JWPR
Journal of World's Poultry Research

2017, Scienceline Publication
J. World Poult. Res. 7(2): 88-93, Jun 25, 2017
Research Paper, PII: S2322455X1700011-7

Effect of Chemically Treated Litter on Ammonia Emmission, Performance and Carcass Characteristics of Broiler Chicken

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Received: 30 April 2017
Accepted: 31 May 2017

ABSTRACT

The condition of litter is a single major factor in deciding the emission of various harmful gases particularly ammonia, which is a major environmental concern, affecting the overall welfare of birds. Therefore, a study was conducted with the objectives to assess the effect of two chemicals namely aluminum sulfate and calcium carbonate on litter ammonia emission, performance and carcass characteristics of broiler chicken. A total of 240 day old Cobb broiler chicks were randomly distributed into four treatment groups, each having 4 replicates of 13 chicks each. In the control group no chemical was added to litter; however, in other groups litter was treated with Aluminum Sulfate (AS) @ 25g/kg; Calcium Carbonate (CC) @ 50g/kg; and combination of 25g Aluminum Sulfate and 50g Calcium Carbonate/kg (ASCC). The results revealed a significant ($P<0.05$) reduction in litter ammonia emission in AS and ASCC groups compared to control and CC, which in turn had no statistical ($P>0.05$) difference among themselves. AS was found to be highly effective in reducing the ammonia emission levels, either by itself or in combination, with values of 9.46 ± 0.35 (AS) and 10.499 ± 0.39 (ASCC) compared to 47.7 ± 2.40 and 51.15 ± 1.85 ppm in CC and control. A significant ($P<0.05$) increase in the Body Weight Gain (BWG) of chicks in AS and ASCC groups with final BWG of 1069.76 g in control, 1358.21 g in AS, 1086.66 g in CC and 1370 g in ASCC. Likewise, an improved FCR of 1.86 was observed in both AS and ASCC groups followed by 1.98 in CC and 1.99 in control. No significant ($P>0.05$) differences were found with respect to various carcass characteristics among treatment groups as compared to control. In conclusion, compared to CC, AS was found to be highly effective in reducing the litter ammonia emission and improving the performance of birds.

Key words: Aluminium sulphate, Ammonia emmsision, Broiler chicken, Performance

INTRODUCTION

Poultry production, particularly broiler chicken production is primarily done under a deep litter system having an absorbent material (known as litter) on floor. Most common litter materials used in various parts of the world include softwood and hardwood shavings, sawdust, chopped straws, seeds and hulls, cardboard peat, sand etc. (Grimes et al., 2002; Lopes et al., 2013). Litter quality plays a significant role because of its effect on bird health, performance parameters, carcass quality and welfare of broilers (Đukić Stojčić et al., 2016). Litter must be kept dry as reported by Ritz et al. (2006) that very wet litter results in high ammonia production which negatively affects productive performance of broilers. Following defecation by birds, the breakdown of fecal matter in litter

To cite this paper: Rashid A, Banday MT, Adil S, Khan AA, Qureshi S, Untoo M, and Pal MA (2017). Effect of Chemically Treated Litter on Ammonia Emission, Performance and Carcass Characteristics of Broiler Chicken. *J. World Poult. Res.*, 7 (2): 88-93.

occurs, leading to the production of various gaseous pollutants; whose concentration and emission is influenced by the litter type, management, humidity and temperature (Redding, 2013).

Amongst these, ammonia is one such gaseous product which is more harmful for the environment, bird and human health. It is a colorless gas, highly irritating, produced up on chemical and microbial breakdown of uric acid after excretion from the bird (Gates et al., 2005). Ammonia formation primarily occurs by microbial degradation of uric acid in litter particularly under the influence of *Bacillus pasteurii*, which is one of the primary uricolytic bacteria (Bacharach, 1957; Schefferle, 1965). These bacteria reportedly require alkaline pH (around 8.5) for their optimum growth (Elliott and Collins, 1982). Reduced feed intake and growth rate of chicken have been reported once ammonia concentrations increases in poultry sheds (Kristensen et al., 2000). When emitted to the atmosphere, ammonia can rapidly react with acidic compounds and gets converted to aerosolized ammonium particles, thereby influencing ecological balance, biodiversity and water systems (Galloway and Cowling, 2002).

