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# Housing Conditions of Broilers as Affected by Charcoal Treated Litter

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## Abstract

Maintaining dry litter is a key objective for successful broilers production. Two different types of litter (wood shavings straw and sand), and three different forms of charcoal in the litter, were arranged as treatments in a totally randomized block design (no treated litter, charcoal crumples, and charcoal pellets). This experiment was conducted to evaluate the housing conditions (airborne and litter conditions) of broilers as affected by charcoal treated litters (wood shavings straw and sand). 180 one day old Cobb broiler chicks were split into six treatment groups, with three individuals per treatment (10 chicks per each). Results of litter conditions as moisture, caking rate and bacterial count showed significant differences ($P \leq 0.05$) among studied litter treatments or types. Sand litter had significant superiority of moisture, caking rate and bacterial count over the wood shavings litter. Also, charcoal crumples and charcoal pellets treated litter decreased litter moisture percentage and bacterial count, while insignificant differences were found in litter pH. The lowest ammonia concentrations inside the poultry house are observed for charcoal crumples and charcoal pellets treated litters. However, no significant differences were found in airborne dust particulates among studied litter treatments or types. The addition of charcoal (crumbles or pellets) to sand litter decreased litter moisture and ammonia levels, over that of wood shavings litter. Finally, charcoal treated sand may be used in place of wood shavings as litter material, with beneficial effects on the birds' health. This is dependent on the effectiveness of the charcoal and the availability of the sand.

**Key Words:** Airborne, Broilers, charcoal, Litter, and litter conditions

## Introduction

Poultry require bedding (litter) for optimal health and productivity. Providing continuous access to "dry and friable" litter is a major concern in the broiler raising industry, and there is a great effort worldwide to enhance and sustain appropriate litter management procedures (Mayne, 2005). As a result, the bird's productivity may be affected by the bedding quality (Lister, 2009). To avoid dry and dusty of litter, it's important to monitor and qualify bird-litter interactions, moisture regulation, ammonia control and litter management (Lai et al., 2009). Incorporating other materials into chicken litter has the potential to save bedding costs and mitigate the negative impacts of utilized built-up litter on bird performance. Charcoal is a promising and interesting idea for use in chicken farming. Composting chicken litter with charcoal, a byproduct of the pyrolysis of organic waste, results in less ammonia emission into the environment (Janczak et al., 2017; Liu et al., 2017). It improves litter water retention without harming broilers in any way (performance, foot score, or health) (Ritz et al., 2011; Linhoss et al., 2019). Since charcoal is commonly produced as byproduct in fuel generation, it can be a low cost, easy-to-access, and all-natural alternative. Charcoal's unique properties include its capacity to inhibit the development of mold and other fungus, to lessen the accumulation of heavy metals in animal organs, to influence digestive processes, to improve the quality of litter and to lessen the release of toxic gases (Kulok et al., 2005). Broiler management is mainly reliant on the quality of the litter used, since this directly affects the performance of the broilers and, by extension, the quality of their eventual products (Farghly et al., 2021a). Lightweight, medium-sized, good absorption property, quick drought, soft and easily compressible, low heat conductivity, low price, and possessing high efficiency of moisture absorption with a suitable drying time are characteristics of good litter materials (Munir et al., 2019; Farghly et al., 2021b). Wood sawdust is the most often utilized form of litter material in broiler farms. Many broiler farmers are looking for alternate bedding materials due to the restricted availability, poor supply, and high cost of wood sawdust (Kuleile et al., 2019; Monckton, et al., 2020). Because of its low cost and availability in New Valley, Egypt, sand has shown strong potential as an alternate bedding material, particularly sand litter, for managing broilers. It was also expected that litter that had been altered with charcoal would enhance both airborne and litter conditions. The purpose of this study is to provide important information about charcoal treated litters and the possible impacts of this method on litter quality, ammonia emissions, litter moisture and airborne dust particulates.

## Materials and methods

This study was carried out at the broiler farm (D /1/092/108) in Nasser city, El-Kharga, New Valley governorate, Egypt. This experiment was planned to evaluate the housing conditions (airborne and litter conditions) of broilers as affected by charcoal treated litters. A total number of 180 one day old Cobb broiler chicks of six groups of treatments, with three replicates for each treatment (10 chicks per each). The experiment used a completely randomized block design with a 2×3 factorial arrangement of treatments: 2 types of litter (wood shavings straw and sand) and 3 charcoal forms in litter (no treated litter, charcoal crumples, and charcoal pellets). Each replicate was kept in a partition of 1 meter square provided with deep litter (8–10 cm) and maintained under continuous lighting. The chicks were reared under 32-33°C temperature at one day of age and then gradually reduced to reach 23°C at the fourth week of age and thereafter. The temperature and relative humidity were recorded daily.

