Effect of dietary coarse corn inclusion on broiler live performance, litter characteristics, and ammonia emission

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ABSTRACT Ammonia (NH_3) emission from non-digested nutrients in poultry creates additional adverse environmental impacts on soil, water, air, and health. Mitigating NH_3 emission has become vital for the poultry industry to remain sustainable. As the presence of large particles in the feed stimulates the broiler gizzard to retain ingesta in the gastrointestinal tract longer and improve digestive efficiency, the inclusion of large particles in feed may lead to less nitrogen (N) and moisture content (MC) in feces such that lower NH_3 production would be expected. This chamber study investigated the effects of dietary coarse corn (CC) inclusion on broiler live performance, litter characteristics, and NH_3 emission. One hundred eighty female broilers (Ross 344 $\times$ 708 strains) at day 21 were randomly placed in 6 chambers with 2 dietary treatments (0% CC and 50% CC), with 3 chambers per treatment and 30 birds per chamber for 3 wks. The results showed that the 50% CC inclusion (1) decreased broiler feed intake and BW without affecting mortality-adjusted feed conversion ratio from day 21 to 42; (2) increased gizzard weight and decreased proventriculus weight; (3) decreased N content and MC in litter; and (4) decreased NH_3 concentrations in the chambers, as well as NH_3 emission from the chambers. Dietary CC inclusion could be an effective way to mitigate broiler litter N content and MC as well as NH_3 emission.

Key words: dietary coarse corn inclusion, broiler live performance, ammonia emission, litter characteristic, poultry chamber

INTRODUCTION

The United States produces approximately 10 billion broilers per year which accounts for a total live weight of 24 million metric tons or 18 million tons of broiler products, with a wholesale value of close to $60 billion (National Chicken Council, 2016). While contributing to the vitality of rural communities and ensuring the sustainability of America's food supply, intensive production of the broiler industry has raised serious environmental concerns (Carlile, 1984; NRC, 2003). In fact, industrialized broiler production facilities are often perceived to be significant emitters of air pollutants (e.g., ammonia [NH_3] and particulates) that may pose threats not only to the health and welfare of animals but also to the surrounding environment and society (Brewer and Costello, 1999). Future compliance with increasingly stringent local, state, and federal air pollution regulations is likely to occur (EPA, 2005). It is anticipated that sustainability and growth of the animal industry to meet increasing demands for affordable meat will likely depend on how health and environmental concerns identified by regulatory agencies and the public are addressed. Mitigation with objective documentation of the air emission problems in the production systems has become vital for the industry to remain sustainable.

Ammonia (NH_3) is the most important air pollutant emitted from broiler production houses (NRC, 2003). It not only adversely affects broiler health and productivity (Beker et al., 2004) but also causes acidification and eutrophication of ecosystems (Skiba et al., 2006). Moreover, atmospheric NH_3 may react with acidic pollutants to form secondary fine particulate matter (i.e., $PM_{2.5}$), compromising ambient air quality (Li et al., 2014). Among various air emission control strategies for animal production industry, feed manipulation is a measure to not only mitigate NH_3 emissions but also improve

animal live performance and welfare (Xu, 2014; EPA, 2017). In broiler production, the feed manipulation strategy requires fundamental understanding of the unique features of the broiler chicken's gastrointestinal tract (**GIT**). A broiler has a separate functional stomach system, with the crop to store and regulate feed intake, the proventriculus (aka the glandular stomach) to initiate gastric digestion, and the gizzard (aka the muscular stomach) to mechanically grind food for particle size reduction and surface area increment and to promote gastric proteolysis (Langlois, 2003). In addition, the gizzard also acts as the pacemaker of gut motility (Chaplin and Duke, 1988; Li and Owyang, 1993; Ferket, 2000; Hetland et al., 2003; Svihus et al., 2004). Large insoluble particles (small stones and so on) may retain in the gizzard to promote its muscular action, which in return increases ingesta retention time, enhances mechanical breakdown of food, and improves nutrient digestibility (Xu, 2014). Feeding dietary structural materials (e.g., small stones and grit) may substantially stimulate gizzard development (Hetland et al., 2003; Amerah et al., 2008). In the broiler's GIT system, the small intestine is short with less surface area to break down substrates. However, peristalsis and reverse peristalsis in the broiler's GIT offset the disadvantage of the short GIT.

As physical characteristics of the feed may exert significant impacts on GIT development, motility, and function, studies have been conducted to optimize poultry GIT function with simple modifications of feed structure (Savory, 1979; Hamilton and Proudfoot, 1995; Picard et al., 1999) and/or with inclusion of whole grain or coarse particles in broiler diets. A greater gizzard weight was observed owing to an increased frequency of gizzard contraction to provide additional grinding needed for processing large particle ingredients (Roche, 1981). Studies have shown that addition of coarse corn (**CC**) to broiler diets increased digesta retention time, decreased digesta pH, enhanced intestinal morphology, and altered bacterial population of the colon, consequently leading to a positive effect on broiler BW, livability, and feed conversion ratio (**FCR**) (Nir et al., 1994; Parsons et al., 2006). Moreover, it has been reported that coarse feed structure not only improved broiler live performance but also decreased nitrogen (**N**) content and moisture content (**MC**) in broiler litter owing to the improved digestive functions and health of the broiler GIT (Xu, 2014).

