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SHORT COMMUNICATION

Utilization of Chemical Blends to Increase Nitrogen and Decrease Pathogens in Duck Litter

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Abstract

This study examined the effects of chemical blends (a combination of alum and aluminum chloride) on pH, N, and pathogens in duck litter during a six-week experiment. In total, 240 Pekin ducks (160 males and 80 females) were individually distributed into 16 pens, in a randomized experimental design consisting of four treatments and four replicate pens per treatment. Our treatments included a control, T1 (75 g alum + 75 g aluminum chloride/kg duck litter), T2 (100 g alum + 100 g aluminum chloride/kg duck litter), and T3 (150 g alum + 150 g aluminum chloride/kg duck litter). There was no difference among treatments in pH and Total N (TN) at weeks 2, 4, and 6 and weeks 1, 4, 5, and 6, respectively. However, there were significant differences in both pH and TN among treatments at weeks 1, 3, and 5 and weeks 2 and 3, respectively. Regarding pathogens, we found small differences in all treatments in *Escherichia coli* populations from weeks 1 to 5 and in *Salmonella enterica* populations from weeks 1 to 3. In conclusion, the addition of chemical blends to duck litter increased TN, which resulted in a lower litter pH, but did not significantly affect pathogen populations.

Key words : Time series analyses, Autoregressive model, Groundwater level, Stream discharge, Riverbank filtration

1. Introduction

A method to reduce Nitrogen (N) and ammonia (NH_3) waste produced from poultry litter was first reported by Cotterill and Winter (1953). Since then, many scientists have stated that adding chemical amendments to poultry litter was the most effective method in controlling NH_3 production and pathogen populations (Moore et al., 1995, 2000; Line, 1998; Choi and Moore, 2008). Alum generally refers to dry $Al_2(SO_4)_3 \cdot 14H_2O \cdot Al^+$Clear (poultry grade alum) in the USA. In a laboratory and field study, Moore et al. (1995, 2000) reported that NH_3 volatilization losses were minimized by the addition of alum to poultry litter, which resulted in a greater total N content in the litter. Regarding pathogens, Line (2002) first suggested that alum as an acidifying agent in litter may reduce pathogens (*Campylobacter*) in broiler flocks. Some other amendments used are aluminum chloride (contains a liquid with 27.8% aluminum chloride and sold as Hyper Ion) and ferrous sulfate. Choi et al. (2008) found that the addition of alum and aluminum chloride in broiler litter reduced total aerobic bacteria population (from 22 to 87% of the

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untreated control) and gram-negative bacteria (from 63 to 99% of the untreated controls), which also lowered litter pH value (from 5.95 to 6.64).

There is limited information about the effects of chemical blends on N and pathogens in duck litter. Furthermore, the use of chemical blends has also been of particular interest to positive environmental benefits for the duck production industry. Therefore, we evaluated the effects of chemical blends (a combination of alum and aluminum chloride) on pH, N, and pathogens in duck litter during a 6-week experiment.

2. Material and Methods

All experiments were carried out in compliance with the animal care guidelines of Gilhong Farm Animal Policy (Geochang, South Korea). A total of 240 (160 male and 80 female) Pekin ducks were randomly distributed into 4 treatments where each treatment includes 4 replicate pens (16 pens in total). Our treatments were control, T1 (75 g alum + 75 g aluminum chloride/kg duck litter), T2 (100 g alum + 100 g aluminum chloride/kg duck litter), and T3 (150 g alum + 150 g aluminum chloride/kg duck litter). Each pen consisted 15 individual ducks. In addition, chemical treatments were top-dressed onto duck litter with thin layers (1-2 cm deep). Duck facilities were equipped with an automatic control system with light, temperature, heating, and ventilation. All individuals had free access to food and water *ad libitum* during the feeding trial that lasted 42 days. Commercial diets were formulated as starter diets (days 1 to 21, 21% crude protein) and finisher diets (days 22 to 42, 17% crude protein).

Litter samples were taken weekly from 4 different sites in each pen and thoroughly mixed by hand. Moreover, approximately 100 g of litter samples were weighed and transferred to individual plastic bags. Before determination of pH, Total N (TN), and microbial analysis, all litter samples were kept in frozen storage. For litter samples, pH and TN were determined according to the methods of AOAC (1998). In order to evaluate microbial analysis, 10 g of litter sample was added 100 mL of PBS buffer (pH 7.0) and mixed in a stomacher. Then, 0.1 mL of the litter suspension (10^0) was transferred to 0.9 mL of sterile distilled water and serially diluted from 10^1 to 10^7 dilutions. The diluted samples were seeded into Difco™ Violet Red Bile agar (Becton, Dickinson and Company, the USA) and Difco™ SS agar (Becton, Dickinson and Company, the USA) to count *E. coli* and *Salmonella enterica*, respectively; the agar plates were incubated at 37°C for 24 h. The colonies were expressed as average colony forming units (cfu)/g litter at 1 through 6 weeks.

Data analyses were performed by using ANOVA in PROC GLM procedure (SAS Institute, Version 9.2, 2008). A significant level of $p < 0.05$ was used to detect differences between treatment means and these means were compared by using Duncan's multiple range test (1955).

3. Results and Discussion

The effects of chemical blend additions on pH and TN in duck litter as a function of time are presented in Table 1. No difference among treatments was observed in pH and TN for weeks 2, 4, and 6 and weeks 1, 4, 5, and 6, respectively. However, there were significant differences in both pH and TN (at weeks 1, 3, and 5 and weeks 2 and 3, respectively) among treatments. In comparison with three different concentrations of chemical blends and controls at 6 weeks, the lowest pH and highest TN values in duck litter were T3 (150 g alum + 150 g aluminum chloride/kg duck litter).

