Final Report: Evaluation of the Use of the AviHome Plenum Flooring System in Commercial Broiler Production in Georgia

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1. Demonstration Background

The purpose of the project was to compare the efficacy of a litter-less, plenum flooring system (LFS, developed by AviHome, LLC) to a traditional litter bedding system on a commercial broiler farm.

Broiler house floors have several types of material that is used to absorb/dilute the manure moisture. These include pine shavings, peanut hulls, rice hulls, corn stover, and chopped straw. In the U.S., broiler farms reuse litter for multiple flocks. This practice results in a buildup of manure within the bedding material with a corresponding increase in ammonia (NH_3) production.

Ammonia in poultry houses lowers performance and may increase disease susceptibility. It has been suggested that NH_3 should not exceed 25 ppm in poultry houses (Carlile, 1984). However, prolonged exposure to concentrations as low as 20 ppm can be detrimental to bird health and performance, when poultry remain in such an environment throughout the production period (Anderson et al, 1964). These recommended levels have been reinforced within a more recent study in which broilers exhibited lower BW gains when exposed to NH_3 levels of 25 ppm or greater (Miles et al, 2004). Broiler feed consumption and feed efficiency has been shown to decrease during exposure to levels of NH_3, ranging from 25 to 125 ppm (Miles et al, 2004; Charles and Payne, 1966; Johnson et al, 1991).

Ammonia is produced as a by-product of the microbial decomposition of the organic nitrogen compounds in manure. Nitrogen occurs as both unabsorbed nutrients in manure and as either urea (mammals) or uric acid (poultry). The volatilization of NH_3 can be highly variable depending on the total NH_3 concentration, temperature, pH, and moisture. Under acidic

conditions (pH values around 7.0 or less) ammonium is the predominant species, and NH_3 volatilization occurs at a low rate.

A number of strategies & technologies to reduce NH_3 generation and volatilization have been studied for many years (Ritz, et al., 2004). Some of the more popular mitigation strategies today are 1) Nutrition, 2) Litter Amendments/Acidifiers, and 3) alternative bedding materials in lieu of wood shavings. While each of the options has their unique advantages, they also come with their limitations while only mitigating and not fully resolving the issues of NH_3 production.

Earlier commercialization attempts of a ventilated flooring system have failed due to the inability to overcome cost and technical issues.

2. Demonstration Objectives

AviHome's goals for the project were to demonstrate the viability of the litter-less flooring system (LFS) in a true commercial setting. Targeted goals were as follows:

- Reduce ammonia levels by 80% or more as compared to the control houses
- Reduce energy use by 10% as it relates to gas and electricity compared to control
- Improve feed conversion by at least 4% as compared to control
- Reduce dust and particulate material by 30% as compared to control
- Increase retention of nitrogen in the manure in lieu of emission

Poultry researchers at the University of Georgia were approached to conduct a commercial scale evaluation of the LFS system. Two broiler farms contracting with two cooperating poultry companies participated in the evaluation of the LFS system with on-site control houses that utilized traditional pine shavings bedding material.

3. Demonstration Set-up

Two commercial broiler farms from two separate poultry companies were part of the LFS evaluation. One farm served as the primary testing site while the other served as an observation site for supplemental data under commercial production management conditions. The primary test farm consisted of 4 tunnel ventilated broiler houses, each with dimensions of 50 feet wide and 500 feet long. The houses are heated with radiant brooders and forced air furnaces. Two of the houses served as standard control housing with traditional pine shavings bedding material. The other two houses were retrofitted to accommodate the LFS. The dirt floors in the treatment houses were leveled and packed to form a stable base for the LFS, which was installed and set up to specifications for function and fan placement by AviHome.

The litter-less flooring system (LFS) manufactured by AviHome is comprised of two 18" x 18" interlocking polymer based tiles to create an air space underneath the birds/manure through which air/moisture can be removed (Pictures 1 and 2). The bottom tile is a configuration of cone pegs that create a continuous air space and is engineered to support typical heavy equipment loads. The top tile which is mounted directly on the bottom tile is purportedly designed to create a permeable screen to wick moisture from the chicken feces while maintaining the manure mass on the top. The proprietary polypropylene polymer blends used to produce the floor are

hydrophobic, inert, and resistant to virtually all chemicals. On the ground, underneath the tiles, is a plastic vapor barrier (Picture 1).

Picture 1. Assembly of the litter-less flooring system (LFS) manufactured by AviHome.

Picture 2. Plenum fan configuration.

