한국가금학회지 제 30권 제 2호, 119~128 (2003)
Korean J. Poult. Sci. Vol. 30, No. 2, 119~128 (2003)

Effect of Aluminum Sulfate Addition to Litter and Dietary Protein Levels of Broilers on Litter Nitrogen Content

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육계에 급여되는 사료중의 단백질 수준과 깔짚 내의 Aluminum Sulfate 첨가가 깔짚 내의 질소 함량에 미치는 영향

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ABSTRACT : The two experiments in this study compared litter nitrogen (N) contents after broiler chicks were raised for 42 days. Experiment 1 compared litter treated with aluminum sulfate (alum) [$Al_2(SO_4)_3 \cdot 14H_2O$] ($T_1$) with nontreated litter (T_2) when the broiler chicks were fed the same levels of dietary protein (23% for 0~3 weeks, 21% for 4~6 weeks). Experiment 2 compared the alum treated litters of broiler chicks fed high protein diets (T_3) having 20.4% protein for 0~3 weeks and 19.3% for 4~6 weeks, with lower protein diets (T_4) having protein levels of 18.0% for 0~3 weeks and 17.0% for 4~6 weeks. Each treatment had four replicate cages. As shown in Table 1, T_1 had a significantly ($P<0.01$) lower pH and significantly ($P<0.05$) higher total N (TN), NH_4-N and inorganic N (IN) than T_2. T_1 and T_2 had similar moisture, organic carbon (OC), NO_3-N and organic N (ON). Alum treatment increased available N (AN) significantly ($P<0.05$) from 13.75±0.01 mg/g to 14.90±0.01 mg/g and predicted available N (PAN) significantly ($P<0.05$) from 15.00±0.01 to 16.50±0.02. The C : N ratios were 18.84±0.40 (T_1) and 19.46±0.10 (T_2) while the C : ON ratios were 28.49±1.15 (T_1) and 28.34±0.20 (T_2) although C : N ratios or C : ON ratios did not show any difference between T_1 and T_2.

In Table 2, T_3 had significantly ($P<0.05$) higher moisture, TN, NH_4-N, ON and IN than T_4, while the pH, OC and NO_3-N were similar in both groups. The AN of T_3 increased significantly ($P<0.05$) from 10.99±0.01 mg/g to 12.98±0.03 mg/g, while the PAN increased significantly ($P<0.05$) from 12.39±0.10 mg/g (T_4) to 14.68±0.30 mg/g (T_3). The C : N ratios increased significantly ($P<0.01$) from 20.07±0.20 (T_3) to 24.40±0.10 (T_4). The C : ON ratios also increased significantly ($P<0.01$) from 28.99±1.15 (T_3) to 35.51±0.20 (T_4). These current research results show increased AN contents and PAN contents in alum treated litter or with increased CP levels regardless of alum treatment. However, none of the litters in this study could initially increase mineralization.

(Key words: AN, C:N, C:ON, IN, Litter, NH_4-N, NO_3-N, OC, ON, PAN, pH)

INTRODUCTION

Excessive application of poultry manure has been demonstrated to have adverse effects on soils (Liebhardt, 1976), crops (Shortall and Liebhardt, 1975; Weil et al., 1979), and water resources due to its nitrogen (N) content. There is a need for increased accuracy in every aspect of land application of poultry manure and bedding materials, resulting in greater demands being placed on the analytical and calculated processes associated with their chemical characterization.

Recent research focuses on the reduction of N pollutants in poultry manure. Application of aluminum sulfate [$Al_2(SO_4)_3 \cdot 14H_2O$], commonly referred to as alum, to poultry litter increased N content in litter and N availability in litter as well as reducing ammonia volatilization losses by as much as 99% (Moore, Jr., 1995; Moore, Jr., et al., 1995). Dietary manipulation in monogastric animals also promises to be a useful tool to reduce N content in litter and ammonia emission (Kerr et al.,

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1995; Paul et al., 1996; Smuts et al., 1995). Jacob et al. (1994) showed that the level of N excreted in poultry waste can be reduced by up to 21% if dietary crude protein (CP) content is lowed by 2.5% with synthetic amino acids. Scientists (Burgess et al., 1998; Moore, Jr., et al., 1995, 2000) have suggested that alum treatment contributes to low litter pH, reduced ammonia emission and increased N content in the litter.

