Effect of chemically amended litter on litter quality and broiler performance in winter

Sarada Prasanna Sahoo, Daljeet Kaur, A.P.S. Sethi, A. Sharma, M. Chandran and Chandrahas

1. Introduction

Population growth, rapid urbanization along with changing lifestyle, shifting food habits and increased per capita income contribute towards rising demand of poultry products. This makes the broiler industry as one of the most profitable agro-economic enterprises. This sector generates lots of employment for the rural masses, particularly for small and marginal farmers.

In broiler production, the deep litter system of housing is very common in India. Litter is an important aspect of deep litter housing system. This poultry litter is the source of volatilized ammonia and its management is a key factor which affects the rate of its emission and health of birds. Keeping litter dry is a critical part of overall management of poultry farm. Litter conditions influence birds’ performance, which in turn affects profit of producers and integrators. Dry litter helps control the ammonia level, providing a healthy flock environment, and reduces condemnation due to hock, footpad burns and breast blisters. Dry litter is also important for the health and welfare of birds, as well as for the labour working at poultry farms. Caked litter increases the ammonia level thus negatively affecting broiler’s health, welfare, growth performance and carcass quality which is well documented by numerous researchers (Reece et al. 1981; Kristensen & Wathes 2000; Miles et al. 2004). Sodium bisulphate in a dry granular form is used extensively in the poultry industry for ammonia control, litter acidification and pathogen reduction for the prevention of many bacterial or stress-related poultry conditions. Sodium bisulphate eliminates ammonia by converting litter ammonium to ammonium sulphate and acidifies the litter by lowering its pH. Similarly, another alternative for poultry litter amendment is application of alum [Al₂(SO₄)₃·14H₂O], which decreases either water-soluble phosphorus or ammonia volatilization individually or both. Alum is used as a cost-effective means to reduce ammonia volatilization from poultry litter in poultry houses (Moore et al. 1995; Gilmour et al. 2004). The treated litter also had beneficial effect on the field application as alum lowers water-soluble phosphorous. Many previous researchers have investigated the effect of litter amendment using the above two compounds. However, no final conclusion could be reached especially in the Indian context. Keeping this in view, the present study was planned to compare the effectiveness of different litter amendments on microclimatic conditions of broiler house along with the quality of litter and the performance of broiler chicks.
2.3. Growth performance

Live weight and feed intake per pen basis were recorded weekly for the calculation of weight gain and feed conversion ratio (feed/gain in body weight), energy efficiency ratio (energy intake/gain in live weight) and protein efficiency ratio (gain in live weight/protein intake) during each week.

2.4. Litter quality and hygiene

Bacterial count: Litter samples were collected individually from six different locations of all the pens. The bacterial load was calculated using Pour Plate Technique (Miles & Misra 1938). Mac Conkey agar (HiMedia® Mumbai) was selected to differentiate lactose fermenter and non-lactose fermenter, where pink colonies indicated lactose fermentation and yellow or white colonies indicated non-lactose fermentation. The Hichrome Escherichia coli agar media (HiMedia® Mumbai) was used for the identification of E. coli (Blue colonies) from non-E. coli (White colonies) bacteria. The total bacterial count (White colonies) was determined by using Brain Heart Infusion agar media (HiMedia® Mumbai). The number of colony forming units (CFU) per gram from the original aliquot/sample can be calculated as CFU per gram = Average number of colonies for a dilution x dilution factor.

Parasitic load: Fecal samples were collected from each pen and screened regularly at biweekly interval for Eimeria oocysts. The samples were examined microscopically. Fecal examination was carried out on fresh fecal material collected immediately after defecation. The qualitative examination of fecal sample was done by using the simple flotation method. The number of oocysts per field was counted as per the Stoll’s dilution method (Soulby 1982).

Litter pH and nitrogen content: 10 gm of litter sample was taken in a 100 ml beaker from individual pen at weekly interval and 50 ml of distilled water was added to it and properly stirred with a glass rod. The content was kept at room temperature for 30 minutes. Then the pH was recorded using the portable pH meter (HANNA® pHep, pocket pH tester) which was calibrated using 7 and 9 standard buffer at room temperature. Litter nitrogen was estimated as per the standard protocol of AOAC International (2000).

Health and sanitary outlook: Broiler chicks under each treatment group were examined on daily basis to record the general health. Four birds selected randomly from each group were examined for general cleanliness at the time of weighing, at weekly interval. The data were recorded in the form of foot pad score and breast blister score relative to litter quality of each group (McWard & Taylor 2000).

2.5. Statistical analysis

The collected data were subjected to statistical analysis using Software Package for Social Sciences (SPSS Version 16.0) available in the Central library, Guru Angad Dev Veterinary and Animal Sciences, Ludhiana. The recorded data were subjected to one-way analysis of variance (Snedecor & Cochran 1989) with comparison among means done by Duncan’s multiple range test (Duncan 1955) with the significance level of p ≤ 0.05.