With advanced understanding of the broiler GIT responses to physical characteristics of feed, it may be hypothesized that coarse ground corn diets would increase broiler gizzard activity and feed retention time in the GIT, leading to less N and moisture in feces such that lower NH_3 production would be expected. The objective of this research was to evaluate the impact of 0 or 50% CC inclusion in diet on growth performance, proventriculus and gizzard weight, and NH_3 production within the environmentally monitored chamber complex.

MATERIALS AND METHODS

The Poultry Chamber Complex and Environmental Parameter Monitoring

This study was approved the Animal Care and Use Committee at North Carolina State University (IACUC#10-129-A). The poultry engineering chamber complex of North Carolina State University was designed and constructed to provide controlled environments for replicated studies of enhancement of poultry production environment, air quality, and welfare (Wang-Li and Shivkumar, 2013). This chamber complex includes 6 identical chamber systems with the bird enclosure (the core chamber) in dimensions of 2.44 m × 2.44 m × 2.44 m. The chamber unit design was modular, lightweight, well insulated, and easy to sterilize.

As shown in Figure 1, each chamber system was equipped with a belt-driven centrifugal blower having a variable frequency drive that achieved various ventilation rates according to bird age and ambient conditions (Wang-Li and Shivkumar, 2013). While most of the exhaust air and fresh intake was introduced into the chamber system through the blower, part of the air was damped out through a manually controlled adjustable damper at the outlet of the blower. The damper opening controlled the amount of fresh air entering the system, and its control was dictated by the ambient and the core chamber temperatures and the blower's revolutions per minute (**RPM**). The core chamber was equipped with drinkers, feeders, lights, and various sensors to monitor the growth environment (Figure 2).

During the experiment, environmental conditions (i.e., temperature and relative humidity) in the core chambers and the flow parameters were continuously monitored. Sensors used to measure the variables are listed in Table 1. All the thermocouple measurements were integrated into a CR1000 data board (Campbell Scientific, Logan, UT) for data acquisition and on-site readings. The adjustment of the system ventilation settings (i.e., blower RPM and damper opening) was dictated by the on-site readings of the core chamber temperature and ambient temperature.

Before placement of the birds, 2 bags of new baled wood shavings were placed in each chamber to provide bedding of 2-inch depth. Each chamber was equipped with 2 fluorescent light bulbs (15 watt). The daily lighting cycle was set at a photoperiod of 16 h of light and 8 h of dark, with the dark period from 2:00 pm to 10:00 pm. The lights' on–off status was controlled by a timer for each chamber.

Dietary Treatments and Broiler Assessment

The experiment was designed to compare the effects of 0 and 50% CC inclusion, as described by Xu (2014), on growth performance, relative gizzard and proventriculus weights expressed as a percentage of BW (i.e., mg/g BW), litter N content and MC, pH level, and NH_3 concentration and emission rate in female broilers from 21
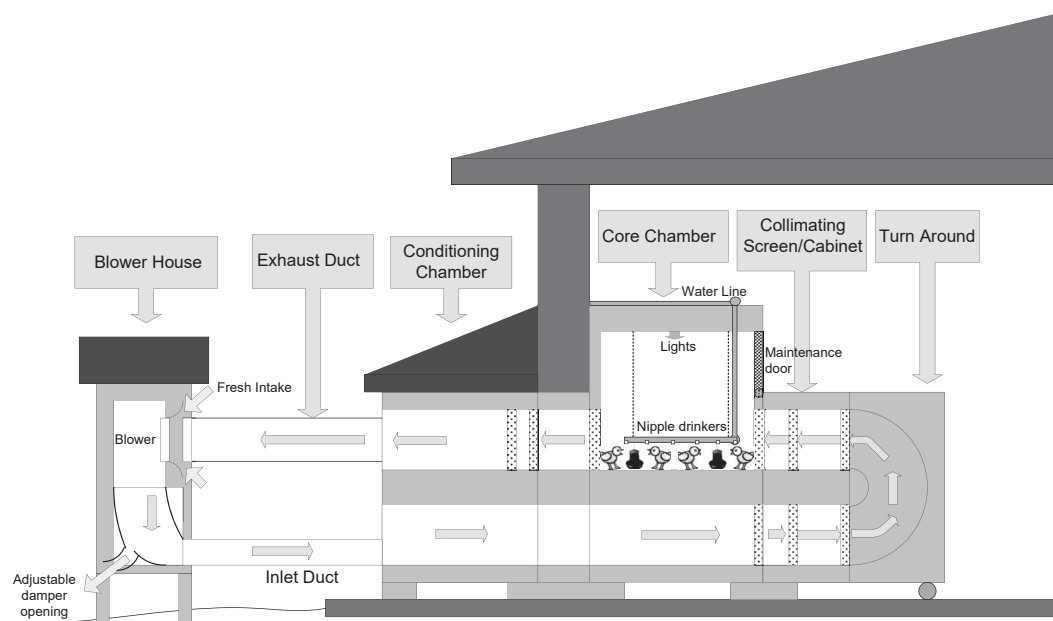
Figure 1. Schematic of the poultry engineering chamber design (Wang-Li et al., 2013).

to 42 D of age reared in poultry chambers with new litter floor.

Corn–soy broiler diets were formulated and manufactured at the NC State Feed Mill Education Unit. The same crumbled grower diet (20.3% CP and 3.05 ME kcal/g) was used for all birds, while 2 formulations of diets were produced by replacing 0 or 50% of fine corn with CC. A hammer mill was used to produce the fine corn, and a roller mill was used to produce CC. Particle sizes and pellet quality of the dietary treatments are listed in Table 2. More details about the feed formulation and manufacture are described by Xu et al. (2015).