The buildings at the primary test site were fitted with monitoring equipment to collect data for the following: 1) gas usage, 2) electricity usage, 3) temperature and relative humidity, 4) ammonia concentration, 5) dust concentration, 6) darkling beetle populations.

The gas, electricity, temperature and relative humidity data were collected every 15 minutes. Ammonia concentrations were monitored every 15 minutes for 3 flocks. Dust concentrations were monitored every 15 minutes for 10 hour periods during three flocks.

The populations of darkling beetles were compared within the housing through use of Arends tube Trap (Safrit and Axtel, 1984). These were 1 foot sections of 2 inch diameter PVC pipe with corrugated cardboard rolled into the tubes. Six traps were placed within each of the houses and left in place for 1 week at the end of each flock and just prior to catch. The number of adult litter beetles were then enumerated for both houses in each treatment.

Foot pad quality was monitored in the last week of each flock. The feet of 100 randomly selected birds were evaluated and assigned a paw score. The paw scores were assigned using a visual ranking system to categorize footpad lesions. A score of "0" for no lesion present, a score of "1" for a mild lesion (lesion ≤ 7.5mm) and a score of "2" for a severe lesion (lesion > 7.5 mm). (Bilgili et al., 2006).

4. Demonstration Results

A total of 6 flocks were monitored during the study with the exception of particulates and NH_3. The NH_3 was monitored for flocks 4-6, the particulates were measured during flocks 1,2, and 4. For reporting purposes, broiler houses with traditional bedding are labeled Control, while the broiler houses with the flooring system were labeled as LFS.

4-A. **Broiler House Production Conditions**

<u>Energy Usage</u>

Energy usage for the LFS houses exceeded that of the control houses (Figures 1 and 2). The LFS houses were more difficult to heat and maintain sufficient temperatures to successfully brood chicks, resulting in additional energy usage compared to the control houses. LFS house set temperature was increased by the grower, based on chick behavior, to achieve warmer floor temperatures suitable for the chicks. Poultry houses use ventilation to control moisture. The grower used a higher ventilation rate in the LFS house to dry the top layer of manure that the birds come in contact with. The original plan was to not use circulation fans in the LFS houses. However, circulation fans were operated to move heat from warmer parts of the house to cooler parts of the house and to break up temperature stratification. As a result, fuel and electricity usage for each flock with the LFS exceeded that of the control houses

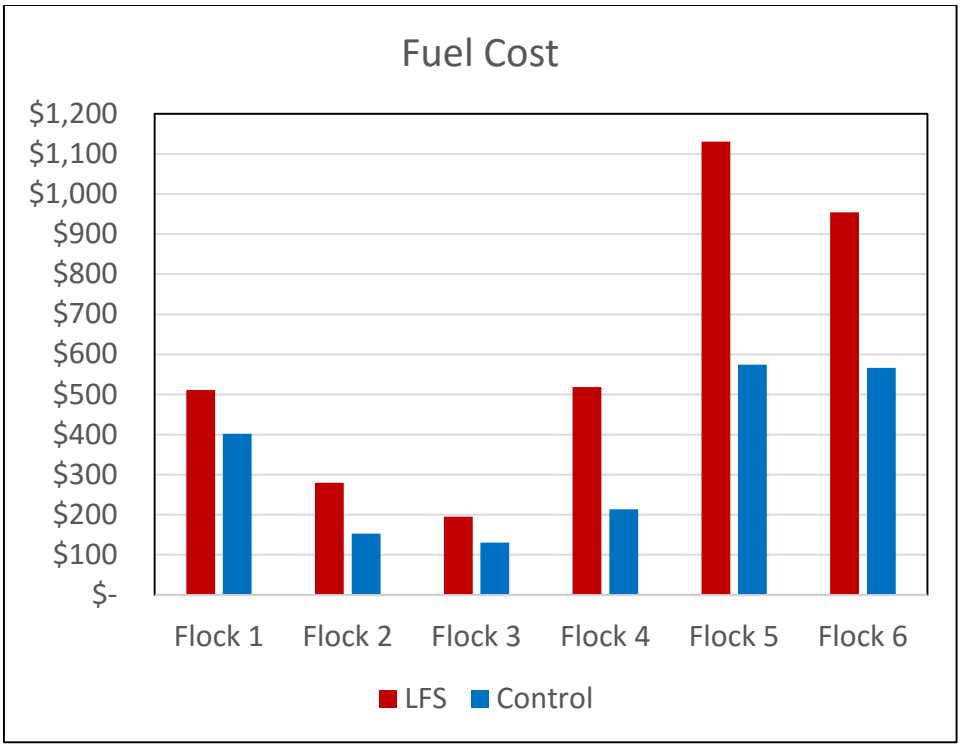

Figure 1. Comparison of pine shaving flooring (Control) with the litter-less flooring system (LFS) on fuels cost per flock.