Therefore, there is an utmost need to contain the production and emission of ammonia from poultry houses by various litter amendments like use of acidifiers, alkaline materials, adsorbers, inhibitors, microbes and enzymes (Shah et al., 2006). In view of this negative impact of ammonia and likely benefit litter amendment, a study was conducted with the objectives to assess the effects of two chemicals namely aluminum sulfate and calcium carbonate on litter ammonia emission, performance and carcass characteristics of broiler chicken.

MATERIALS AND METHODS

Ethical approval

The experimental protocol was approved by the Institutional Animal Ethics Committee, J&K, India.

Bird Husbandry and experimental diets

The experiment was conducted at the Research Farm of the Division of Livestock Production and Management, Faculty of Veterinary Sciences and Animal Husbandry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shuhama, Srinagar, India. A total of 208 day old Cobb broiler chicks were procured from a reputed source and reared together in battery cages until 7 days of age. On 8th day, the chicks were randomly distributed into four treatment groups, each having 4 replicates of 13 chicks. The litter material used was saw dust which is cheap and readily available in Indian subcontinent. Dry aluminum sulfate and calcium carbonate were procured from the market and added to fresh litter by top dressing onto its surface. The treatment groups were as follows: Control in which no chemical was added to litter; litter treated with Aluminum Sulfate (AS) @ 25g/kg; Calcium Carbonate (CC) @ 50g/kg; and combination of 25g Aluminum Sulfate and 50g Calcium Carbonate/kg (ASCC).

Chicks of each replicate were housed in individual floor pens on deep litter for a period up to 6 weeks of age. Birds had free access to feed (commercially available) and water throughout and were maintained on a constant 24 hours light schedule. All chicks were vaccinated against New castle disease with F_1 strain vaccine and Infectious bursal disease with B_2K vaccine on 5th and 16th day of age respectively in accordance with regional veterinary authority. All the treatment groups were maintained in similar rearing conditions as per the standard protocol.

Ammonia Emission

At the end of trial, litter condition was evaluated. The litter samples from five locations within each pen (four peripheral-equidistant from each pen corner, and one central) were collected and thoroughly mixed to obtain representative sample of the entire pen. The ammonia released from litter samples was determined as per the method of Hernandez and Cazetta (2001) which is based on gaseous ammonia fixation by micro-diffusion. The litter samples from five locations within each pen (four peripheral-equidistant from each pen corner, and one central) were collected and thoroughly mixed to obtain representative sample of the entire pen. Representative sample of 100 g of fresh litter was weighed from each pen every week and placed in a 500 ml cylindrical flask and leveled. A 50 ml beaker containing 10 ml of 2 % boric acid solution was placed on the top of the litter and the flask was closed and incubated for 20 hours at 30^{o} C. The boric acid solution was then titrated against 0.1 N sulfuric acid with methyl orange and bromocresol green indicator. Ammonia released from litter (mg/100g litter) was calculated by multiplying the amount of sulfuric acid used (A) by its normality and the molecular weight of ammonia (17). This released ammonia in mg was converted into ppm/100 g litter as:

Ammonia released (ppm / 100 g litter) = A x N x 17x10

A = Volume of sulfuric acid spent (ml)
N = Normality of sulfuric acid
17 = Molar mass of ammonia
10 = Conversion coefficient from mg to ppm

Performance of birds

The body weight of birds was recorded on an individual basis and Body Weight Gain (BWG) was calculated at weekly intervals and the weighed quantity of feed was placed in the feed bins allotted to each replicate and feed was offered adlib from the respective feed bins. At weekly intervals the feed left in the respective bins known as residual feed was weighed again to determine the replicate wise Feed Consumption (FC) during that week. Feed Conversion Ratio (FCR) (i.e. feed: gain in body weight) of birds was worked out at weekly intervals for the entire experimental period by taking into consideration the weekly feed consumption and body weight gain.