3. Results and discussion

3.1. Growth parameter

During the sixth week of experiment there was significant variation (p < .05) in average body weight of SBTL (1912 g) and ATL (1865 g) groups compared to the lower average body weight in...
the control (1822 g) group (Table 2). The FCR values varied from 1.98 to 2.02 in both the treatment groups against 2.10 in the control group. The efficiency of utilization of feed was significantly better in the SBTL group than both ATL and the control group in the first phase of growth. Significantly higher protein, energy and net feed consumption by the chicks of both the treatment groups resulted in more weight gain. This resulted in better FCR, PER and EER values indicating higher efficiency of utilization of feed, protein and energy in broiler chicks maintained on amended litter groups (ATL and SBTL) compared to the control group. Lower survivability per cent was recorded in the control group as compared to both the other treatment groups. Previous studies on litter amendment also demonstrated improved weight gain and feed conversion for broilers raised over the alum-treated litter as compared to the untreated litter group (Guo & Song 2009).

Broilers raised on using litter amendment products exhibited significantly enhanced weight gain, better feed conversion in comparison to birds raised on untreated litter. The data on survivability proved that there was no significant influence of litter treatment products on rate of mortality. Moore et al. (2004) also reported low mortality with the use of litter treatment products as corroborated in the present study. The reduction in mortality percentage may be attributed to improved litter quality which might have reduced the ammonia level.

### 3.2. Moisture content and litter pH

The moisture content of litter of control group was higher than that of both the treatment groups. Among the litter-treated groups, the SBTL group had more moisture content than the ATL group. During the entire experimental period, the moisture content of control group was always on higher side, whereas the ATL group had the least. However, the variation in moisture content was statistically non-significant among all groups (Figure 1).

At the start of experiment the pH of litter used in all the groups was 7.9. At the end of the second week, the pH was significantly (p < .05) reduced to 1.5 and 3.9, respectively in SBTL and ATL groups. This acidic pH level was maintained up to fourth week of rearing due to acidic nature of litter treatment products in the treated groups. Among the litter treatment groups, the pH of SBTL group was significantly reduced (p < .05) in comparison to the ATL group though the acidic pH was maintained in both the litter-treated groups. Fifth week onwards, litter pH rebounds to alkaline levels in all the treatment groups (Figure 2).

Since chemical compounds used in the litter treatment were relatively acidic, in the presence of water, they caused a large drop in litter surface pH when initially applied. They also maintained this acidic property up to 4 weeks of experiment. Sodium bisulphate being more acidic than alum, the SBTL group caused larger initial pH fall than the alum. Litter pH rebounded back to near-neutral levels with advancement of time. However, litter pH for the treated litter groups were lower (i.e. more acidic) than the untreated control group at the end of the experiment. Similar type findings were reported by Mc Ward and Taylor (2000) while using alum and sodium bisulphate as litter amendment. According to some reports, reduction in manure pH resulted in reduced ammonia volatilization (Burgess et al. 1998; Smith et al. 2001). Alum addition has also been shown to have zero effect on litter moisture (Burgess et al. 1998). As reported by Elliott and Collins (1982), ammonia release from litter is related to litter pH and moisture. Ammonia emissions have been positively correlated with litter pH (Carr et al. 1990) and negatively correlated with litter moisture content (Ferguson et al. 1998).

### 3.3. Bacterial load

At the end of the second week of experiment the E. coli count was significantly higher in the control group (8.35 ± 0.08) relative to the ATL group (7.67 ± 0.33) and the SBTL group (8.11 ± 0.07) (Table 3). The lower bacterial count of the litter-treated groups might be due to drastic reduction in pH of litter sample. By the end of the experiment, minor variation in E. coli count among all the groups indicated clear-cut correlation of bacterial count with pH of litter. Similar trends were observed during bacterial count of Salmonella and Salmonella-like organisms in the litter samples. However, there was statistically significant difference (p < .05) in Salmonella and Salmonella-like organisms count among all the groups was observed. The total bacterial count (TBC) was significantly higher in the control group than that of both the treatment groups. As days advanced, the TBC increased among the litter-treated groups due to the shift of pH from acidic to alkaline at the end of experiment. During the study period, data revealed lower values of litter moisture and pH activity

![Figure 1. Effect of different treatments on moisture.](image-url)
correlating positively with reduced bacterial activity and better performance with respect to growth and survivability rate. *E. coli*, *Salmonella* and TBC reduced remarkably due to extreme acidic pH and less moisture content of litter. Similar findings were also obtained by MacWard and Taylor (2000) and Line and Bailey (2006) who reported the reduction in pathogens in litter-treated groups. According to Lines (2002), lower litter pH results in reduced pathogen levels in the litter and on bird carcasses.

### 3.4. Parasitic load

At the onset of experiment *Eimeria* oocysts count was almost similar in all three groups. With advancement of time the count increased in both the treatment groups than control group. Among these two treatment groups, the SBTL oocysts count was comparatively lower than that of ATL group. However, the numerical difference among all the treatment groups was statistically not significant.