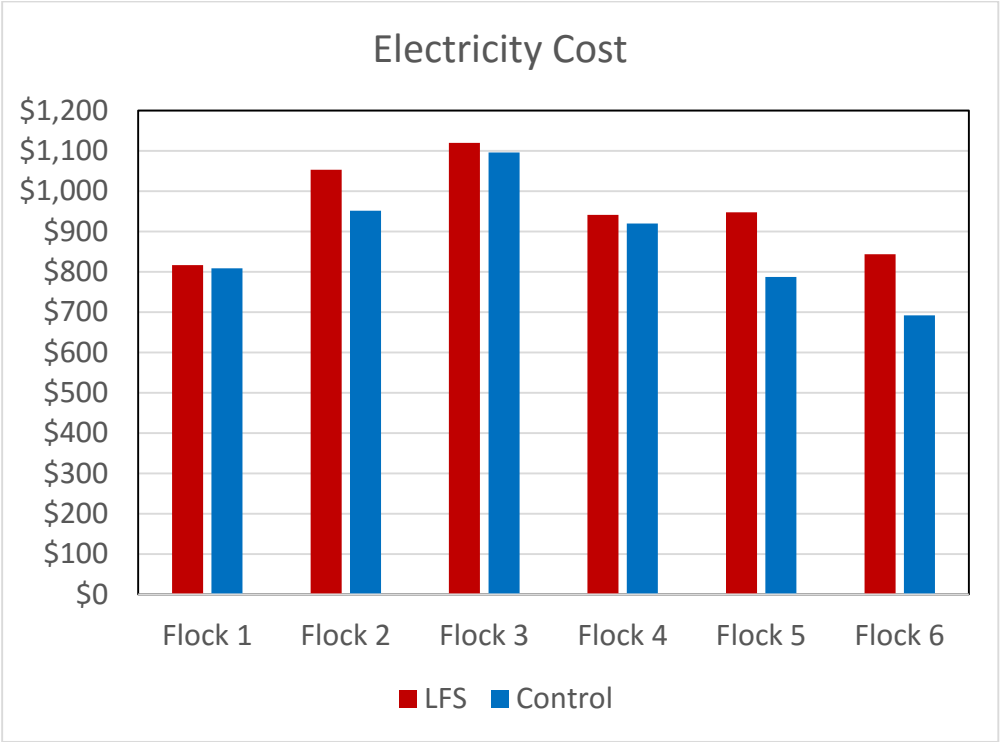

Figure 2. Comparison of pine shaving flooring (Control) with the litter-less flooring system (LFS) on electricity cost per flock.

Temperature and Relative Humidity

The temperature and relative humidity, following adjustment for brooding temperatures in the LFS houses, responded very similar between the two flooring systems with analogous results in each flock (Figures 3-8)