No entirely satisfactory procedure for measuring the N contents of the poultry manure litter used for soil and plants exists. However, scientists (Bitzer and Sims, 1988; Chadwick et al., 2000; Douglas and Magdoff, 1991; Knezek and Miller, 1976) have hypothesized parameters to build equations. Total N (TN) is the addition of total Kjeldahl nitrogen (TKN) and NO_3-N + NO_2-N (Douglas and Magdoff, 1991). Organic nitrogen (ON) = TN - inorganic nitrogen (IN) (Bitzer and Sims, 1988), or ON = TN - (NH_4-N + uric acid) (Chadwick et al., 2000), or ON = TKN - NH_4-N (Douglas and Magdoff, 1991). IN = NH_4-N + NO_3-N (Bitzer and Sims, 1988). Available nitrogen (AN) = IN + 0.4 × ON (Knezek and Miller, 1976). Predicted available nitrogen (PAN) = 80 % IN + 60 % ON (Bitzer and Sims, 1988). The manure carbon : nitrogen (C : N) ratio (Castellanos and Pratt, 1981; Floate, 1970; Serna and Pomares, 1991) and C : ON ratio (Chadwick et al., 2000) are also parameters for estimating the chemical compositions of poultry manure and litter.

This research evaluated N contents quantitatively in broiler litter after raising broilers for 42 days on these litters under two different experimental conditions. These chemical estimates of the litters included pH, moisture, TN, ON, IN, AN, PAN, C : N and C : ON.

MATERIALS AND METHODS

1. Experimental Design

These two projects compared the N content in litters collected from cages of broilers raised for 42 days. One project (experiment 1 or Table 1) compared alum treated manure (T_1) and non-treated manure (T_2) of chicks fed the same protein levels of 23% for 0~3 week-old broilers and 21% for 4~6 week-old broilers. The other project (experiment 2 or Table 2)

Table 1. Mean(±SEM) values of nitrogen contents and available nitrogen contents in broiler litter(Expeimental 1)

	T_1	T_2	Significance	Reference
pH	8.01 ±0.01	8.53±0.01	**	
Moisture (%)	54.88 ±1.20	53.04±1.40	NS	
OC[1] (%)	46.53 ±0.50	45.34±0.20	NS	
TN[2] (%)	2.47 ±0.03	2.33±0.01	*	Douglas and Magdoff (1991) TN = TKN + NO_3-N + NO_2-N
NH_4-N (%)	0.83 ±0.02	0.73±0.01	*	
NO_3-N (mg/g)	0.065±0.007	0.051±0.001	NS	
ON[3] (mg/g)	16.33 ±0.50	16.00±0.01	NS	Bitzer and Sims (1988) ON = TN - IN
IN[4] (mg/g)	8.37 ±0.02	7.35±0.01	*	Chawick et al. (2000) IN = NH4-N + NO_3-N
AN[5] (mg/g)	14.90 ±0.01	13.75±0.01	*	Knezek and Miller (1996) AN = IN + 0.4 • ON
PAN[6] (mg/g)	16.50 ±0.02	15.00±0.01	*	Bitzer and Sims (1988) PAN = 80% IN + 60% ON
C : N[7]	18.84 ±0.04	19.46±0.10	NS	
C : ON	28.49 ±1.15	28.34±0.20	NS	

[1] OC = organic carbon; [2] TN = total nitrogen; [3] ON = organic nitrogen; [4] IN = inorganic nitrogen;
[5] AN = available nitrogen; [6] PAN = predicted available nitrogen; [7] C : N = carbon : nitrogen.
** P< 0.01; * P< 0.05; NS = not significant.

Table 2. Mean(± SEM) values of nitrogen contents and available nitrogen contents in broiler litter(Expeimental 2)

	T3	T4	Significance	Reference
pH	7.92 ±0.01	7.65 ±0.01	NS	
Moisture (%)	56.21 ±0.09	50.78 ±1.50	*	
OC[1] (%)	44.55 ±0.50	45.63 ±0.20	NS	
TN[2] (%)	2.22 ±0.03	1.87 ±0.01	*	Douglas and Magdoff (1991) TN = TKN + NO_3-N + NO_2-N
NH_4-N (%)	0.68 ±0.02	0.58 ±0.01	*	
NO_3-N (mg/g)	0.034±0.013	0.045±0.001	NS	
ON[3] (mg/g)	15.37 ±0.40	12.85 ±0.11	*	Bitzer and Sims (1988) ON = TN − IN
IN[4] (mg/g)	6.83 ±0.04	5.85 ±0.01	*	Chawick et al. (2000) IN = NH_4-N + NO_3-N
AN[5] (mg/g)	12.98 ±0.03	10.99 ±0.01	*	Knezek and Miller (1996) AN = IN + 0.4 • ON
PAN[6] (mg/g)	14.68 ±0.30	12.39 ±0.10	*	Bitzer and Sims (1988) PAN = 80% IN + 60% ON
C : N[7]	20.07 ±0.20	24.40±0.10	NS	
C : ON	28.99 ±1.15	35.51±0.20	NS	

