

# Research Note: Stocking density effects on production qualities of broilers raised without the use of antibiotics

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**ABSTRACT** In no antibiotics ever (NAE) broilers, enteric diseases pose a threat to intestinal health and generally welfare, which can be exacerbated because of stocking density. Through knowledge of litter condition and management, disease can be minimized, and broiler welfare can be improved. To evaluate how stocking density influences NAE broilers raised in conventional housing, we evaluated production traits for broilers raised at two stocking densities within a single commercial house. Over the course of 4 flocks, 78,960 Cobb 500 broilers were raised in an industry-style tunnel ventilated house. The house was divided into four equally sized pens, each representing one of two stocking densities. An industry standard stocking density (SSD; 0.23 m<sup>2</sup> per bird) and low stocking density (LSD; 0.27 m<sup>2</sup> per bird) were each assigned to two pens per flock and were alternated for each subsequent flock raised. Litter moisture content, body weight, mortality, and feed conversion (FCR) were

evaluated and averaged over all four flocks for both stocking densities. Data were analyzed in JMP with an ANOVA, and means were separated by Tukey's honestly significant difference. As expected, the litter moisture content was significantly larger in the more densely packed SSD pens at weeks 2, 3, 4, and 6, totaling 0.242 moisture content on average at week 6 vs. 0.217 in LSD pens at the same flock age ( $P = 0.035$ ). Weekly body weight and final flock FCR were not significantly impacted by stocking density. No association was observed in mortality between the broilers raised in SSD and LSD. The results from this study indicate that the two densities examined were comparable in their growth and efficiency. Additional management pressure would exist to handle the increase in litter moisture in flocks placed at SSD in a production setting; although, raised in the same barn at the same time, the impact of SSD vs. LSD was minimal in this study.

**Key words:** broiler, stocking density, no antibiotics ever

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## INTRODUCTION

Understanding consumer perception on broiler welfare is important as it dictates changes in live production management within the broiler industry. A number of studies and reviews have been dedicated to evaluating consumer demand on production practices, with many noting increasing levels of consumer concern on welfare (Vanhonacker and Verbeke, 2009; de Jong and van Trijp, 2013; McKendree et al., 2014; Thaxton et al., 2016; Tonsor, 2018). Consumer concern for the way that food animals are raised has created a movement

toward transparency from producers and the industry (Verbeke et al., 2007). To maintain profitability, it is important for producers to be able to satisfy changing consumer demands while still producing a safe and efficient product.

Consumer demand has also led to decreasing the use of antibiotics in a production setting (Thaxton et al., 2016). Antibiotics have been used by the poultry industry to maintain productive flocks, reduce disease, and enhance growth as reviewed in Donoghue (2003). The uses also included a feed additive growth promotant, which has allowed for producers to have animals that have a lower feed conversion (Tollefson and Miller, 2000). Owing to changing consumer perceptions in animal production, the Food and Drug Administration developed a protocol to approve and determine the safety of antimicrobial drugs used in meat animals.

Antibiotic use in the poultry industry has historically been used to create a safe and affordable product. The

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anti-inflammatory and stress prevention that comes with subtherapeutic antibiotics have a bigger role in broiler health than the actual antimicrobial effect (Cervantes, 2015). When antibiotics are given at a subtherapeutic level for the majority of the production life, they serve as an antimicrobial growth promoter. The benefits of antimicrobial growth promoter can include increased body weights (BW), decreased feed conversion, healthier birds, and a more efficient product (Stutz and Lawton, 1984; Miles et al., 2006).

The antibiotics approved for long-term uses are those that are not absorbed by the digestive tract of the animal (Donoghue, 2003). Although the reduction of subtherapeutic antibiotics resulted in an increase in infections and illness within a flock, the use of prebiotics, probiotics, and good management practices makes it possible to produce poultry products.

In no antibiotics ever (NAE) production schemes, management techniques are more critical to producing healthy broilers than ever before to reduce incidence of disease (Cervantes, 2015). One major focus in management is maintaining high litter quality. Litter quality is correlated with the amount of moisture, which is directly impacted by the number of broilers in the given space (Ritz et al., 2009).

High stocking densities typically cause increased moisture in the litter, promote higher temperatures, and increases levels of ammonia (Ritz et al., 2009). Largely, litter quality reflects the amount of wet litter in the house, which is determined when the amount of moisture being added to the litter exceeds the amount being evaporated (Dunlop et al., 2016). Excessive wet litter can cause problems for broilers because of the amount of time broilers spend in direct contact with the ground. It often results in an increased bacteria load (Wilkinson et al., 2011), footpad dermatitis (Taira et al., 2014), breast blisters (Kaukonen et al., 2016), or hock burns. As the broiler industry continues to change in production management, it is important to understand the impact of adjusting production standards, including stocking density, in nonconventional broilers. In this study, we evaluate stocking density influence of NAE broilers on litter moisture and production traits.