One hundred eighty female broilers (Ross 344 × 708 strains) at 21 D of age were randomly placed in the 6 chambers for 3 wks, with 3 chambers per treatment and 30 birds per chamber. More specifically, chambers 1, 3, and 5 were for 0% CC treatment, and chambers 4, 4, and 6 were for 50% CC treatment. The broilers were raised in the chambers from 21 D to 42 D. Broilers' BW and feed intake were determined at 21 and 42 D of age. During the study, only one mortality occurred on the fifth day of the experiment. Birds were checked twice a day and mortality was removed out of the chambers and weighed to calculate adjusted FCR (**AdjFCR**) by chamber using the following equation:

$$AdjFCR = FI/BWG \qquad (1)$$

where BWG is the total BW gain, including the BW of the mortality that occurred during the experiment period.

All the birds in each chamber were euthanized at 42 D for gizzard and proventriculus weight measurements. The surrounding fat of the organs was trimmed, the contents of the organs were removed, and then, the organs were rinsed, blotted dry, and weighed, measurements being expressed as a percentage of BW in mg/g BW.

The experiment was a completely randomized block design of CC inclusions (0 and 50%), with the chamber serving as the experimental unit. Differences in live performance, litter N content and MC, pH level, and NH_3 concentration and emission rate between treatments were considered significant at $P \leq 0.05$ or $P \leq 0.01$.

Litter Sampling and Characteristic Analysis

A spatial variation of manure deposition was observed in each chamber floor. In response to bird positioning, more manure was deposited along the drinker line and at the inlet of ventilation airflow of the chamber (Figure 3). To capture the spatial variations of the litter
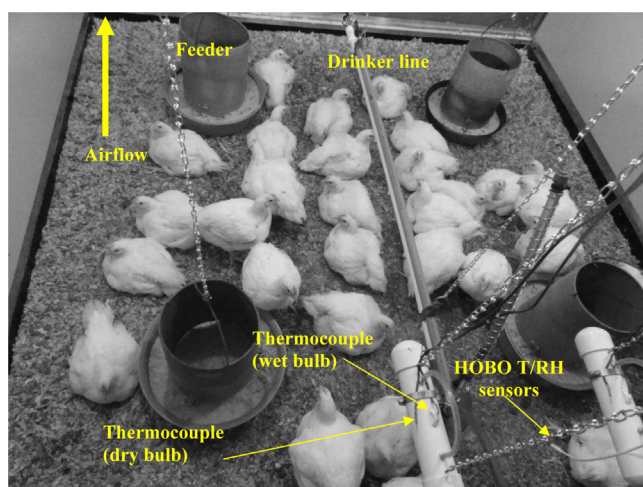

Figure 2. The core chamber equipped with 4 feeders and a water line with 6 nipple drinkers.

Table 1. Measured variables and equipment.

Variables	Instrument and sensor	Vendor
Air velocity	Hot-film anemometer, range: 0 to 75 m/s, accuracy: ±2%	Dwyer, Inc.
System pressure drop	Digital manometer kit, 0–10 in of water, accuracy: ±1%	Dwyer, Inc.
	Setra pressure transmitter (0–5 in of water), accuracy: ±1%	Setra Systems, Inc.
	Magnehelic gauges (0–0.5, 0–1, 0–2, 0–5 in of water), accuracy: ±2%	Dwyer, Inc.
Blower RPM	Hall-effect RPM sensor	
Temperature and relative humidity (RH) (the core chamber)	HOBO Pro v2 External T/RH Sensor & Logger, Model U23-002	Onset Computer Corporation
	T-type thermocouples (for dry and wet bulb temperature measurements in the core chamber and one ambient location)	

Abbreviation: RPM, revolution per minute.

characteristics for better understanding of the treatment effect, at the end of the experiment, 18 litter samples (from 14 locations and 4 underneath the feeders) were taken from each chamber for analyses of total N, total Kjeldahl nitrogen (**TKN**), total ammonia nitrogen, nitrate N, nitrite N, MC, and pH (Liu et al., 2008). Figure 3 illustrates the litter sampling locations. For each chamber, an area-weighted average method was used to calculate mean values of the analyzed parameters. These area-weighted means were used to test differences among the chambers and between the treatments.

In addition to N analyses on the built-up litter samples, the fresh bedding material (wood shavings) and feed samples were taken and analyzed for MC and N content. In each chamber, five birds were randomly selected to be euthanized and ground for analysis of N content and MC in the beginning (birds into the chambers) and at the end (birds out of the chambers).

Ammonia Emission Rate Determination

Ammonia Concentration–Airflow Rate Method
Ammonia concentrations in the 6 chambers were simultaneously measured using passive dosi-tubes at the locations shown in Figure 4. The following two types of GASTEC Color Dosimeter Tubes were used to perform on-the-spot time-weighted average (**TWA**) monitoring of NH_3 in ppm hours: (1) Ammonia No. 3DL (GSTC 810-3DL): measurement range of 0.1–10 ppm; sampling hours in 1–10 h; detecting limit in 0.02 ppm (maximum, 10 h) and (2) Ammonia No. 3D (GSTC 810-3D):

Table 2. Average particle size and pellet durability index (PDI).