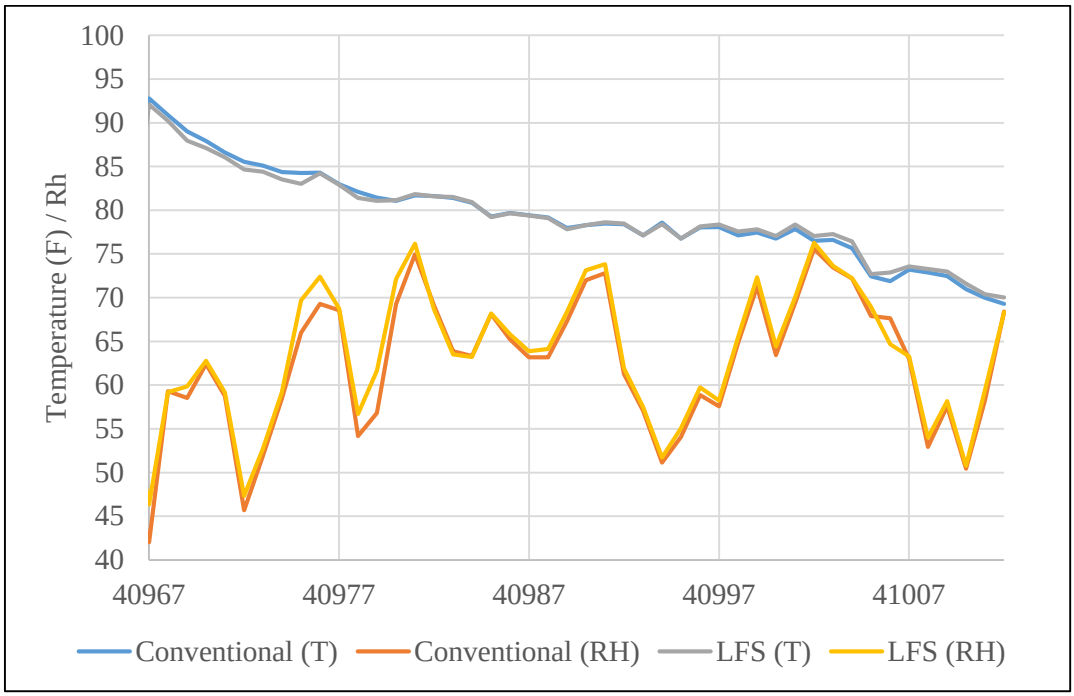

Figure 3. Flock 1 broiler house temperature and relative humidity.

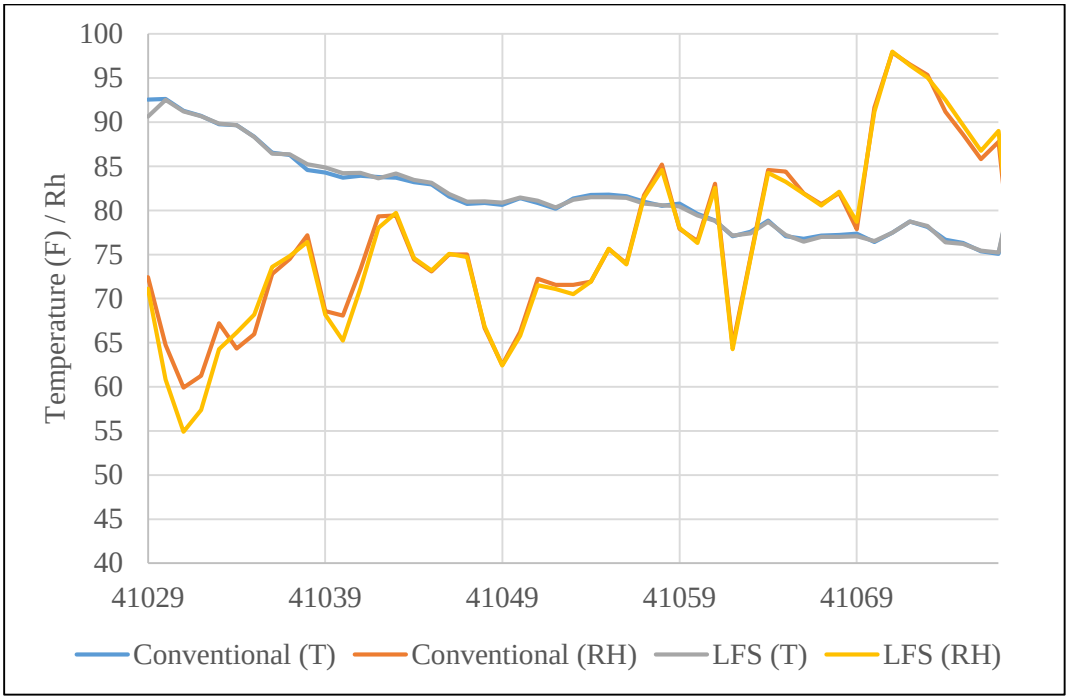

Figure 4. Flock 2 broiler house temperature and relative humidity.