Increased levels of chemical blends were responsible for a small increase in TN, which resulted in a lower litter pH (Table 1). Our results were in

Table 1. Effects of the addition of chemical blends on pH and total nitrogen in duck litters as a function of time

Week	Treatment[1]				SEM[2]	p-value
	Control	T1	T2	T3		
pH						
1	7.15^{bc}	7.35^{a}	7.26^{ab}	7.08^{c}	0.024	0.0218
2	7.09	7.01	6.43	6.19	0.075	0.1329
3	7.51^{a}	7.17^{ab}	6.69^{b}	6.58^{b}	0.081	0.0428
4	7.07	7.50	7.03	7.10	0.045	0.2402
5	7.91^{a}	7.19^{b}	6.98^{b}	7.13^{b}	0.072	0.0057
6	7.30	6.89	6.85	6.76	0.042	0.1451
Total nitrogen (%)						
1	1.64	1.80	1.82	1.84	0.017	0.4169
2	1.33^{b}	1.29^{b}	1.38^{b}	1.60^{a}	0.025	0.0267
3	1.19^{b}	1.35^{a}	1.32^{a}	1.25^{ab}	0.013	0.0295
4	1.07	1.24	1.12	1.19	0.014	0.0770
5	1.07	1.18	1.02	1.09	0.012	0.1105
6	1.10	1.16	1.18	1.24	0.011	0.2338

[a-c]Means in the same row followed by different superscripts differ significantly ($p < 0.05$)
[1]T1: 75 g alum + 75 g aluminum chloride/kg duck litter; T2: 100 g alum + 100 g aluminum chloride/kg duck litter; T3: 150 g alum + 150 g aluminum chloride/kg duck litter
[2]Values are expressed as means ± standard errors

accordance with those of Moore et al. (2000) who showed that alum treatment increased total N values of the broiler litter and decreased NH_3 volatilization. Similarly, Brewer (1998) estimated that total N release from a poultry house including 20,000 broilers that were applied alum at the recommended rate would be 131 kg compared with an untreated house (296 kg), during 6-week feeding trials.

We present the effects of chemical blend additions on *E. coli* and *Salmonella enterica* in duck litter as a function of time in Table 2. Small differences were found in *E. coli* and *Salmonella enterica* populations in all treatments from weeks 1 to 5 and weeks 1 to 3, respectively. At week 1, three different concentrations of chemical blends seemed to reduce *E. coli* and *Salmonella enterica* populations in the duck litter soon after application and activation of the products. During the experiment, *E. coli* and *Salmonella enterica* populations in duck litter were not significantly affected by the addition of three different rates of chemical blends. Our results were not in line with the findings of Line (2002) who suggested that alum treatment reduced pathogens in duck litter by suppressing microbial growth and activity. Moreover, Line (2002) indicated that the pH reduction caused by application of acidic compounds (such as alum) could be a possible mechanism for reducing *Campylobacter* populations in the broiler litter. However, Line (2002) showed no decrease in *Salmonella* colonization frequency and populations in the ceca in any of the treatments (alum and sodium bisulfate). Currently, the causes of the ineffectiveness of chemical blends on *E. coli* and *Salmonella enterica* populations in duck litter are ambiguous.

4. Conclusion

Our study indicated that increasing levels of chemical blends applied to duck litter was responsible for a small increase in TN content, which resulted in a lower litter pH. However, using three different concentrations of chemical blends caused no remarkable effect on *E. coli* and *Salmonella enterica* populations in the litter as a function of time.

Table 2. Effects of the addition of chemical blends on pathogens in duck litters as a function of time

Week	Treatment[1]				SEM[2]	p-value
	Control	T1	T2	T3		
E-coli (log 10 cfu/g)						
1	5.33^{a}	5.33^{a}	3.34^{b}	5.51^{a}	0.187	P<0.0001
2	4.23^{b}	3.18^{c}	3.15^{c}	4.68^{a}	0.140	P<0.0001
3	5.02^{a}	4.54^{b}	4.23^{b}	4.47^{b}	0.060	0.0031
4	4.90^{a}	4.70^{ab}	4.54^{a}	4.53^{a}	0.032	0.0242
5	4.49^{a}	4.15^{a}	3.48^{b}	3.28^{b}	0.103	0.0002
6	3.35	3.18	3.31	3.23	0.014	0.7314
Salmonella enterica (log 10 cfu/g)						
1	6.03^{a}	5.90^{ab}	5.18^{c}	5.72^{b}	0.068	P<0.0001
2	5.26^{b}	5.26^{b}	5.82^{a}	5.98^{a}	0.069	0.0004
3	3.79^{a}	3.36^{b}	3.23^{b}	3.73^{a}	0.050	0.0077
4	3.38	3.53	3.48	3.54	0.013	0.4983
5	4.34	4.21	4.18	4.10	0.018	0.4036
6	3.57	3.31	3.38	3.46	0.020	0.6886

[a-b]Means in the same row followed by different superscripts differ significantly ($p < 0.05$).
[1]T1: 75 g alum + 75 g aluminum chloride/kg duck litter; T2: 100 g alum + 100 g aluminum chloride/kg duck litter; T3: 150 g alum + 150 g aluminum chloride/kg duck litter.
[2]Values are expressed as means ± standard errors.

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