A total of 36 litter samples were collected, 12 from each treatment, to determine the bacterial count in the litters when the birds were 8, 12, 16, and 20 weeks old (Farghly et al., 2015). At the same time, the moisture content and pH of several litter samples were measured. Farghly's techniques were used to assess the moisture content and pH of the litter samples (2012). Briefly, 10 gram of litter samples were suspended in 100 ml deionized water for 30 minutes to assess pH. The pH values were measured until steady readings were achieved. According to Saraz et al. (2013) a total of 27 samples were obtained by weekly to assess the concentration of airborne ammonia (AC) within the house, with nine samples from each group (three from each replication) taken at 10 a.m. Similarly, to the ammonia measurement, 48 litter samples were collected to estimate the quantity of suspended airborne dust particles (DC; $mg/m^3$) using specialist equipment (Laser dust monitor calibration, model LD-1 (H), No PS-33). Caking rate, 2 persons assessed each pen for the quantity of litter cake (on a scale of 1 to 5), where 1 = no litter cake and 5 = entire pen coverage with caked litter (Farghly et al., 2018). The obtained data were subjected to analysis of variance using SAS software's General Linear Models Procedure (SAS, 2009). Duncan (1955) was used to find variations in mean values across groups. For the analysis of variance, the following model was used:

$$Y_{ijkl} = \mu + Gi + Mj + (G \times M)\, ij + E_{ijl}$$

Where: $Y_{ijkl}$ = observation, $\mu$ = overall mean,

$G_i$ = litter type effect (i = 1-3) $M_j$= charcoal treated litter effect (j=1-2)

$(GxM)_{ij}$ = litter type x charcoal treated litter interaction $E_{ijkl}$ = experimental error.

## Results

### 1. Litter quality and conditions

Bedding materials quality (Moisture, litter pH, bacterial count, and caking rate) were presented in Table 1. From the present data, it could be detected that there were significant differences ($P \leq 0.05$) in the average moisture due to litter type and charcoal treatments at 6 weeks of age. The average moisture for wood shavings litter had significantly ($P \leq 0.05$) higher than that of sand litter. Also, at same age, the average bacterial count and caking rate for wood shavings litter had significantly ($P \leq 0.05$) higher than that of sand litter, while the litter type and charcoal treatments had insignificant effect on litter pH value. There were no significant differences in all measurements of litter conditions due to charcoal forms, except that of the average moisture and bacterial count at 6 weeks of age (Table, 1). For moisture percent and bacterial count, it was significantly ($P \leq 0.05$) higher in untreated litter with charcoal than charcoal treated litters (crumbles or pellets). There was significant interaction between litter materials and charcoal forms on the average moisture, bacterial count, and caking rate. At 6 weeks of age, the average moisture and bacterial count for litter types (wood shavings+ charcoal crumbles, wood shavings+ charcoal pellets, sand+ no charcoal, sand+ charcoal crumbles, sand+charcoal pellets) had significantly ($P \leq 0.05$) lower than litter type of wood shavings+ no charcoal. Caking rate of litter in treatments (sand+charcoal crumbles) and (sand+charcoal pellets) was significantly ($P \leq 0.05$) lower than that of (wood shavings+ no charcoal) treatments. While, litters (wood shavings+ charcoal crumbles), (wood shavings+ charcoal pellets) and (sand+ no charcoal) showed intermediate values. Poor litter quality makes it easier for bacteria and other microorganisms to grow, which can lead to infections.