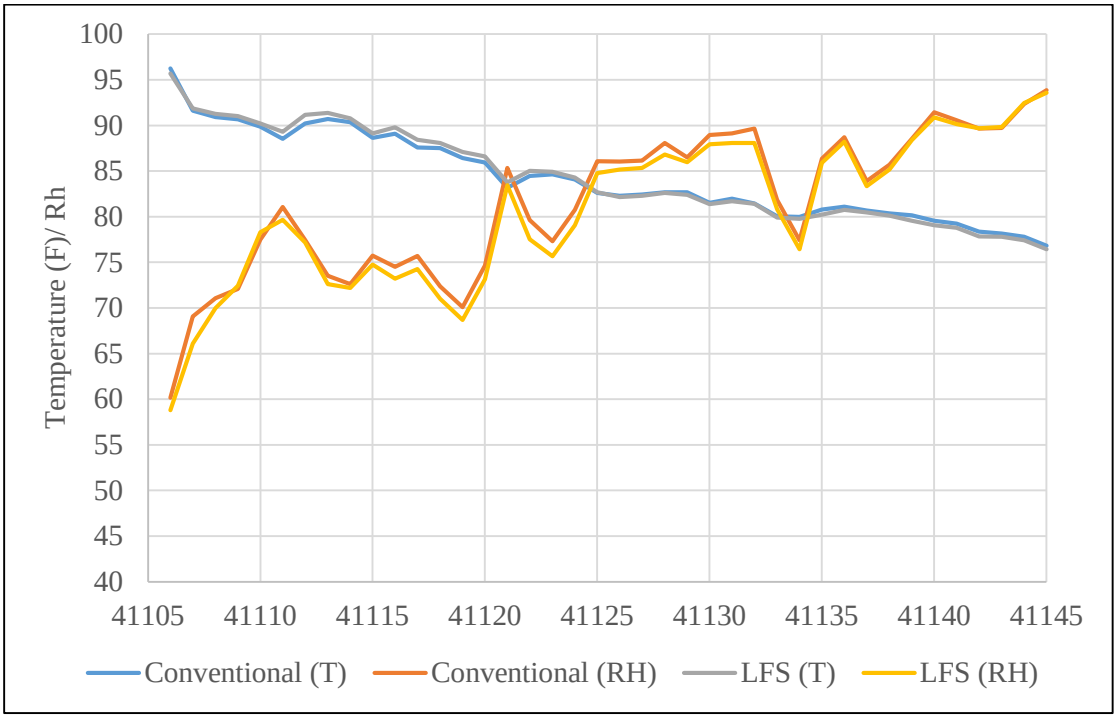

Figure 5. Flock 3 broiler house temperature and relative humidity.

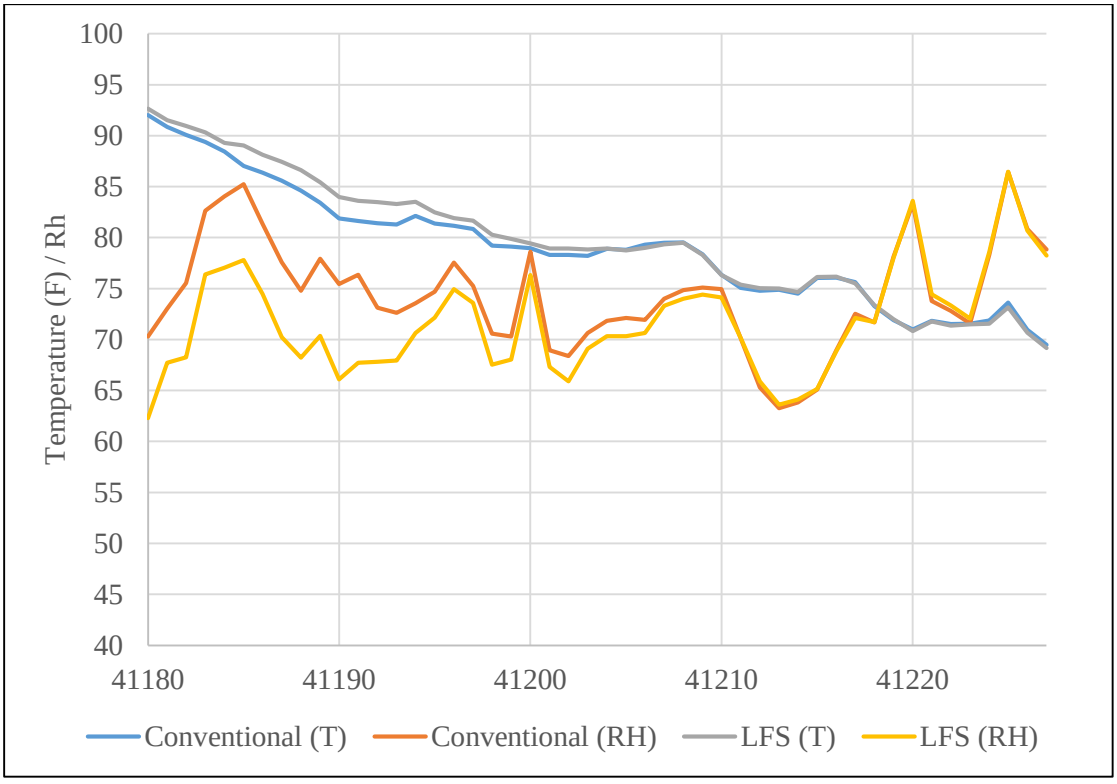

Figure 6. Flock 4 broiler house temperature and relative humidity.