Feed treatment	Particle size[1]	PDI[2]
Fine corn	301 μm	–
Coarse corn	1,314 μm	–
0% CC diet	422 μm	89.7%
50% CC diet	591 μm	84.3%

Abbreviation: CC, coarse corn.
[1]Particle size distribution was determined by ASAE S319.3.
[2]Pellet durability index was determined by ASAE standard S269.4.

measurement range of 2.5–1,000 ppm; sampling hours in 0.5–10 h; detecting limit in 0.5 ppm (maximum, 10 h)

The TWA NH_3 concentrations were calculated using the following equation:

$$NH_3(ppm) = \frac{ppm-h}{t} \quad (2)$$

where NH_3 (ppm) is the TWA NH_3 concentration in ppm, ppm-h is the Dosimeter tube reading in ppm h, and t is the actual sampling time in h.

Dosimeter tubes was used to calculate the NH_3 emission rate; the measured NH_3 concentration in ppm was first converted to mass concentration in mg/m^3 using the following equation that was derived from the ideal gas law (Cooper and Alley, 2002):

$$C_{mass} = \frac{P}{R \times T} NH_3(ppm) \times MW_{NH3} \quad (3)$$

where C_{mass} is the NH_3 mass concentration in mg/m^3, P is the chamber air pressure in atm, R is the ideal gas constant (0.082 L-atm/gmol-K), T is the chamber air temperature in K, and MW_{NH3} is the molecular weight of NH_3 (17 g/gmol).

The NH_3 emission rate was then calculated based on NH_3 mass concentration and the airflow rate using the following equation:

$$ER_{NH_3} = C_{mass} \times Q_{ave} \quad (4)$$

where ER_{NH3} is the NH_3 emission rate in mg/h and Q_{ave} is the TWA airflow rate in m^3/h.

Because the RPM of the blower and damper opening were adjusted in response to the changes of the chamber temperature and ambient temperature, the airflow rate varied during the different time of day and throughout the data collection period. Therefore, the TWA airflow rate was used for emission rate calculation. This TWA airflow rate was determined using the following equation:

$$Q_{ave} = \frac{\sum Q_i \times t_i}{t} ER_{NH_3} = C_{mass} \times Q_{ave} ER_{NH3} = C_{mass} \times Q_{ave} \quad (5)$$
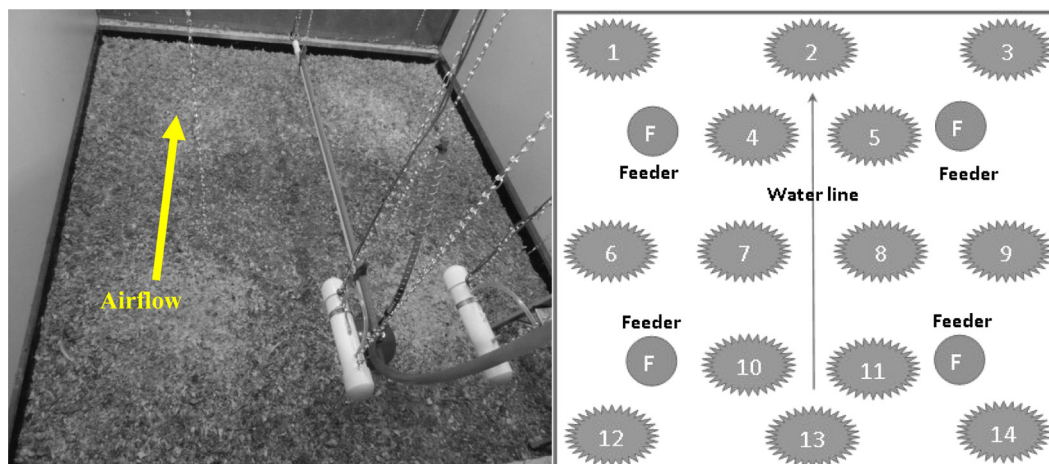
Figure 3. Spatial variation of manure deposition on the floor (left) and the 18 litter sampling locations (right) in each chamber.

where Q_i is the airflow rate (m^3/h) at a given RPM and damper opening setting, t_i is the duration (hr) when the system was operated at the given RPM and damper opening setting, and t is the NH_3 tube total sampling duration (hr).

Nitrogen Mass Balance Method Although the ammonia concentration–airflow rate (**NH_3-Q**) method provides emission rate assessment with temporal resolution, it requires continuous measurements of NH_3 concentration and ventilation airflow. When real-time measurements of NH_3 concentration and/or the ventilation rate become cost prohibitive or unavailable, the nitrogen mass balance (**NMB**) method has been used as an alternative way to estimate TWA ammonia nitrogen losses from animal facilities (Keener and Zhao, 2008; Li et al., 2010; Shah et al., 2013). In this experiment, measurements of the NH_3 concentrations and the chamber airflow rates became invalid whenever the maintenance doors of the core chambers were open for birds (twice daily). Consequently, uncertainties remain in emission rate determination by the NH_3-Q method. Therefore, to further confirm the treatment effect on NH_3 reduction, the NMB method was also conducted to estimate the TWA N loss in each chamber over the 3 wks of the experimental growth period. In this mass balance approach, NH_3 loss was estimated as a fraction of the N mass flow. More specifically, the N content of each mass balance component was analyzed and used to calculate the difference between N inputs and outputs, as defined in Equation 6. The calculated difference was assumed to be the N loss due to NH_3 emission as the N losses in other forms (nitrate N and nitrite N) were negligible. Based on the mass of the N loss in each chamber, the TWA NH_3 emission rate was calculated using Equation 7.