## METHODS

### Broiler Management

The study was approved by the Fresno State Institutional Animal Care and Use Committee (proposal #150). The experiment was conducted using four flocks of Cobb 500 broilers in a commercial-style tunnel ventilated house. The facility has a dirt subfloor and 4 inches of rice hull bedding. It is equipped with evaporative coolers, 10 tunnel fans, 2 exhaust fans, automatic feeders, and industry standard drinker lines. The house was divided into four equal pens for this study. Each pen is equipped with a designated 12-ton capacity feed tank, which allowed feed conversion to be calculated.

**Table 1.** SSD and LSD pen assignments for each flock.

Flock	Pen 1	Pen 2	Pen 3	Pen 4
1	LSD <sup>1</sup>	SSD <sup>2</sup>	LSD	SSD
2	SSD	LSD	SSD	LSD
3	LSD	SSD	LSD	SSD
4	SSD	LSD	SSD	LSD

Abbreviations: LSD, low stocking density; SSD, standard stocking density.

<sup>1</sup>LSD density = 0.27 m<sup>2</sup> per bird.

<sup>2</sup>SSD density = 0.23 m<sup>2</sup> per bird.

At the day of hatch, the broilers received a live coccidiosis vaccine via spray. Birds were placed within each pen designated as either an industry standard (SSD) or low (LSD) stocking density, where SSD was designated at 0.23 m<sup>2</sup> per bird and LSD at 0.27 m<sup>2</sup> per bird. Designated pens for SSD and LSD were rotated throughout the house for each flock (Table 1). To achieve the SSD, two of the four pens in the house were placed with 5,355 broilers, and the two LSD pens were placed with 4,515 broilers. Over four flocks, a total of 78,960 broilers were raised until 6 wk of age.

Flocks were straight-run and raised in accordance to industry standards until day 42. Broilers had ad libitum access to feed and water. Broilers were monitored through an in-person evaluation three times a day throughout the duration of the grow-out period. Daily mortality was recorded.

### Litter Moisture

Weekly, litter moisture was evaluated using an adapted method from the study by Fairchild and Czarick (2011). Each of the four pens were subdivided into four collection sections, with 10 collection locations within each section. At each location spot, a shovel was used to remove all of the litter within a 15.24 × 15.24-cm square, which was collected in to a bucket and thoroughly mixed. After collecting from all locations within the section, litter samples were pooled and mixed. Mixed pooled samples were equally divided among three quart-sized bags for replication. Fifty grams from each bag was weighed and put into an aluminum pan, with three replicates per bag. The pans were put into a drying oven at 49°C for 48 h, until all of the moisture had been eliminated. Pans were removed from drying oven and weighed to calculate moisture content as (dried litter weight)/(total litter weight).

Weekly pen BW averages were estimated through weekly weighing of 100 individuals evenly distributed in each pen using an Electro Samson poultry scale (Brecknell, SA3N253, Fairmont, MN) with a shackle attachment. Beginning day 28, the birds were externally sexed, and equal numbers of males and females were weighed. At the end of each flock, feed conversion ratio was calculated by (feed consumption for each pen)/(estimated flock weights).

### Statistical Analysis

To accommodate for environmental variation in different parts of the broiler house and between seasons

**Table 2.** Proportion of moisture in the litter for SSD and LSD over four flocks.

Stocking density	SSD <sup>1</sup>	LSD <sup>2</sup>	<i>P</i> value
Week 1	0.081 ± 0.002	0.073 ± 0.003	0.051
Week 2	0.124 ± 0.005 <sup>a</sup>	0.095 ± 0.003 <sup>b</sup>	<0.001
Week 3	0.201 ± 0.006 <sup>a</sup>	0.160 ± 0.004 <sup>b</sup>	<0.001
Week 4	0.264 ± 0.007 <sup>a</sup>	0.238 ± 0.008 <sup>b</sup>	0.023
Week 5	0.279 ± 0.004	0.269 ± 0.005	0.177
Week 6	0.242 ± 0.008 <sup>a</sup>	0.217 ± 0.008 <sup>b</sup>	0.035

<sup>ab</sup>Means with difference superscripts in the same row differ within each time point ( $P < 0.05$ ).

Values reported weekly as (dried litter weight)/(total litter weight) averaged by stocking density ± SEM by week.

Abbreviations: LSD, low stocking density; SEM, standard error of the mean; SSD, standard stocking density.

<sup>1</sup>SSD density = 0.23 m<sup>2</sup> per bird.

<sup>2</sup>LSD density = 0.27 m<sup>2</sup> per bird.

the flocks were raised in, data collected for each pen and flock were considered together. Means of raw and calculated data were compared with an ANOVA, and means were separated using Tukey's honestly significant difference in JMP Pro (version 11.0.0; SAS Institute Inc., Cary, NC). Significance was determined at  $P \leq 0.05$ .

## RESULTS AND DISCUSSION

At the end of the first week of production across all flocks, the litter in the designated SSD areas was calculated at a proportion of 0.081 moisture vs. 0.073 measured in the LSD areas (Table 2). This difference approached significance at  $P = 0.051$ . As is expected with increasing the number of birds within a space, litter moisture content increased as the flocks aged. The more heavily stocked SSD pens exhibited a significant increase in litter moisture beginning at week 2, which extended into weeks 3, 4, and 6. At week 6, a 0.025 difference existed between the SSD and LSD litter.