Carcass characteristics

At the end of trial, two birds per replicate were selected at random and utilized for carcass evaluation study. The birds were weighed before fasting and slaughtered by the Halal method and a bleeding time of 2 minutes was allowed. The shanks were cut off at the hock and carcass was subjected to scalding process at 60°C for 30 seconds. The feathers were removed completely by hand picking leaving the skin intact. Thereafter, the abdominal cavity was opened to expose the visceral organs. Slaughter characteristics, yield of giblets and vital organs were calculated as per the method of Salahuddin et al. (2000).

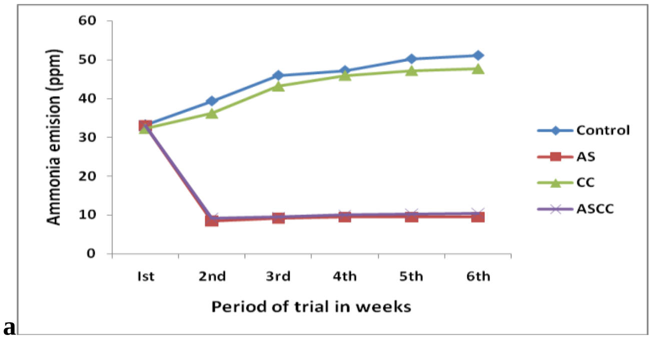
Statistical analysis

Data generated was grouped and tabulated treatment wise and analyzed statistically using Software Package for social Sciences (SPSS version15.0). The data were subjected to one-way analysis of variance as per Snedecor and Cochran (1980). The difference within the means were estimated using Duncan's multiple range test (Duncan, 1955) by considering the differences at significant level ($P<0.05$).

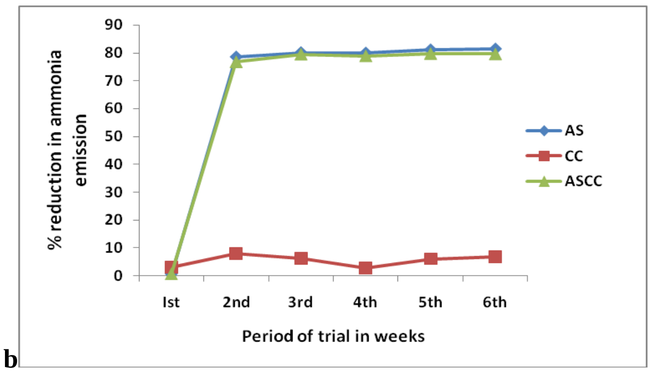
RESULTS AND DISCUSSION

Ammonia emission

There was no significant ($P>0.05$) difference in the litter ammonia emission between control and CC, however, a significant ($P<0.05$) reduction in was recorded in AS and ASCC (Figure 1a). AS was found to be highly effective in reducing the ammonia emission levels, either alone or in combination, with values of 9.46 ± 0.35 (AS) and 10.499 ± 0.39 (ASCC) compared to 47.7 ± 2.40 and 51.15 ± 1.85 ppm in CC and control during last week of trial. The reduction in ammonia volatilization from the litter due to application of AS alone was by as much as 81.50 % and by combined application in ASCC group was 79.47 %. However, CC were effective in reducing the ammonia volatilization by only 6.74 % (Figure 1b).



a



b

Figure 1. a) Weekly ammonia emission in various groups and, **b)** percent reduction in ammonia emission compared to control in litter amended groups.

These results are in accordance to the earlier reports of and Do et al. (2005) and Loch et al. (2011) who found AS very effective in reducing the ammonia content. Similarly Moore (1995) observed that AS and ferrous sulfate reduced the ammonia volatilization from litter by as much as 99 and 58 % respectively. Nagaraj et al. (2007) also recorded reduction in ammonia emission by using litter amendment with sodium bisulphate. The litter amendments have been reported to reduce the litter moisture and subsequently the ammonia emission as wet litter has been associated with excessive ammonia production Do et al. (2005). Moreover, Sahoo (2016) found more cake formation in untreated litter as compared to the chemically treated litter. Caked litter negatively affects broiler chicken and contributes to more ammonia generation (Kristensen et al., 2000; Miles et al. 2004). Further, as per Terzich (1997), litter pH has a decisive role in ammonia volatilization and the main ureolytic bacterium (Bacillus pasteurii) cannot grow in neutral pH but thrives in pH higher than 8.5 (Terzich et al., 2000). Since, the AS is acidic and CC is alkaline, it could be hypothesized that AS might have decreased the litter pH well below the neutral level, which would have hampered the growth of Bacillus pasteurii, thereby reducing the ammonia production drastically. It results in substantial amount of nitrogen in litter to remains in inorganic form, thus improving its value as a fertilizer as well (Moore, 1995).