$$(NH_3-N)_{loss} = \big(N_{feed} \times M_{feed} + N_{chicken-in} \times M_{chicken-in} + N_{little-in} \times M_{little-in}\big)$$
$$- \big(N_{mortality} \times M_{mortality} + N_{chicken-out} \times M_{chicken-out} + N_{litter-manure} \times M_{litter-manure}\big) \tag{6}$$

where $(NH_3-N)_{loss}$ is the N loss due to NH_3 emission (g), N_{feed} is the dry basis N content of feed, (g/g, in decimal form), M_{feed} is the mass of total feed intake (g), $N_{chicken-in}$ is the dry basis N content of incoming chickens (g/g, in decimal form), $M_{chcicken-in}$ is the mass of total incoming chicken (g), $N_{litter-in}$ is the dry basis N content of incoming litter (new bedding) (g/g, in decimal form), $M_{litter-in}$ is the mass of total incoming litter (g), $N_{mortality}$ is the dry basis N content of mortality (g/g, in decimal form), $M_{mortality}$ is the mass of total mortality (kg), $N_{chicken-out}$ is the dry basis N content of finishing chickens (g/g, in decimal form), $M_{chcicken-out}$ is the mass of total finishing chickens (kg), $N_{litter-manure}$ is the dry basis N content of litter with manure (g/g, in decimal form), and $M_{litter-manure}$ is the mass of litter with manure (kg).

Figure 4. Illustration of the NH_3 monitoring location in each chamber. NH_3, ammonia.

$$ER_{NH_3} = \frac{(NH_3-N)}{D} \times \frac{17}{14} \tag{7}$$

Table 3. Comparisons of the mean BW, feed intake, and AdjFCR.

Treatment	21 D BW (g)		42 D BW (g)		21–42 D FI (g)		21–42 D AdjFCR	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
0% CC	767	7	2778[A]	24	3706[A]	71	1.84	0.049
50% CC	787	4	2704[B]	55	3587[B]	105	1.87	0.005

Means with A and B are significantly different at $P \leq 0.01$.
Abbreviations: AdjFCR, adjusted feed conversion ratio; CC, coarse corn; SD, standard deviation.

where ER_{NH_3} is the TWA emission of NH_3 (g/D); 17/14 is the conversion factor of N loss to NH_3 emission, with 17 being the molecular weight of NH_3 and 14 being the molecular weight of N; and D is the duration of the experiment (from 21 to 42 D).

RESULTS AND DISCUSSION

Effect of 50% CC Inclusion on Live Performance

Table 3 summarizes the average BW, FI, and AdjFCR between the 2 dietary treatments. There were significant differences in BW and FI, with lower means for the 50% CC diet treatment. It was observed that dietary CC inclusion decreased the pellet durability index (Table 2) that negatively affected FI. Decreased FI led to decreased BW. However, it did not affect FCR from 21 to 42 D of age.

The effect of dietary CC inclusion on decreased feed intake and BW gain agrees with previous reports. Amerah et al. (2008) reported that feed intake of pelleted diets decreased ($P < 0.05$) when wheat or corn particle size increased (284 to 890 μm and 297 to 528 μm dgw, respectively). Decreased feed intake was thought to be related to poorer pellet quality owing to CC inclusion (Corzo et al., 2011; Lilly et al., 2011). Amerah et al. (2008) also reported coarse grinding improved FCR of broilers fed with both wheat- and corn-based diets
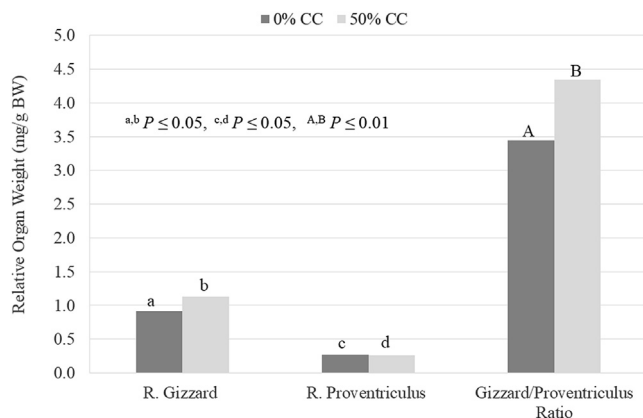
Table 4. Area-weighted averages[1] of litter TKN content (%), MC (%), and pH.

Chamber ID	TKN content by dry mass	MC	pH
Chamber 1	3.08	37.19	7.55
Chamber 2	2.54	36.05	7.70
Chamber 3	2.73	35.03	7.69
Chamber 4	2.35	31.82	7.49
Chamber 5	2.87	37.56	7.70
Chamber 6	2.44	33.10	7.25

Abbreviations: MC, moisture content; TKN, total Kjeldahl nitrogen.
[1]The area-weighted averages were calculated based on 18 samples from 14 locations plus 4 feeder locations (Figure 3). Because the representative areas by each of the samples are not the same, no standard deviation was calculated, but Figures 6 and 7 illustrate the spatial variations.

than fine grinding. The FCR improvement was probably related to enhanced gizzard activity caused by dietary inclusion of coarse grain.