[1] OC = organic carbon; [2] TN = total nitrogen; [3] ON = organic nitrogen; [4] IN = inorganic nitrogen;
[5] AN = available nitrogen; [6] PAN = predicted available nitrogen; [7] C : N = carbon : nitrogen.
** P< 0.01; * P< 0.05; NS = not significant.

compared higher levels of protein (T_3) which were 20.4% for 0~3 week-old broilers and 19.3% for 4~6 week-old broilers and lower levels of protein (T_4) which were 18.0% for 0~3 week-old broilers and 17.0% for 4~6 week-old broilers using alum treated litter for both treatments (T_3 and T_4). There were 4 replicate cages for each treatment in the individual experiments.

2. Sampling Broiler Litter and Amendments

Broiler litter was collected from growth cages that had been used to raise broilers to 6 weeks of age for the two experiments. Litter consisted of rice hulls at a depth of 10 cm in each cage when the experiment started. The alum was applied to the litter (T_1, T_3 and T_4) at a rate of 20 g alum per kg litter at that time, since alum contributes to reducing ammonia emissions and increasing N content of litter (Moore, Jr., 1995; Moore, Jr., et al., 1995). Alum was applied as a top dressing with garden rake to a depth of 0.6 cm of the rice hull in each treated cage (Moore, Jr. 1995; Reece et al., 1979).

All litter was collected immediately after the birds were removed. After collecting rice hulls from each cage separately, litter from each cage was mixed thoroughly and 100~150 g of fresh litter was weighed and placed plastic containers (Moore, Jr., 1995). Rice hulls were stored moist (as obtained) at 4℃ for no more than 2 weeks prior to analysis (Bitzer and Sims, 1988; Douglas and Magdoff, 1991).

3. Litter N Fraction

The pH of each litter sample was determined by adding 5 g of litter to 50 ml of distilled water and allowing it to stand at room temperature for 30 minutes prior to measurement of H^+ concentration (Veloso et al., 1974). Moisture was determined by drying at 60℃ for 3 days (Kithome et al., 1999). NH_4-H content of filtered extracts after shaking 40 g (fresh weight) of litter with 200 ml 2 M KCl for 2 hr was determined by steam distillation with a $Mg(OH)_2$ suspension in 1% boric acid solution and titration with 5 mM sulphuric acid and methyl red-methylene blue indicator. The NO_3-N and NO_2-N in the remaining ammonium free KCl extract was reduced to ammonium by adding Devardras alloy, and the concentration was determined (MAFF, 1986). TKN was determined on the fresh broiler litter according to the method of MAFF (1986). Organic carbon (OC) was determined on dried ground material following digestion with dichromate (MAFF, 1986).

The other N contents in litter were calculated by the following simplified equations: TN = TKN + NO_3-N + NO_2-N (Douglas and Magdoff, 1991); ON = TN - IN (Bitzer and Sims, 1988); IN = NH_4-N + NO_3-N (Bitzer and Sims, 1988; Chadwick et al., 2000); AN = IN + 0.4 x ON (Knezek and Miller, 1976); PAN = 80 % IN + 60 % ON (Bitzer and Sims, 1988).

ON can be calculated with three different equations depending on authors including that of Bitzer and Sims (1988) equation. Douglas and Magdoff (1991) did research on about 19 different manures including poultry manures (various cow manures, horse, sheep, pigs and chickens). The ON equation which they used in their study was ON = TKN - NH_4-N. The equation, ON = TN - (IN + uric acid), was suggested by Chadwick et al. (2000) when poultry manure was handled. In their research various types of dairy, beef, pig, broiler and layer manures analyzed handled. However, Bitzer and Sims (1988) collected twenty poultry manure (PM) samples during March 1985 from stockpiled manure and poultry houses to use for their laboratory as well as field research. They found three equations: PAN = 80 % IN + 60 % ON, IN = NH_4-N + NO_3-N and ON = TN - IN. This research used the equations of Bitzer and Sims (1988).

