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Acidifier application rate impacts on ammonia emissions from US roaster chicken houses

Sanjay B. Shah [a,*], Jesse L. Grimes [b], Edgar O. Oviedo-Rondón [b], Philip W. Westerman [a]

[a] Department of Biological and Agricultural Engineering (BAE), North Carolina State University (NCSU), Raleigh, NC 27695, USA
[b] Department of Poultry Science, NCSU, Raleigh, NC 27695, USA

HIGHLIGHTS

► Ammonia emission rates from four roaster houses were measured over eight flocks.
► Each house received a different acidifier (sodium bisulfate) application rate.
► The control treatment daily ammonia–N emission rate was 100 g per 500-kg live-mass.
► Emission rates were inversely correlated with the acidifier application rate.
► The acidifier is limited in its ability to reduce ammonia emissions.

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ABSTRACT

Due to its potential environmental and public health impacts, emissions of ammonia (NH_3) as well as several other gases from US livestock farms may be regulated. Broiler houses are important sources of NH_3 emissions. However, there are no emissions data from roaster (8–12 wk old broilers, ~4 kg ea.) houses. Producers treat the litter in broiler houses with acidifiers, such as sodium bisulfate (SBS, $NaHSO_4$) to reduce ammonia production and protect bird health. However, there is very little data on the effect of acidifiers, particularly at high application rates on ammonia emissions. The impact of different SBS application rates [High (0.95–1.46 kg m^{-2}, whole house), Medium (0.73 kg m^{-2}, whole house), Low (0.37–0.49 kg m^{-2}, whole house), and Control (0.37–0.49 kg m^{-2}, brood chamber)] on ammonia emissions was evaluated in commercial roaster houses over 22 months spanning eight flocks. Ammonia emission from each fan was measured with an acid scrubber that operated only when the fan operated. Emissions were calculated using >95% measured data with the rest being estimated using robust methods. Exhaust ammonia–N concentrations were inversely correlated with the SBS application rates. Emission rates on animal unit (AU, where 1 AU = 500 kg live-mass) basis (ER, g d^{-1} AU^{-1}) were reduced by 27, 13, and 5%, respectively, in the High, Medium, and Low treatments vs. the Control treatment (mean: 100 g d^{-1} AU^{-1}, range: 86–114 g d^{-1} AU^{-1}). Emission rates for the Control treatment measured in this study on roasters were mostly higher than ERs in the literature. Differences in ERs are not only due to diet, environmental and management conditions, but also due to measurement methods.

1. Introduction

Decomposition of uric acid and urea in manure results in ammonia (NH_3) formation in livestock barns, livestock waste storage, and treatment units. The US Environmental Protection Agency (USEPA) attributed ~71% of the total US NH_3 emissions to livestock production (USEPA, 2004). Ammonia emission from animal feeding operations (AFOs) is important at the regional scale or larger because of its magnitude as well as atmospheric deposition and haze effects (National Research Council, 2003). Gates et al. (2008) estimated that broiler (meat chicken) houses emitted 0.24–0.32 million Mg of NH_3 per year.

Since high in-house NH_3 concentrations can degrade bird health (Miles et al., 2004), many broiler producers use ventilation to maintain acceptable NH_3 concentrations. However, venting NH_3 may come at a price because the USEPA may regulate AFO air emissions. The USEPA has already completed collection of baseline emissions data under the National Air Emissions Monitoring Study

* Corresponding author. Tel.: +1 919 515 6753; fax: +1 919 515 7760.
E-mail address: sanjay_shah@ncsu.edu (S.B. Shah).

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(NAEMS) from a California broiler farm (Lin et al., 2012). There are several other recent studies (e.g., Moore et al., 2011; Roumeliotis et al., 2010) on broiler NH_3 emissions.

While there has been a trend toward raising larger broilers known as roasters (8–12 wk old) or roaster chickens (Federal Register, 2011), all broiler NH_3 emission studies currently in the literature involve birds ≤3.3 kg ea. whereas roasters exceed 4 kg ea. Because diets and feed efficiency vary between broiler and roasters, additional information on emissions from larger birds is needed.

Broilers are raised on solid bedding (e.g., pine shavings) that also accumulates feces, spilled feed, and water; this mixture, known as litter, serves as a reservoir for NH_3. Broiler producers use litter amendments (or additives) such as acidifiers to reduce NH_3 production. Acidifiers such as PLT® (sodium bisulfate, $NaHSO_4$; abbreviated as SBS hereafter) when applied to the litter, reduce pH, inhibiting microbial formation of NH_3 as well as conversion of ammonium (NH_4) to NH_3; this may reduce NH_3 generation and improve bird performance (Shah et al., 2006). There are many studies on amendment impact on in-house NH_3 concentration (e.g., McWard and Taylor, 2000; Moore et al., 2000) but only two studies (Moore et al., 2008; Wheeler et al., 2008) on amendment effects on NH_3 emissions could be located. In both of these studies, NH_3 emissions from smaller birds (not roasters) were evaluated using lower acidifier application rates. The NAEMS baseline data were collected without the use of any amendment (Lin et al., 2012). If AFO emissions are regulated, data would be required for a range of conditions, including different bird masses and acidifier application rates.