Effect of 50% CC Inclusion on Gizzard and Proventriculus Weights (in mg/g BW)

Comparison of the dietary treatment effect on the relative organ weights is shown in Figure 5. The relative gizzard weight and gizzard-to-proventriculus ratio were significantly higher in 50% CC treatment. On the other hand, 50% CC decreased the relative proventriculus weight. As the gizzard is the key gastric organ to reduce coarse particles to smaller size for improved digestive efficiency (Xu, 2014), a large, well-developed gizzard may enhance enzymatic digestion efficiency and improve energy utilization and nutrient digestibility (Duke, 1989, 1992; Amerah et al., 2007). Increased gizzard weight due to increased corn particle size was a logical consequence of enhanced mechanical grinding activity (Dahlke et al., 2003; Parsons et al., 2006), but the inverse relationship between gizzard and proventriculus weights has seldom been reported in the literature. The relative relationship between gizzard and proventriculus weights indicated that broilers may adjust their mechanical and enzymatic digestive function according to the physical structures of the feed. Therefore, CC inclusion may result in improved nutrition digestibility, leading to less N content in excreta.


Figure 5. Comparison of the dietary treatment effect on the organ weights. CC, coarse corn.

Table 5. Bird N content (%) and MC (%) at the end of the experiment.

Chamber ID	N content by dry mass	MC
Chamber 1	7.27	61.75
Chamber 2	7.03	60.57
Chamber 3	7.08	61.07
Chamber 4	7.17	61.88
Chamber 5	7.22	62.17
Chamber 6	7.66	64.07

Abbreviations: MC, moisture content; N, nitrogen.
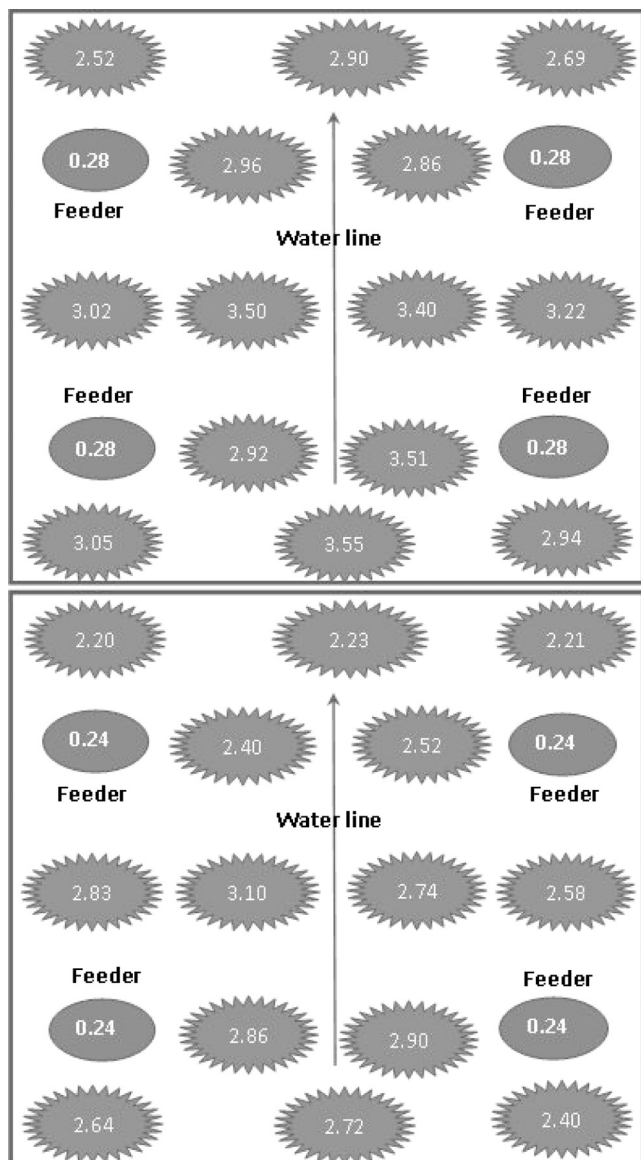
Figure 6. Spatial variations of litter TKN content (% by dry mass) between 0% CC (top) and 50% CC (bottom) treatments. CC, coarse corn; TKN, total Kjeldahl nitrogen.
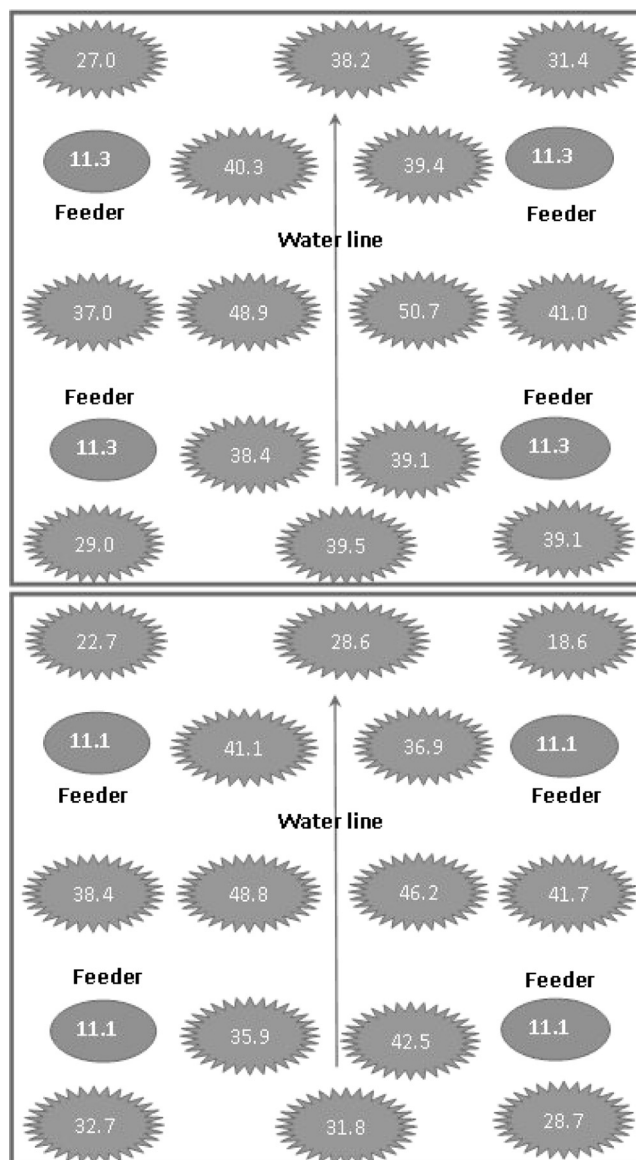
Figure 7. Spatial variations of litter MC contents (%) between 0% CC (top) and 50% CC (bottom) treatments. CC, coarse corn; MC, moisture content.