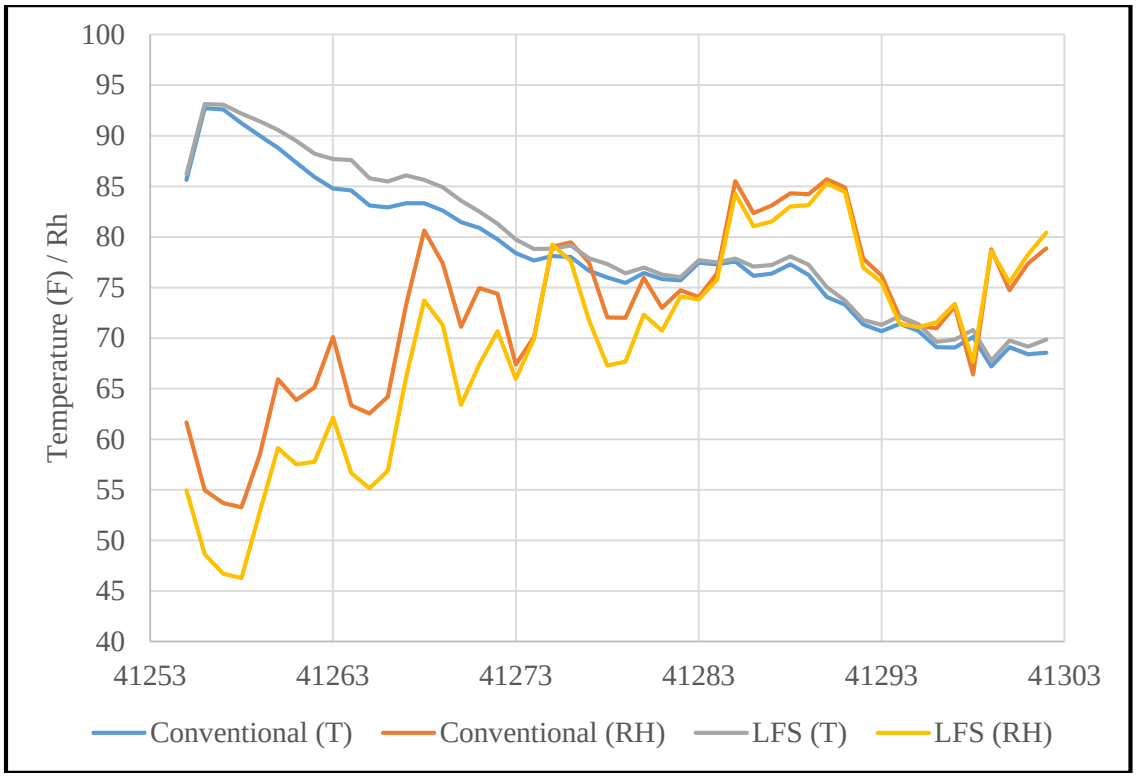

Figure 7. Flock 5 broiler house temperature and relative humidity.