### 2. Airborne quality and conditions

Airborne quality (indoors temperature, relative humidity, ammonia, and dust level) was presented in Table 2. The proportions of airborne quality (temperature, relative humidity, ammonia, and dust level) were similar among bedding materials collected at 0 wk. of age. The average ammonia and dust concentration remarkably increased toward the end of the trials coinciding with the increase in the age of the birds. No significant differences due to litter materials were found in all factors of airborne quality (indoors temperature, relative humidity, ammonia, and dust level). It could be detected that there were significant differences ($P \leq 0.05$) in airborne ammonia proportion between untreated litter with charcoal than charcoal treated litters (crumbles or pellets) at 6 wks. of age. Airborne ammonia level in house of the birds reared on untreated litter with charcoal was significantly ($P \leq 0.05$) higher than of those reared on charcoal treated litters (crumbles or pellets). There was a significant interaction effect between litter materials and charcoal forms on ammonia proportion and dust level at 6 wks. of age. Ammonia level in airborne of treatments (wood shavings+ charcoal crumbles, wood shavings+ charcoal pellets, sand+ charcoal crumbles, sand+charcoal pellets) was the lowest ($P \leq 0.05$) compared to treatment (wood shavings+ no charcoal). While ammonia level of treatments (sand+ no charcoal) showed intermediate values. In regard with dust level, the average airborne dust particulates concentrations ($mg/m^3$) for wood shavings+ no charcoal was the highest of values among the tested litter types, while treatments (sand+ charcoal crumbles, sand+charcoal pellets and sand+ no charcoal) had the lowest values of dust particulates concentrations ($mg/m^3$).

**Discussions**

Litter characteristics are difficult to be identified because there are so many different factors. These include litter moisture content (the opposite of dry matter content), friability, stickiness, manure content, pH, microbial activity and diversity, particle size, caking (thickness, area coverage and wetness) and temperature. Several management practices make it worse for the litter to be wet and stick at the same time. The properties of the bedding material and how the litter is handled affect performance. Caked litter is made when the layers of litter are pressed together into a single, wet layer on top of the bedding. This makes a thick, dense layer that holds most of the moisture and feces in the litter (Shepherd and Fairchild, 2010). Farghly (2012) and Farghly et al. (2015) concluded that the type of bedding and how it looks affects the amount of moisture in the bedding. Because of this, the type of bedding may indirectly affect the housing conditions of the broilers and the rate of caking. Grimes et al. (2006) and Atencio et al. (2010) went almost to similar findings: that the type of bedding material did not affect how often bedding clumped. The amount of water in the litter should be kept between 15 and 30%, and ideally below 25%. (Malone and Marsh Johnson, 2017). Litter with a moisture content of more than 25% used to be called "wet litter," and it lost its ability to cushion, insulate, and hold water (Dunlop et al., 2016). Petek et al. (2014) found that the type of bedding has a big effect on the pH of the bedding. Neither the type of litter used, nor any manipulation had any effect on the temperature, relative humidity, or dust level within house. On the other hand, there was a rise in litter ammonia levels in the control group (no charcoal). In addition to encouraging water release from the litter and the breakdown of organic material deposited with feces, these aerobic conditions foster aerobic microbial activity that produces heat for comfort (Lister, 2009; El-Kholy et al. 2020). Depending on the applicable standard and jurisdiction, it is advised to keep the ammonia concentration below 10 to 25 ppm (Malone and Marsh Johnson, 2017; Aviagen Inc., 2018). According to Miles et al. (2011), ammonia production begins when the moisture content of the litter is as low as 20% and rapidly rises until it reaches a peak at 37.4 to 40.4% moisture content when the litter temperature is 18.3 °C or 46.8 to 51.1% moisture content when the litter temperature is 40.6 °C. This means that to greatly reduce ammonia generation, litter must be extremely dry. In comparison to various forms of bedding, Farghly (2012) discovered a remarkable variation in ammonia concentrations and dust creation. Moisture content affects the amount of ammonia in the broiler's house (van Emous et al., 2019). It is similarly crucial that litter not be too dry (less than 15% moisture content), since this might raise the health concerns associated with dust for employees and chickens and lower production (Lai et al., 2009; Lister, 2009; Lai et al., 2012). There have been attempts to create and use litter assessment score guidelines to standardize the technique (Bassler et al., 2013; Kheravii et al., 2017). To what extent litter material influences ammonia emissions? Management procedures including ventilation and litter management, particularly lowering litter moisture content (Miles et al., 2011), have a significant effect in minimizing ammonia concentration within the chicken house. One of the byproducts of the pyrolysis of organic materials is charcoal. In addition to creating charcoal (solid), bio-oil and syngas are also produced during the pyrolysis of biomass (gas). According to Linhoss et al. (2019), adding charcoal to pine shavings boosted their water capacity up to a 20% increment rate before increasing it again to a 75% increment rate. Possible stress brought on by eliminating caking fecal waste from the pens might be the reason of the impact of charcoal in the litter. The amount of cake in the litter was lower in the 20% charcoal pens treatment than in the other pens treatments. According to Flores et al. (2021), the litter's capacity to adsorb nitrogen rose as the amount of charcoal in the litter increased. Furthermore, Linhoss et al. (2019) demonstrated that adding charcoal to pine shavings at rates of 10% and 20% enhanced their ability to store water by 21.6 and 32.2%, respectively. It's possible that the 20% charcoal treatment in the litter decreased the quantity of litter cake in certain pens, requiring less time to clean the pens. In current study, higher charcoal content in the litter resulted in lower pathogen loads. Flores et al. (2021) found that charcoal treatment had no effect on ammonia emission from the litter or litter moisture. It's worth mentioning that charcoal litter amendments did not lower ammonia levels when they were not acidified (Ritz et al., 2011).