4. Statistical Analyses

t-tests were used for determining significant differences between T_1 and T_2 or between T_3 and T_4. The probability value used to determine significance was 0.05 or above this value (Snedecor and Cochran, 1969).

RESULTS AND DISCUSSION

1. The analytical Parameters for Litter N Quantitation

The pH values of T_1 and T_2 in experiment 1 are significantly different ($P< 0.01$), while experiment 2 did not show any difference between T_3 and T_4 although pH values for T3 and T_4 were lower than T_1 and T_2. These results coincide with reports that alum like numerous other acidic compounds were effective in lowing litter pH and reducing ammonia utilization (Burgess et al., 1998; Moore, Jr., et al., 1995, 2000). Reducing manure pH may result in reduced ammonia volatilization (Ferguson et al., 1998b; Smith et al., 2001). On the other hand, reduced dietary crude protein (CP) intake is the most common form of dietary manipulation to reduce ammonia volatilization (Ferguson et al., 1998b; James et al., 1999). Ferguson et al. (1998b) showed reducing dietary CP from 215 to 165 g/kg did result in a significant reduction in manure pH, but there was no significant reduction of pH between 215 g/kg dietary CP and 196 g/kg dietary CP. There was a 0.28 unit difference in pH between T_3 and T_4 (Table 2) which was not significant probably due to the lack of a significant difference in CP levels between T_3 and T_4 . Small changes in pH actually represent large changes in H^+, as shown by a three fold increase in H^+ when mean pH values varied from 5.0 to 5.5 when a low CP (165 g/kg) and a high CP (215 g/kg) were fed (Ferguson et al., 1998b). Based on these variable pH values, Table 2 suggest that the chemical composition of manures is highly variable (Swift et al., 1979).

In experiment 1, moisture content did not vary between T_1 and T_2, but there was a significant difference ($P< 0.05$) between T_3 and T_4 (experiment 2). Alum addition has not been shown to effect litter moisture (Burgess et al., 1998), but dietary CP levels were shown in this study to affect litter moisture content (Table 2). Reductions in dietary CP from 215 g/kg to 196 or 165 g/kg resulted in lowered litter moisture, but reductions from 196 to 165 g/kg did not change litter moisture (Ferguson et al., 1998a). NH_3 release from litter is regulated by litter pH and moisture (Elliot and Collins, 1982) with reports of NH_3 emission being positively correlated (Carr et al., 1990; Elliot and Collins, 1982; Nahm, 2002) and also negatively correlated (Ferguson et al., 1998a) with litter moisture.

Organic carbon (OC) levels are shown in Tables 1 and 2. No significant differences between T_1 and T_2 or T_3 and T_4 were shown because the same rice hulls were used in each cage. Total C contents, readily mineralizable N and total N have been found to be unrelated to mineralized N in one study (Chadwick et al., 2000). During manure decomposition, substrate composition changes (Chadwick et al., 2000; Mindermann, 1968) and the concentration of recalcitrant material such as lignin increase.

The lignin fraction has been demonstrated to control N mineralization over a 12 week period following application of manures of different diets (Kristensen, 1996), showing a negative relationship between manure lignin content and mineralization.

The alum treated litter (T_1) or increased dietary CP on alum treated litter (T_3) had significantly higher ($P<0.05$) TN concentrations (Tables 1and 2). These results are verified by other reports (Kulling et al., 2001; Moore, Jr., et al., 1995; Shreve et al., 1996). Moore, Jr., et al. (1995) reported that the addition of alum in broiler litter resulted in an increase of TN content in litter, causing decreased ammonia volatilization. Reduction in dietary protein, when there is no major effect on performance, increases N utilization and simultaneously reduces NH_3 emission (Phillips et al., 1999). Kulling et al. (2001) reported that the reduction of the dietary CP decreased NH_3 and total N emissions considerably both in complete slurry and the farm yard manure (FYM)/urine-rich slurry (USL). Jacob (1994) found that 28% of N in broiler manure was reduced when 2.5% of CP in broiler diet was decreased with amino acid supplementation. Table 2 may explain that dietary CP supply substantially affected the N contents of the excreta (litter) regardless of using alum in the litter.