The overall objective of this study was to evaluate the impact of different SBS application rates (treatments) on NH_3 emissions from roaster houses. Specific objectives were to (1) compare exhaust NH_3 concentrations as affected by treatment and season, (2) evaluate emission rates (ER) from different treatments and seasons, including the contribution of cold-weather (minimum) ventilation, and (3) compare our control treatment ERs with published data. Acidifier application rate effects on in-house NH_3 concentrations and bird performance will be presented elsewhere.

2. Materials and methods

2.1. Farm description and management

The farm was located near Tar Heel, in southeastern North Carolina (NC). It had eight tunnel-ventilated broiler houses 12.5 m × 152.4 m (Fig. 1) aligned N–S and built during 2005–2006. The houses were identical in construction and equipment. The houses had drop ceilings and solid sidewalls on one side while the other sidewall had 1-m curtain. Each house had 11 belt-driven 1.22-m fans and three 0.91-m direct drive fans (Fig. 1). Minimum ventilation was provided by the three 0.91-m fans and one 1.22-m fan (fan 11) (Fig. 1) with fresh air being brought in through intermittent, sidewall inlets operated on static pressure. During warm weather, the houses were tunnel-ventilated with air brought in through 0.15-m thick cool cell pads at one end and exhausted through the other end (Fig. 1). Each house was heated with 17 propane radiant brooders and had its own propane tank and gas meter.

The operations of the fans, curtains, brooders, cool cells, and foggers were controlled by an environmental controller that was adjusted by the producer based on bird comfort. The minimum ventilation fans were timer-controlled while the tunnel fans were controlled by thermostat. There were 13 stages of ventilation (Fig. 2), of which, the first three stages were for heating while the last four stages were for tunnel ventilation. Fig. 2 also shows how the fans were staged; e.g., fans 12 and 13 are operated simultaneously while fan 6 follows fan 5, and so on.

Day-of-hatch Ross chicks, ranging from 20,000 in summer to 21,300 in winter, were placed in each house and raised to ~4 kg ea. and marketed at ~63 d; downtime between flocks was 10–21 d. The chicks were center-brooded in the middle 40% of the house (brood chamber) for 12–14 d and then released into the expansion brooding area (70% of floor area) for another week. The integrator treated the brood chamber with 0.37–0.49 kg m^{-2} (0.075–0.1 lb ft^{-2}) of SBS per flock, increasing with litter age, except for the mid-summer flock that received no SBS. The birds were phase-fed with starter, grower, finisher, and withdrawal diets. Mortalities were recorded daily for each house. After the birds were marketed, the house was de-caked, i.e., the wet, matted fecal cake material (top 25–50 mm) was removed. Litter was completely cleaned out every 2.5–3 years but the houses were not cleaned out during the study.

2.2. Treatment and experimental designs

There were four SBS (Jones-Hamilton Co., Walbridge, OH, USA) application rates or treatments (Table 1) and each treatment was applied to a pair of adjacent broiler houses but emissions were measured from only one of the two houses. While SBS was applied at different rates in the High, Medium, and Low treatments in the whole house, in the Control treatment, it was only applied in the brood chamber (Table 1), consistent with the integrator's standard litter treatment program. Monitoring was performed for eight flocks (Table 1) beginning September 2007 through June 2009. The study began with birds placed on litter that had supported two flocks and litter was not cleaned out during the study.

In the High treatment, the application rate was gradually increased in the brood chamber with each successive flock to balance the SBS application rate to the NH_3 challenge in the house as is standard industry practice. The maximum planned application rate

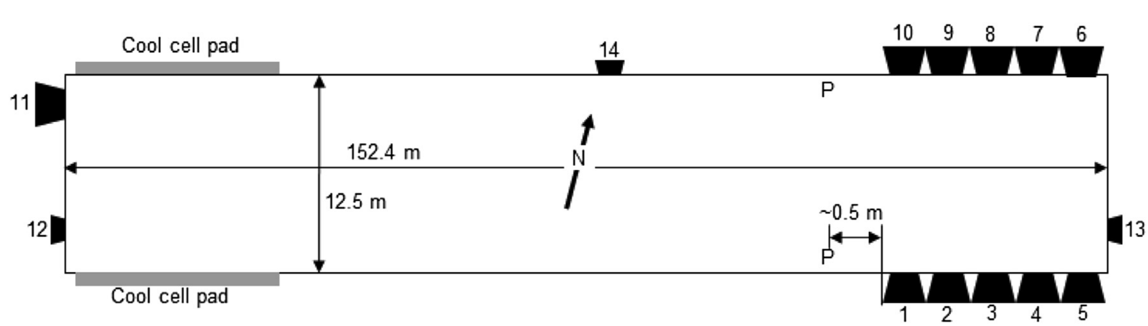

Fig. 1. Layout of the broiler house. Fans 1–11 are 1.22-m fans while fans 12–14 are 0.91-m fans. Differential pressure sensors (P) were installed on the inside walls of the house. Drawing not to scale.