Effect of 50% CC Inclusion on Litter Characteristics

Litter characteristics were measured by litter N content, MC, and pH values. Comparisons of the litter characteristics and the bird samples' N content and MC at the end of the experiment are shown in Tables 4 and 5. Because the litter samples were collected from 18 locations, the area-weighted averages were calculated. In addition, the spatial variations in the litter TKN and MC between 2 treatments are illustrated in Figures 6 and 7. In general, litter TKN and MC shared the same spatial distribution pattern, with the higher values in the locations at the chamber flow entrances and in the center around the water line.

In comparison of the mean N content by treatment, the 50% CC diet produced significantly higher N content

and lower litter TKN and MC, but the difference in litter mean pH between treatments was not significant (Figure 8).

Because wet litter is associated with problems of NH_3 production and animal health and welfare issues, it has become a serious concern in broiler industry. The CC inclusion could be a very useful and practical method to decrease wet litter occurrence.

Effect of 50% CC Inclusion on NH_3 Concentration

Figure 9 shows the measured NH_3 concentrations by chamber and by treatment. The experiment started at 21 D of age with a stocking density of 30 birds per chamber. One mortality occurred in chamber 5 on the fifth
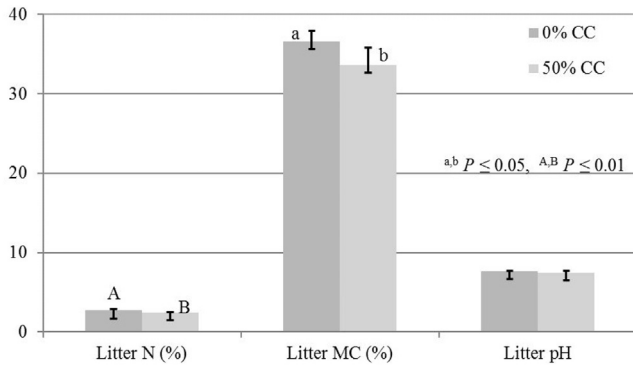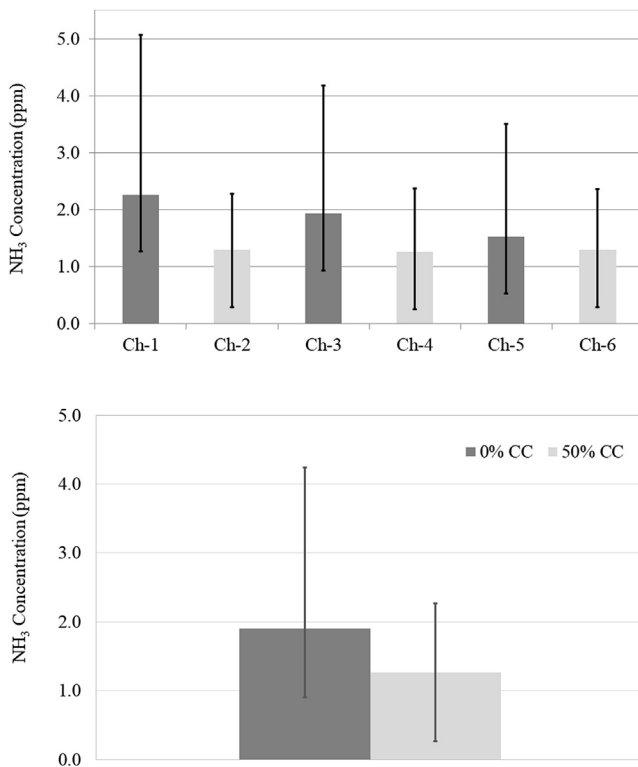
Figure 8. Effect of the dietary treatments on the litter characteristics. Means with different letters are significantly different. CC, coarse corn; MC, moisture content; N, nitrogen. Means with A and B are significantly different at $P \leq 0.01$.
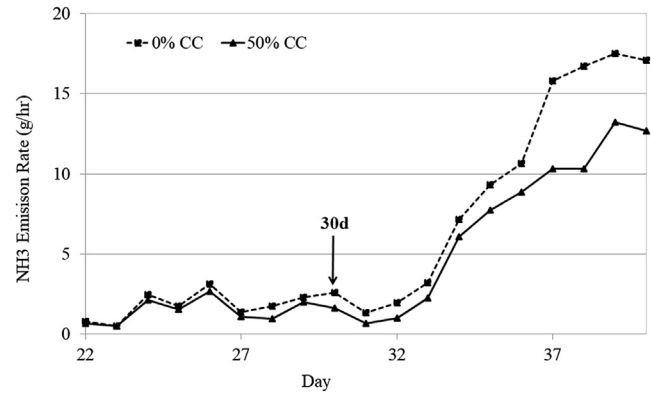