## Conclusions

To control and efficiently maintain the litter quality and conditions within the house, one of the numerous management strategies that may be used is to modify the formation of the litter using charcoal. By accelerating the drying process and reducing the risk of harmful pathogens, dust and gases being present in the chicken's environment, the addition of charcoal (crumbles or pellets) to sand litter reduced the amount of moisture and ammonia levels in the litter. This was more effective than using wood shavings litter, which had higher levels of both. The preference efficiency of charcoal determines whether charcoal-formed sand litter can be utilized as a substitute to traditional litter materials for developing broilers especially in regions which had sand availability like New Valley in Egypt.

## Conflicts of Interest/ Competing interest

The authors declare that they have no competing interests.

## Ethical statement

All the experimental procedures and the study protocol have been approved by the National Animal Care and Use Committee, and the experiments were performed in accordance with the internationally accepted standard ethical guidelines for animal use and care according to **National Research Council (2010).**

## List of Abbreviations

| | |
|---|---|
| CF | Charcoal forms |
| WPSA | World Poultry Science Association |

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**Table 1: Effect of litter materials and charcoal forms on litter quality**

| Treatments | Moisture % | | Litter pH | | Bacterial count /One gram ($10^{-3}$) | | Caking rate score | |
|---|---|---|---|---|---|---|---|---|
| | 0 wk. | 6 wk. | 0wk | 6 wk. | 0 wk. | 6 wk. | 0 wk. | 6 wk. |
| **Litter materials (LM):** | | | | | | | | |
| **LM1:** Wood shavings | 7.22 | 20.7 $^{a}$ | 5.04 | 9.22 | 6.03 | 31.8 $^{a}$ | 0.00 | **2.25 $^{a}$** |
| **LM2:** Sand | 4.48 | 17.1 $^{b}$ | 6.18 | 9.26 | 4.25 | 24.9 $^{b}$ | 0.00 | **1.20 $^{b}$** |
| **SEM** | 0.71 | 1.03 | 0.45 | 1.11 | 0.53 | 1.14 | 0.00 | **0.35** |
| **P value** | 0.526 | 0.018 | 0.321 | 0.521 | 0.189 | 0.025 | 0.511 | **0.019** |
| **Charcoal forms (CF):** | | | | | | | | |
| **CF0:** No charcoal | 5.88 | 22.1 $^{a}$ | 5.66 | 9.00 | 5.14 | 31.7 $^{a}$ | 0.00 | **2.18** |
| **CF1:** Charcoal crumbles | 5.81 | 17.7 $^{b}$ | 5.65 | 9.37 | 5.14 | 27.3 $^{b}$ | 0.00 | **1.54** |
| **CF2:** Charcoal pellets | 5.87 | 17.0 $^{b}$ | 5.54 | 9.35 | 5.15 | 26.0 $^{b}$ | 0.00 | **1.47** |
| **SEM** | 0.60 | 1.18 | 0.54 | 1.32 | 0.59 | 1.18 | 0.00 | **0.30** |
| **P value** | 0.170 | 0.030 | 0.185 | 0.450 | 0.755 | 0.031 | 0.325 | **0.562** |
| **LM x CF interactions:** | | | | | | | | |
| **G1: LM1x CF0** | 7.23 | 24.2 $^{a}$ | 5.06 | 8.89 | 6.05 | 36.9 $^{a}$ | 0.00 | **2.92$^{a}$** |
| **G2: LM1x CF1** | 7.18 | 19.3 $^{b}$ | 5.11 | 9.35 | 5.92 | 30.2 $^{b}$ | 0.00 | **2.02$^{ab}$** |
| **G3: LM1x CF2** | 7.26 | 18.7 $^{b}$ | 4.96 | 9.41 | 6.11 | 28.2 $^{b}$ | 0.00 | **1.82$^{ab}$** |
| **G4: LM2x CF0** | 4.52 | 20.0 $^{b}$ | 6.25 | 9.11 | 4.22 | 26.5 $^{bc}$ | 0.00 | **1.44$^{ab}$** |
| **G5: LM2x CF1** | 4.44 | 16.1 $^{c}$ | 6.19 | 9.39 | 4.35 | 24.3 $^{c}$ | 0.00 | **1.06$^{b}$** |
| **G6: LM2x CF2** | 4.48 | 15.3 $^{c}$ | 6.11 | 9.28 | 4.19 | 23.8 $^{c}$ | 0.00 | **1.11$^{b}$** |
| **SEM** | 0.59 | 1.18 | 0.61 | 1.91 | 0.72 | 1.25 | 0.00 | **0.15** |
| **P value** | 0.829 | 0.030 | 0.109 | 0.862 | 0.642 | 0.019 | 0.925 | **0.043** |

