulted in lower rice hull pH in alum treatments as either top dressing or mixing methods compared to controls.

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