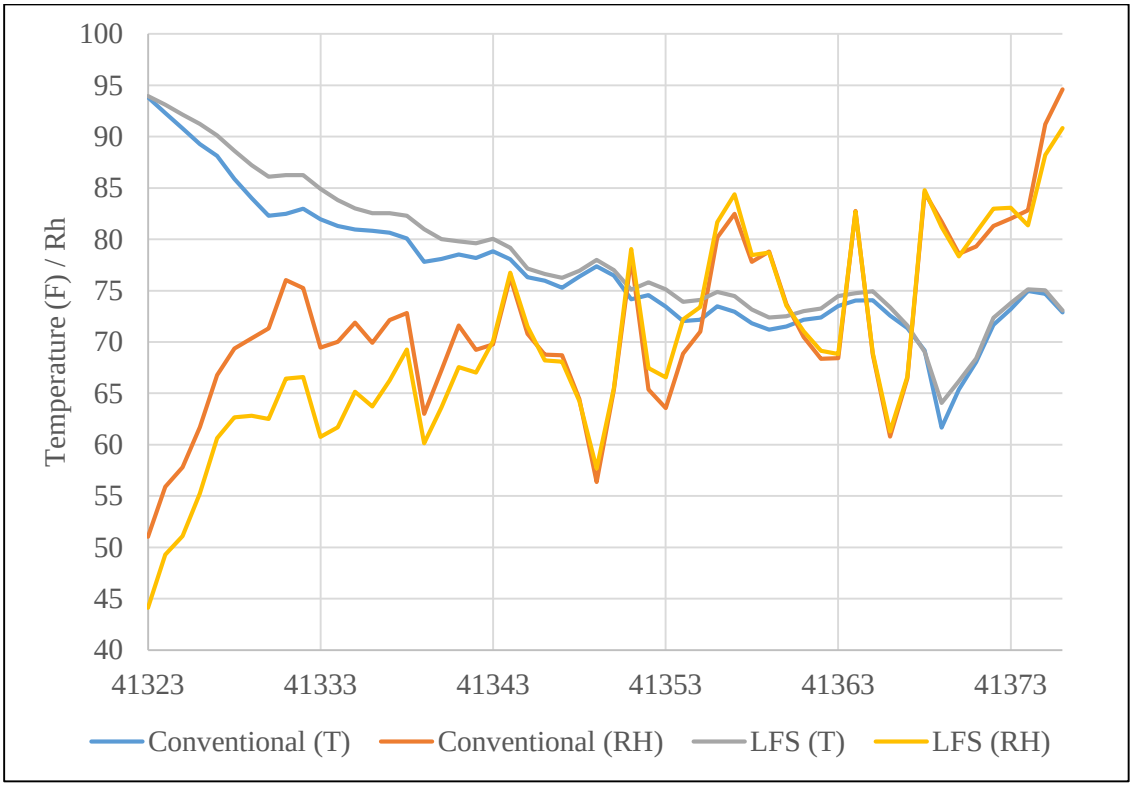

Figure 8. Flock 6 broiler house temperature and relative humidity.

Ammonia Concentrations

In-house NH_3 concentration in parts per million (ppm) was monitored using MSA Chillgard RT Ammonia Monitors, which employ photoacoustic spectroscopy for trace gas detection.

Ammonia was reduced within the LFS housing during the initial 4-5 weeks for each flock studied. The levels of NH_3 concentration within the broiler houses were similar in weeks 5-7 once the birds reached the period of their fastest growth and largest volume of manure deposition (Figures 9-11).

The grower cleaned out one of the control houses and applied fresh pine shavings prior to Flock 4. This was part of the farms normal operating procedures. Both of the Control houses would have been cleaned out, but due to rainy weather and the amount of time available between flocks, only one house was able to be completely cleaned and rebedded with 3 inches of fresh shavings. As a test, 1.5 inches of shavings was placed on top of the LFS in one treatment house. Ammonia levels similar to the LFS houses were observed in the Control house with fresh bedding during the first 2 weeks. The Control house with the fresh shavings and the LFS house with 1.5 inches of shavings had similar NH_3 levels as the Control house that had used litter. The LFS house with a light dusting of shavings had the lowest NH_3 during the first 5 weeks. All houses had similar NH_3 concentrations during the last two weeks of the flock (Figure 9).