In this study, there was a significant difference ($P<0.05$) in NH_4-N between T_1 and T_2 or T_3 and T_4, while there was no difference in NO_3-N contents (Tables 1 and 2). In the current experiment, the NO_3-N and NO_2-N contents in the litter were low, especially NO_2-N contents (1% of the IN), so NO_2-N contents were not reported in the Tables. NH_4-N and NO_3-N are both IN. The NH_4-N is the dominant form of IN in poultry manure (Douglas and Magdoff, 1991). A result of the increase in NH_4-N of poultry manure was not accompanied by a paralleled decrease in NO_3-N (Hadas et al., 1993). The addition of alum resulted in a doubling of the N content in the litter and a substantial amount of this N was in the inorganic form (Kithome et al., 1999; Moore, Jr., 1995). The N content of the litter was significantly reduced by reducing the CP content of the diet. Ferguson et al. (1998a) calculated that within the acceptable range of CP contents of commercial grower diets (19 to 21%), for every percentage point reduction in dietary CP (and supplementation with amino acids) there will be corresponding 7% reduction in the N content of the litter. In this study, NH_4-N did not parallel the NO_3-N while alum addition increased NH_4-N, and the current data (Table 2) may actually explain that the N content of the litter was proportional to the CP level rather than alum addition.

Mineralization from organic forms to mineral forms (inorganic form) of N is a prerequisite for plant uptake. The plant-available N is principally ammonium (NH_4-N) and uric acid in poultry manure which is the fraction of associated with immediate plant uptake, volatilization of ammonia and nitrate leaching (Smith and Chambers, 1993, 1995; Unwin et al., 1991). TN, TKN and ON are significantly correlated with the amount of N mineralized as well as the fraction of ON mineralized during the incubation (Douglas and Magdoff, 1991; Nahm, 2000). In general, between 40 to 90% of the TN content of solid manures and slurries is present in organic forms, which are more slowly available for plant uptake than the mineral fraction (MAFF, 1994).

2. The Calculated Parameters for Litter N Quantitation

The values of ON, IN, AN, PAN, C : N and C : ON are all calculated, and they are important to provide farmers with reliable guidance on the N supply from the ON content as well as supply from the IN content (Bitzer and Sims, 1988; Douglas and Magdoff, 1991; Chadwick et al., 2000), AN values (Bitzer and Sims, 1988; Knezek and Miller, 1976), PAN values (Bitzer and Sims, 1988), C : N ratios (Chadwick et al., 2000; Kirchmann and Witter, 1989 Mary and Recous, 1994) and C : ON ratios (Chadwick et al., 2000; Klausner et al., 1994).

In Table 1, the content of IN in T_1 was significantly higher ($P< 0.05$) than that of T_2 , while the ON and IN of T_3 in Table 2 were significantly higher ($P< 0.05$) than those of T_4. Alum treated litter inhibited volatilization and resulted in significant by high concentrations of IN in the litter at 42 days than the control diet (Moore, Jr., 1995). A high dietary CP level caused an increase in the amount of N fraction in poultry manure (Ferguson et al.,1998b; Kulling et al., 2001). The results of Table 2 suggested that IN and ON contents in two treatments (T_3 and T_4) were positively related to dietary CP content although T_3 and T_4 used alum treated litter. The rate of N mineralization from manures is controlled, as with other organic materials, by the decomposting organisms, the physical climate and the chemical composition of the organic material (Swift et al., 1979).

The percentage ON of TN contents in Tables 1 and 2 were 66.1% (T_1), 68.7% (T_2), 69.2% (T_3) and 68.7 % (T_4). The percentage IN of TN in Tables 1 and 2 were 33.9% (T_1), 31.5% (T_2), 30.8% (T_3) and 31.3% (T_4). The ON fraction of manures can represent up to 99% and as low as 14% of the TN content in manures (Chadwick et al., 2000), while the ON was readily mineralizable and varied between manure types. On the other hand, from 20 to 40% of TN in poultry manure may be in the inorganic forms (Sims, 1986, 1987). In most cases of poultry manure, 40 to 60% of added ON was mineralized within 90 to 150 days after manure incorporation in soil (Sims, 1986). Bitzer and Sims (1988) also reported that 60% of manure ON will be mineralized during the 4 to 5 months of the normal growing season for corn.