Performance of birds

At the end of third week, there was a significant ($P<0.05$) increase in the body weight gain (BWG) of chicks in AS and ASCC groups as compared to CC and control (Figure 2). A similar trend in the BWG was observed throughout the experiment with final BWG in of 1069.76 g in control, 1358.21 g in AS, 1086.66 g in CC and 1370 g in ASCC. Likewise, significantly ($P<0.05$) highest FC (Figure 3) and improved FCR were observed in AS and ASCC groups in comparison to CC and control. At 6 weeks of age, improved FCR of 1.86 was observed in both AS and ASCC groups followed by 1.98 in CC and 1.99 in control (Figure 4). Thus, aluminum sulfate alone and in combination with calcium carbonate was found to be highly effective in improving the BWG and FCR of broiler chicken.

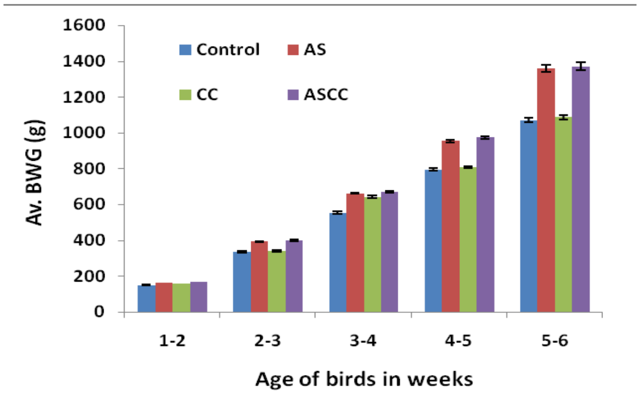


Figure 2. Average weekly body weight gain (g) in broiler chicken reared on chemically amended litter.

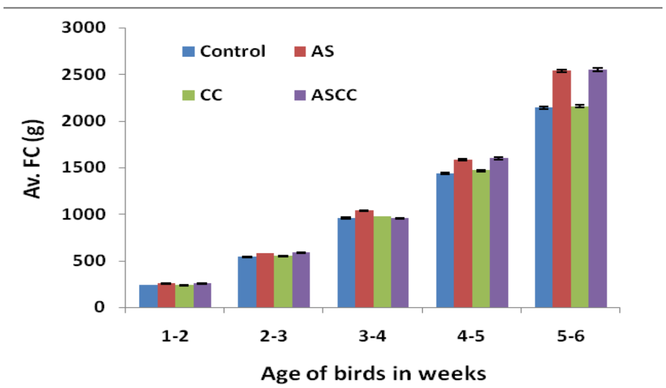


Figure 3. Average weekly feed consumption (g) broiler chicken reared on chemically amended litter.

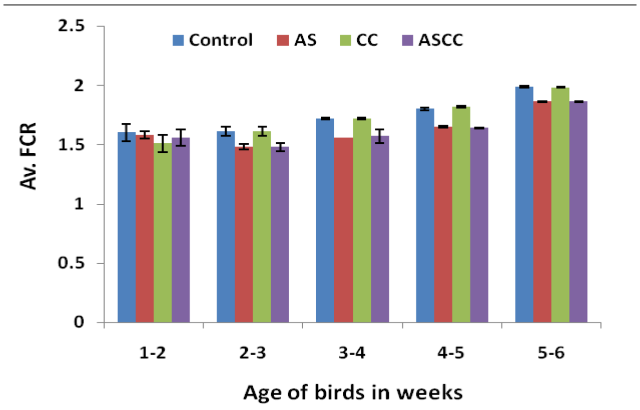


Figure 4. Average weekly FCR of broiler chicken reared on chemically amended litter.