### 3.5. Nutritive value of litter

The percentage available nitrogen is a direct indicator of the crude protein content. The crude protein content of litter was numerically higher in the SBTL group closely followed by the ATL group than the control group throughout the study period. Among the litter-treated groups, SBTL maintained numerically higher level of litter nitrogen than the ATL group. Higher ash content value was recorded in all the groups with the advancement of time; however, there was no significant difference in percent ash obtained from the litter samples of all the groups in the entire experimental span (Table 4).

The nitrogen content of the litter from treated groups was higher than that of control group. The acidic nature of the litter did not allow the free ammonium ion to convert to ammonia resulting in more nitrogen retention. The higher nitrogen value contributed to more crude protein percentage indicating the suitability of litter in alternative feeding practices for livestock. Choi and Moore (2008) also observed the improved nitrogen percentage due to litter amendment. Similarly, Burgess et al. (1998) reported that regardless of litter source, the treatment of litter samples with Al₂(SO₄)₃ by the small batch method resulted in significantly higher nitrogen values. The addition of alum at the higher rate resulted in a doubling of the nitrogen concentration in the litter, which would enhance the value of poultry litter as a fertilizer source for improving crop yield.

### 3.6. Health and sanitary outlook

No litter treatment-related serious health problems were observed throughout the study period. Only one incidence of leg abnormality was observed in the control group with foot pad score 3 as compared to overall 0 score of the entire treatment groups. The breast blister score was nil among the treatment as well as the control group. Formation of litter cakes in the control was intensive and more frequent with respect to

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**Table 3. Pathogen load of litter of different treatments.**

| Period (week)          | Parameters                      | Control      | ATL         | SBTL         |
|------------------------|---------------------------------|--------------|-------------|--------------|
| End of second week     | *E. coli*, CFU in log 10        | 8.35₁₀ ± 0.08| 7.67₁₀ ± 0.33| 8.11₁₀ ± 0.07|
|                        | *Salmonella* and *Salmonella*-like microbes, CFU in log 10 | 7.58₁₀ ± 0.16| 7.40₁₀ ± 0.10| 7.32₁₀ ± 0.21|
|                        | TBC, CFU in log 10              | 8.58₁₀ ± 0.02| 8.32₁₀ ± 0.02| 8.13₁₀ ± 0.14|
|                        | Parasitic count, Oocysts/gm     | 3027.00 ± 58.77| 3142.33 ± 54.73| 3028.00 ± 47.06|
| End of fourth week     | *E. coli*, CFU in log 10        | 8.56₁₀ ± 0.11| 8.09₁₀ ± 0.31| 8.32₁₀ ± 0.16|
|                        | *Salmonella* and *Salmonella*-like microbes, CFU in log 10 | 7.99₁₀ ± 0.06| 7.58₁₀ ± 0.16| 7.26₁₀ ± 0.14|
|                        | TBC, CFU in log 10              | 8.86₁₀ ± 0.03| 8.71₁₀ ± 0.05| 8.59₁₀ ± 0.05|
|                        | Parasitic count, Oocysts/gm     | 7110.33 ± 127.41| 6265.00 ± 172.24| 5272.67 ± 155.68|
| End of sixth week      | *E. coli*, CFU in log 10        | 8.64₁₀ ± 0.04| 8.42₁₀ ± 0.05| 8.50₁₀ ± 0.08|
|                        | *Salmonella* and *Salmonella*-like microbes, CFU in log 10 | 8.16₁₀ ± 0.07| 7.78₁₀ ± 0.17| 7.92₁₀ ± 0.04|
|                        | TBC, CFU in log 10              | 9.03₁₀ ± 0.06| 8.78₁₀ ± 0.03| 8.65₁₀ ± 0.03|
|                        | Parasitic Count, Oocysts/gm     | 9373.00₁₀ ± 154.07| 7267.00₁₀ ± 202.63| 6904.33₁₀ ± 159.90|

Note: Mean value bearing different superscripts in a row differs significantly ($p < .05$).
size and thickness of cakes than those observed in both the litter-treated groups.

There was overall better hygiene of the broiler chicks and less cake formation of litter in the litter-treated groups than that of control group. Haslam et al. (2007) reported an increase in the prevalence of foot pad dermatitis, hock burn and breast blister lesions in broiler chicken due to the decrease in litter quality. Estevez (2002) and Mayne (2007) suggested that the combination of ammonia and wet litter was responsible for development of breast blisters lesions and moisture was a factor for increased foot pad dermatitis in young turkeys.

4. Conclusion

The present study revealed that litter amendment has an important role in augmenting broiler growth performance, survivability and efficient utilization of feed, protein and energy. Sodium bisulphate litter at 25 gm/sq. ft. was more effective in controlling pH, microbial load and improved the ambient environment of broiler chicks than alum at 90 gm/sq. ft. But both the litter treatments had performances better than that of control group with respect to weight gain, FCR, survivability, pathogen load and litter quality. So the use of acidifier in litter is beneficial to maintain the litter quality which directly enhances the productivity in broiler production without any adverse effect.

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Disclosure statement

No potential conflict of interest was reported by the author.

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