Table 1 showed that the values of AN were 14.90 mg/g (T_1) and 13.75 mg/g (T_2) as well as PAN values were 16.50 mg/g (T_1) and 15.00 mg/g (T_2). Table 2 provided that AN values were 12.98 mg/g (T_3) and 10.99 mg/g (T_4) as well as PAN values were 14.68 mg/g (T_3) and 12.39 mg/g (T_4). These results suggested that T_1 and T_3 groups are better N fertilizer than the T_2 and T_4 groups. As many scientists (Ferguson et al., 1998a,b; Kulling et al., 2001; Moore, Jr., 1995) reported, the AN and PAN may be elevated when TN and IN are higher due to litter alum treatment (T_1) or higher dietary CP levels (T_3). The present data of Table 2 supported the theory that CP levels were superior to alum treatment for controlling N contents in litter.

Practical information on the rate and extent of N mineralization is necessary to predict N availability because excessive applications of poultry manure has adverse effects on soils (Liebhardt, 1976) and crops (Shortall and Liebhart, 1975; Weil et al., 1979). Douglas and Magdoff (1991) reported that organic residues such as poultry manure without high levels of toxic metal are usually applied to agricultural soils at rates based on assumed contributions of AN to the growing crop. They said there is no acceptable test for assessing potential AN supply from residues. Although the actual contribution will depend on soil characteristics and climate as well as residue characteristics, a chemical index might be useful in ranking residues according to potential AN contribution (Douglas and Magdoff, 1991). Sims (1986) said that an efficiency figure must be included to allow for losses of IN such as volatilization of NH_3, and leaching losses during the growing season. Bitzer and Sims (1988) concluded that their results indicated use of the PAN approach resulted in the attainment of comparable yields with three poultry manures and ammonium nitrates although plant ear leaf N levels were consistently lower with the manures. However, not many scientists have done the research about AN and PAN even though scientists have been doing the research for predicting N availability with C : N ratios and C : ON ratios.

The values of C : N ratios were 18.84 (T_1) and 19.46 (T_2) and the values of C : ON ratios were 28.49 (T_1) and 28.34 (T_2) in Table 1, while the values of C : N ratios were 20.07 (T_3) and 24.40 (T_4) and the values of C : ON ratios were 28.99 (T_3) and 35.51 (T_4) in Table 2. There were no significant differences between T_1 and T_2 for both C : N ratio and C : ON ratio, but there were significant differences ($P< 0.01$) between T_3 and T_4 and value of T_4 was higher than that of T_3 for both C : N and C : ON ratios. Within manure types, the C : N ratio was inversely related to manure N content since mainly N varied (Kulling et al., 2001). The lower the C : N ratio means the greater the mineralization rate (Kirchmann, 1985; Mary and Recous, 1994). The current study showed that adding alum would not affect C : N and C : ON ratios, but increasing protein content in broiler diets resulted in lower C : N and C : ON ratios. Further research is required to determine whether adding alum or increasing CP levels with alum coincides with decreased N content in litter. Poultry manure composting has a high potential for NH_3 volatilization because N concentrations are generally high and C/N ratios are low. When composting a low C/N ratio material such as poultry layer manure, it may be beneficial to add C in addition to the N to immobilize some of the N (Kithome et al., 1999). N mineralization is greater from manures with low C : ON ratios than manures with high C : ON ratios (Chadwick et al., 2000). Reviewing different approaches for reducing NH_3 emissions from livestock buildings, Phillips et al. (1999) identified the best options as 1) dietary manipulation and 2) increasing the C : N ratio by generous use of bedding.

Serna and Pomares (1991) demonstrated a strong relationship between the C : N ratio and N mineralization, $r = -0.69$, while Floate (1970) showed the same relationship in sheep feces to be weak, r = −0.56. Another study (Castellanos and Pratt, 1981) found no relationship between C : N ratios and N mineralization for a variety of fresh and stored animal manure. Organic materials with C : ON ratios of 15 or more will immobilize N, while C : ON ratios of less than 15 result in mineralization with lower C : ON ratios having greater mineralization rates (Kirchmann, 1985; Mary and Recous, 1994). When the C : N ratio increased from 14 to 25, the NH_3 emissions of manure decreased (Beck et al., 1997; Maeda and Matsuda, 1997). No NH_3 emissions were reported when the C : N ratio was above 40 (Maeda and Matsuda, 1997). Chadwick et al. (2000) suggested that the manure C : ON ratio was the best accounting for 40% of the variation in mineralization measured. A better assessment is needed under field conditions for the interaction between manure organic N pools and N mineralization.