These results are in agreement with findings of Guo and Song (2009) who reported that broilers grown on AS treated litter had better weight gain in comparison with birds raised on untreated litter. However, Do et al. (2005) and Alkis and Celen (2009) found no significant difference in bird performance between the broilers reared on AS and combination of AS and calcium carbonate treated litter and control respectively. Birds in AS and ASCC groups consumed more feed and had better FCR than CC and control. Moore et al. (2000) also reported that birds on alum-treated litter had 4 % increased body weight and 3 % better FCR than in control. In the present study, the improvement in BWG of birds raised on chemically treated litter might be attributed to the reduction in ammonia production in AS group, which in turn has a role in alleviating the stress of birds (Kling and Quarles, 1974). Thus, reduction in ammonia emission in AS and ASCC groups might have improved the well-being of birds, resulting in better growth and FCR.

Carcass characteristics

Among various slaughter traits, no significant ($P>0.05$) difference was found among various groups as compared to control (Table 1). Moreover, there was no significant ($P>0.05$) difference in the percent yield of giblets viz. gizzard, heart, liver and spleen; and weight of adrenal gland and bursa of fabricius among various treatment groups as compared to control (Table 2). These results are in contrast to Arias and Andkoutsos (2006) who reported improved dressed yield as a result on chemical treatment of litter with copper sulphate and attributed it to antibacterial activity of the chemical, thereby, improving the carcass quality of birds. Further, in the present study, no effect on yield of giblets and weight of vital organs was observed, thus confirming the reports of Younis et al. (2016) who used AS and copper sulphate in their study.

In conclusion, due to As's acidic nature, it was found to be highly effective in reducing the ammonia emission compared to CC. This in turn had a positive effect on the birds as indicated by improved performance in AS group. Hence, the practice of acidic litter amendments rather than alkaline ones must be encouraged for beneficial broiler production.

Table 1. Effect of chemically amended litter on slaughter characteristics of broiler chicken up to 6 weeks of age (mean ± S.E)

Parameter	T_1	T_2	T_3	T_4
Pre-slaughter live weight (g)	1809 ± 127.3	1886 ± 51.07	1864 ± 128.8	1913 ± 71.08
De-feathered wt (g)	1646.6 ± 115.5	1713 ± 67.65	1683.3 ± 113.1	1723 ± 87.65
Dressed weight (g)	1296.6 ± 81.01	1360 ± 50.0	1316.6 ± 72.1	1370 ± 49.1
Dressing percentage	71.74 ± 0.57	72.07 ± 0.97	70.77 ± 1.43	71.77 ± 1.35

No significant difference was found among means of various treatments

Table 2. Effect of chemically amended litter on yield of giblets and weight of vital organs in broiler chicken up to 6 weeks of age (mean ± S.E)

Parameter	T_1	T_2	T_3	T_4
Gizzard weight, %	2.18 ± 0.19	2.18 ± 0.09	2.28 ± 0.29	2.19 ± 0.29
Heart weight, %	0.59 ± 0.08	0.58 ± 0.01	0.62 ± 0.04	0.57 ± 0.03
Liver weight, %	2.39 ± 0.14	2.44 ± 0.15	2.41 ± 0.26	2.46 ± 0.15
Spleen weight, %	0.21 ± 0.01	0.19 ± 0.02	0.22 ± 0.017	0.19 ± 0.01
Adrenal gland weight (mg)	66.8 ± 0.43	67.2 ± 0.32	67.0 ± 0.19	66.9 ± 0.38
Bursa of fabricius weight (g)	7.40 ± 0.29	7.39 ± 0.27	7.41 ± 0.23	7.38 ± 0.25

No significant difference was found among means of various treatments

Consent to publish

All persons gave their informed consent prior to their inclusion in the study.

Competing interests

The authors declare that they have no competing interests.

Author's contributions

This study is the part of M.V.Sc. Thesis of the first author AR, who carried out the research under the guidance of MTB. SA, AAK, SQ, MU` and MAP helped during the trial, processing of samples and analysis of data. SA also helped in the technical writing of the article and its final revision. All authors have read and approved the final version of the manuscript.

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