a-----c Means within columns followed by different superscripts are significantly different ($P \leq 0.05$).

**Table 2: Effect of litter materials and charcoal forms on airborne quality**

| Treatments | Indoors Temperature C° | | Relative humidity % | | Ammonia (AM), PPM | | Dust level (mg/m$^3$) | |
|---|---|---|---|---|---|---|---|---|
| | 0 wk. | 6 wk. | 0 wk. | 6 wk. | 0 wk. | 6 wk. | 0 wk. | 6 wk. |
| **Litter materials (LM):** | | | | | | | | |
| **LM1:** Wood shavings | 32.81 | 24.61 | 48.96 | 57.55 | 3.54 | 15.24 | 6.08 | **8.50** |
| **LM2:** Sand | 32.57 | 24.55 | 49.50 | 56.59 | 3.55 | 14.03 | 4.04 | **7.38** |
| **SEM** | 1.30 | 1.17 | 1.28 | 1.41 | 0.55 | 1.15 | 0.21 | **0.39** |
| **P value** | 0.790 | 0.342 | 0.854 | 0.475 | 0.872 | 0.646 | 0.432 | **0.148** |
| **Charcoal forms (CF):** | | | | | | | | |
| **CF0:** No charcoal | 32.78 | 24.70 | 49.46 | 58.18 | 3.58 | 16.85 $^{a}$ | 5.20 | **8.42** |
| **CF1:** Charcoal crumbles | 32.64 | 24.51 | 49.12 | 56.68 | 3.53 | 13.65 $^{b}$ | 4.98 | **7.61** |
| **CF2:** Charcoal pellets | 32.65 | 24.54 | 49.12 | 56.36 | 3.53 | 13.42 $^{b}$ | 5.02 | **7.80** |
| **SEM** | 1.11 | 0.59 | 1.11 | 1.35 | 0.24 | 1.08 | 0.28 | **0.22** |
| **P value** | 0.425 | 0.365 | 0.178 | 0.265 | 0.652 | 0.033 | 0.917 | **0.825** |
| **LM x CF interactions:** | | | | | | | | |
| **G1: LM1x CF0** | 32.86 | 24.75 | 48.86 | 58.92 | 3.66 | 17.44 $^{a}$ | 6.21 | **9.16 $^{a}$** |
| **G2: LM1x CF1** | 32.75 | 24.52 | 49.31 | 57.24 | 3.45 | 14.11$^{b}$ | 5.93 | **8.11 $^{ab}$** |
| **G3: LM1x CF2** | 32.81 | 24.56 | 48.72 | 56.49 | 3.51 | 14.18 $^{b}$ | 6.11 | **8.24 $^{ab}$** |
| **G4: LM2x CF0** | 32.69 | 24.65 | 50.06 | 57.43 | 3.49 | 16.25$^{ab}$ | 4.18 | **7.68 $^{b}$** |
| **G5: LM2x CF1** | 32.52 | 24.49 | 48.93 | 56.11 | 3.61 | 13.19$^{bc}$ | 4.03 | **7.11 $^{b}$** |
| **G6: LM2x CF2** | 32.49 | 24.52 | 49.52 | 56.22 | 3.55 | 12.65 $^{c}$ | 3.92 | **7.36 $^{b}$** |
| **SEM** | 1.03 | 0.89 | 1.25 | 1.42 | 0.45 | 1.18 | 0.32 | **0.18** |
| **P value** | 0.711 | 0.522 | 0.362 | 0.632 | 0.189 | 0.021 | 0.451 | **0.044** |

a--c Means within columns followed by different superscripts are significantly different ($P \leq 0.05$).