In conclusion, these results support the hypothesis that litter may contain more N, indicating a better N fertilizer, when alum is added to broiler litter or when CP is increased in broiler diets regardless of treating the litter with alum. None of the litters in the current research might initially increase N mineralization.

CONCLUSION

The current study showed that the N contents in broiler litter were significantly higher in the T_1 and T_3 groups than the T_2 and T_4 groups. Adding alum to the litter or increasing dietary CP levels of broiler diets from the starting period with or without alum treatment in litter might result in the litter being a better N fertilizer. These results could be possible when accurate values of nutrients are obtained analytically and calculated quantitatively, which could quantitatively predict N mineralization and protect excessive application of poultry manure litter resulting in adverse effects on soil, crops and water resources. Although even under these carefully controlled experimental conditions, other factors may have clearly influenced mineralization rates.

ACKNOWLEDGEMENTS

The authors appreciate the help of Nickolas Nahm from Lincoln-Way High School of Illinois for feeding the chickens and his analytical work for this research.

적 요

본 연구에서는 육계를 케이지에서 42일간 사육후에 깔짚 내에 함유된 각 질소 함량을 비교하였다. 실험 1에서는 전 사양기간 동안 같은 수준의 단백질 사료를 병아리에게 급여하였으며(0~3주: 23% CP, 4~6주 : 21% CP), 깔짚(litter)에는 앨럼[$Al_2(SO_4)_3 \cdot 14H_2O$]을 처리한 구($T_1$)와 처리하지 않은 구($T_2$)로 나누어 비교하였다. 실험 2에서는 모든 처리구에 앨럼을 처리한 후 급여되는 사료 내에 고 단백질 사료(T_3, 0~3주령에서 20.4% CP, 4 ~6주령에서 19.3% CP)와 저 단백질 사료(T_4, 0~3주령에서 18% CP, 4~6주령에서 17.0% CP)를 급여하여 분으로 배출되는 질소의 함량을 비교하였다. 각각의 실험에서 처리구당 4반복으로 하였다. 깔짚에서 pH는, T_1에서 현저하게 낮았으며($P<0.01$), 총 질소(TN) 함량과 암모늄태 질소(NH_4-N)는 T_2의 값보다 유의하게($P<0.05$) 높았다. 그러나 깔짚 내에 함유되어 있는 수분 함량, 유기탄소 함량(OC), 질산태 질소 함량(NO_3-N) 그리고 유기태 질소 함량(ON)은 차이가 없었다. 이용 가능한 질소 함량(AN)은 alum을 깔짚에 처리한 구(T_1)에서 14.90±0.01 mg/g으로 높았으며($P< 0.05$), 이용 가능한 질소질의 예상치(PAN)는 T_1구에서 16.50 ± 0.02 mg/g으로 T_2보다 높게($P<0.05$) 나타났다. C : N 비율은 T_1에서 18.84±0.40이고 T_2에서 19.46± 0.10 이었으며, C : ON 비율에서는 T_1에서 28.49±1.15이고, T_2에서 28.34±0.20로 나타났지만 처리구간에(C : N 과 C : ON 경우) 차이는 통계적으로 인정되지 않았다. T_3의 깔짚에 속하는 수분 함량, TN, 암모늄태 질소 (NH_4-N), ON 그리고 IN 함량은 T_4의 깔짚 내에 속하는 함량보다 높게($P< 0.05$) 나타났지만 깔짚내 pH, OC 그리고 질산태 질소(NO_3-N) 함량은 T_3와 T_4에서 차이를 보이지 않았다. T_3의 AN 함량은 12.98 ± 0.03 mg/g으로 T_4의 10.99±0.01 mg/g보다 높았으며($P<0.05$), PAN 함량은 T_3에서 14.68±0.30 mg/g 으로 T_4의 12.39±0.10 mg/g보다 높았다($P<0.05$). C : N 비율은 T_3 값(20.07 ± 0.20) 이 T_4 값(24.40 ± 0.10)보다 낮았으며($P<0.01$), C : ON 비율 역시 T_3 값(28.99±1.15 이 T_4 값(35.51 ±0.20)보다 낮았다($P<0.01$).

본 연구 결과 깔짚 내의 AN과 PAN 값은 alum을 깔짚에 처리하였거나 alum 처리에 관계없이 단백질 수준이 높은 구에서 높게 나타났다.

(색인어 : AN, C:N, C:ON, IN, Litter, NH_4-N, NO_3-N, OC,

ON, PAN, pH)

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