Significant variation in BW between SSD and LSD at the same time points were not detected (Table 3), contrary to what was seen in the study by [Zuowei et al. \(2011\)](#). In addition, the average calculated mortality was not determined to be significantly different between the two stocking densities (Table 4). Weekly SSD mortality reached its peak in week 4 at 0.021, compared with 0.012 in LSD birds, but this difference was not significant ( $P = 0.531$ ). Overall, mortality was not significantly variable between the two stocking densities.

**Table 3.** Body weight (g) of SSD and LSD over four flocks.

Stocking density	SSD <sup>1</sup>	LSD <sup>2</sup>	<i>P</i> value
Week 1	168.96 ± 4.83	169.52 ± 5.74	0.941
Week 2	461.53 ± 13.86	460.96 ± 13.97	0.977
Week 3	954.81 ± 19.71	951.97 ± 21.36	0.923
Week 4	1598.91 ± 24.51	1625.56 ± 24.38	0.453
Week 5	2286.67 ± 19.40	2296.31 ± 27.34	0.778
Week 6	2946.65 ± 62.43	3016.39 ± 43.10	0.375

Values reported as averages ± SEM by week.

Abbreviations: LSD, low stocking density; SEM, standard error of mean; SSD, standard stocking density.

<sup>1</sup>SSD density = 0.23 m<sup>2</sup> per bird.

<sup>2</sup>LSD density = 0.27 m<sup>2</sup> per bird.

**Table 4.** Mortality of SSD and LSD over four flocks.

Stocking density	SSD <sup>1</sup>	LSD <sup>2</sup>	<i>P</i> value
Week 1	0.014 ± 0.001	0.014 ± 0.001	0.765
Week 2	0.006 ± 0.001	0.007 ± 0.000	0.828
Week 3	0.017 ± 0.010	0.009 ± 0.002	0.477
Week 4	0.021 ± 0.012	0.012 ± 0.004	0.531
Week 5	0.012 ± 0.003	0.011 ± 0.002	0.862
Week 6	0.010 ± 0.001	0.011 ± 0.002	0.725

Values reported weekly as (mortality)/(number of birds) averaged by stocking density ± SEM by week.

Abbreviations: LSD, low stocking density; SEM, standard error of mean; SSD, standard stocking density.

<sup>1</sup>SSD density = 0.23 m<sup>2</sup> per bird.

<sup>2</sup>LSD density = 0.27 m<sup>2</sup> per bird.

The total percent mortality averaged over all flocks for all LSD birds was 4.42%, compared with 3.59% in SSD birds.

Finally, a significant difference between SSD (1.67) and LSD (1.81) feed conversion was not observed ( $P = 0.093$ ). It is important to note that had more data points existed in the calculation of average FCR for both SSD and LSD, where bird weight and feed consumption were measured on a per bird basis, and the difference reported may result in statistical significance. Ultimately, while the difference was not significant, the 0.14 disparity in FCR translates into a substantial cost in feed between stocking densities for the purpose of this study. Flock effects were not present.

The results of the present study indicate that increasing the amount of space per broiler from an industry SSD at 0.23 m<sup>2</sup> per bird to a lower stocking density at 0.27 m<sup>2</sup> per bird did not significantly influence the mortality, feed conversion, or BW. Based on these results, NAE birds weight raised until day 42 at an SSD will result in increased litter moisture; however, both moisture values were within an acceptable range for broiler production ([Watkins, 2001](#)), which can mitigate bacterial load and ammonia production in litter with high moisture content ([Dumas et al., 2011](#), [Miles et al., 2011](#)). Importantly, an increase in litter moisture is associated with increased foot pad dermatitis lesions ([Shepherd and Fairchild, 2010](#)). Finally, minimal impact was recorded for mortality and FCR between stocking densities in this study.

[Zuowei et al., 2011](#) reared 1,896 conventional broilers until day 42, assigned to high (42 kg) and low (26 kg) stocking densities, where the broilers raised in high stocking densities had an overall lower BW and higher FCR than broilers raised in low stocking densities. [Simitzis et al., 2012](#) evaluated 208 broilers raised in stocking densities of either 6 bird/m<sup>2</sup> or 13 birds/m<sup>2</sup> until day 48. Overall, broilers raised at 6 bird/m<sup>2</sup> averaged 218 g heavier than the broilers raised at 13 birds/m<sup>2</sup>. Yet, the broilers raised at 13 birds/m<sup>2</sup> had a lower FCR.

The present study does represent large-scale application of stocking density evaluations in a commercial setting revolving around economically important traits. External and internal evaluations were not completed in this study, so associations of health parameters as it

relates to increased litter moisture between stocking densities were not assessed; however, the processing plant did not report a difference in condemnation rate between SSD and LSD broilers. An evaluation on the impact of economically important afflictions associated with increased mortality (e.g., breast burns) is warranted in future work evaluating stocking density.

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