Figure 10. Comparison of NH_3 emission rates between dietary treatments over time. CC, coarse corn.

day of the experiment (26-D-old bird) such that there were only 29 birds in chamber 5 for the rest of the experiment. Consequently, NH_3 concentration and emission of chamber 5 were the lowest among chambers with the same diet treatment (0% CC). In general, chambers with 0% CC diet (chambers 1, 3, and 5) had higher NH_3 concentration than the chambers with 50% CC diet (chambers 2, 4, and 6) ($P \leq 0.01$).

Effect of 50% CC Inclusion on NH₃ Emission

Based on the NH_3-Q method, NH_3 emission rates over time were calculated (Equation 4) and shown in

Figure 10 for treatment comparison. The difference in NH_3 emission rates (mg/h) was not significant until the birds reached the age of 30 D, with the average emission rates of 2.6 g/h and 1.6 g/h for the 0% CC and 50% CC treatments, respectively. Although one of the 0% CC treatment chambers (chamber 5) had one less bird most of the time, this treatment produced significantly higher mean NH_3 emission rates over time than the chambers under 50% CC diet treatment. Comparison of the overall average emission rates by the NH_3-Q method suggests that the 50% CC diet treatment produced significantly less emissions than the 0% CC treatment ($P \leq 0.01$). This was likely related to the decreased litter N content and MC and altered GIT function, as evidenced by increased gizzard weight and decreased proventriculus weight due to CC inclusion.

As the NH_3 and airflow rate data were invalid and excluded from NH_3 emission rate calculation by the NH_3-Q method whenever the chamber doors were open, the NH_3-Q method underestimated the NH_3 loss over the experiment period. As shown in Figure 11, the NMB method produced significantly higher NH_3 losses (kg) than the NH_3-Q method for both dietary treatments. The difference of the total NH_3 losses under the 2 treatments was significant by the NH_3-Q method, but not significant by the NMB method. Similarly, the NMB method was not able to detect significant difference in emission rates for 0% CC and 5% CC diet treatments, 122 ± 14.7 g/D and 121 ± 1.8 g/D, respectively.

CONCLUSIONS

This chamber study investigated the effects of dietary CC inclusion on broiler live performance, litter characteristics, and NH_3 emission. Comparisons indicated that 50% CC inclusion (1) decreased broiler FI and BW owing to decreased pellet quality, but did not affect AdjFCR from 21 to 42 D; (2) increased gizzard weight and decreased proventriculus weight; (3) decreased N content and MC in litter; and (4) decreased NH_3 concentrations in the chambers, as well as NH_3 emission from the chambers.

Figure 9. Comparison of NH_3 concentrations by chamber (top) and by treatment (bottom). CC, coarse corn.
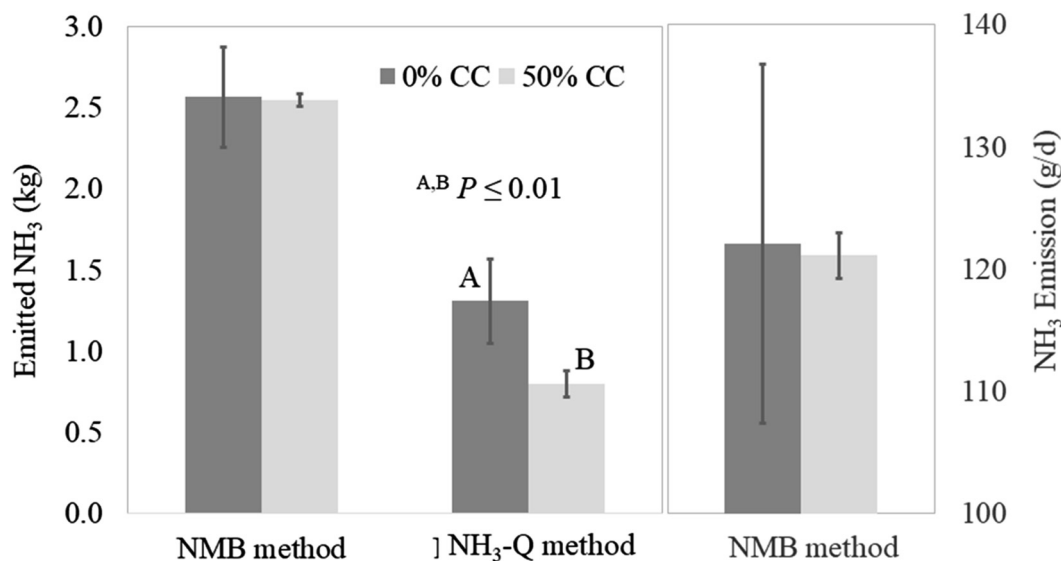
Figure 11. Total NH$_3$ mass (kg) losses (left) and the time-weighted emission rate (g/D) (right) from 21 D to 42 D. CC, coarse corn; NH$_3$-Q, ammonia concentration–airflow rate; NMB, nitrogen mass balance.

In summary, the dietary CC inclusion could be a way to mitigate broiler litter N content and MC as well as NH$_3$ emission.

ACKNOWLEDGMENTS

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