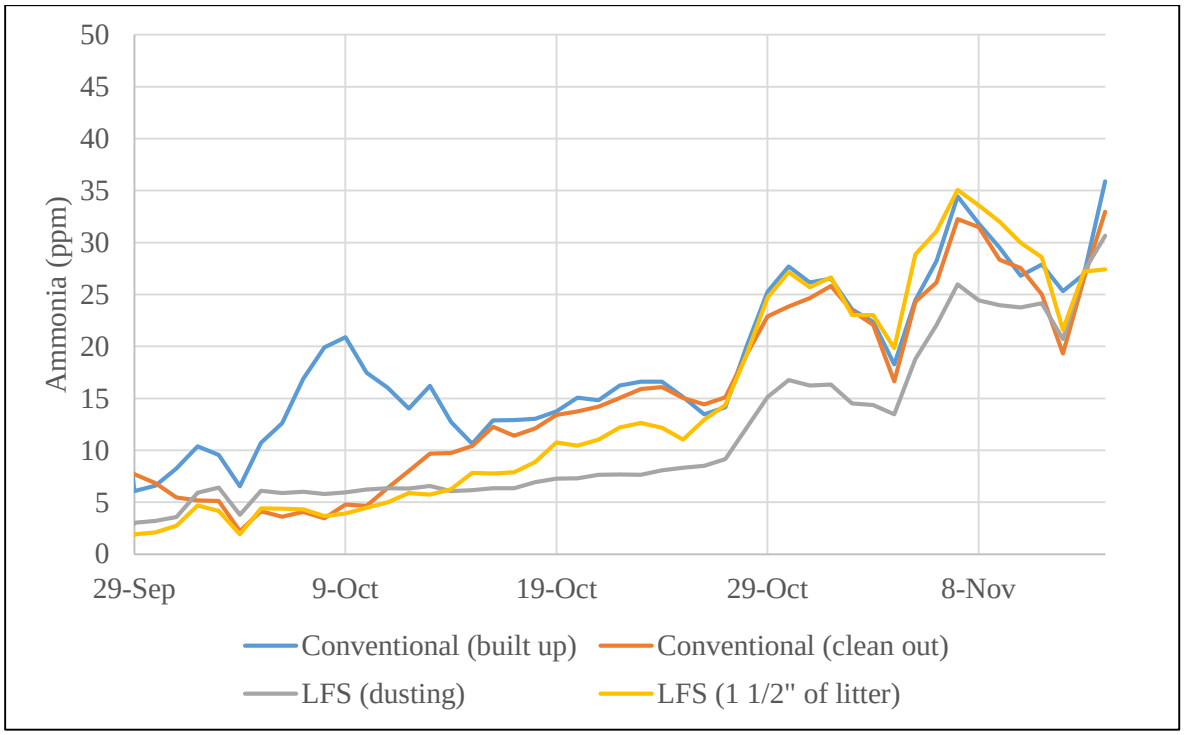

Figure 9. Comparison of ammonia concentration (ppm) among the four broiler houses (Flock 4). One Control house was cleaned out and fresh shavings applied and the other had used litter. One LFS house had a dusting of shavings on the floor while the other LFS house had 1.5 inches of bedding.

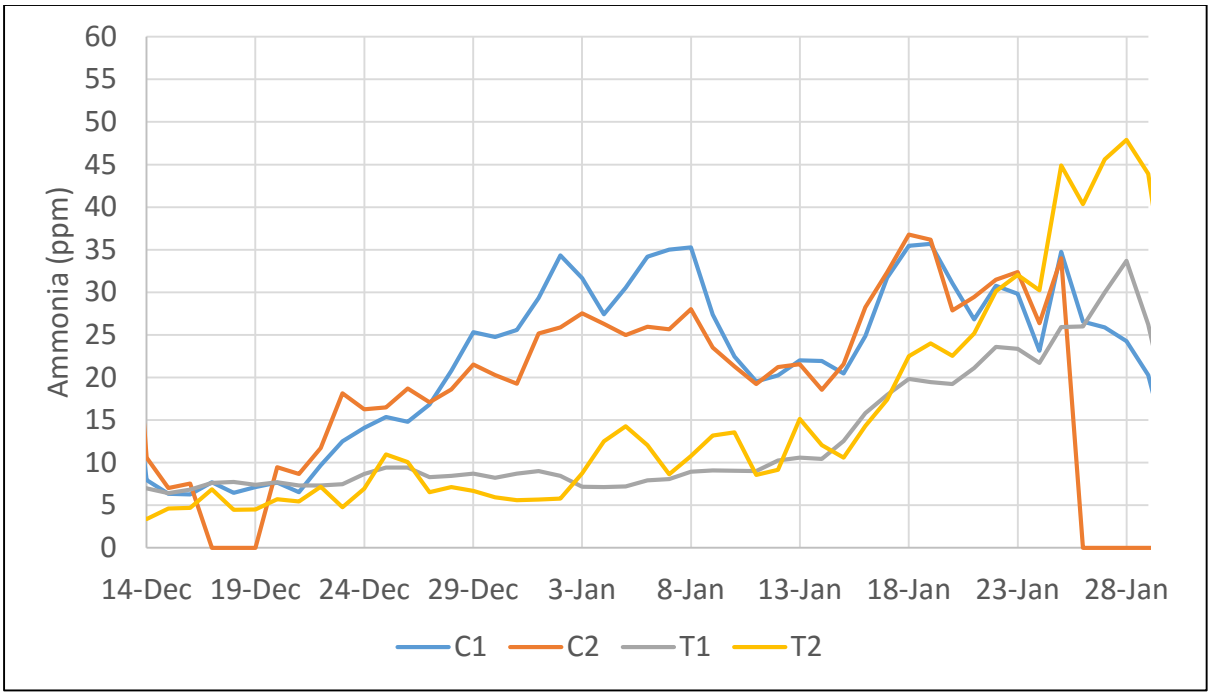

Figure 10. Comparison of pine shaving flooring (C1, C2) with the litter-less flooring system (T1, T2) on in-house ammonia concentration (ppm) for Flock 5.

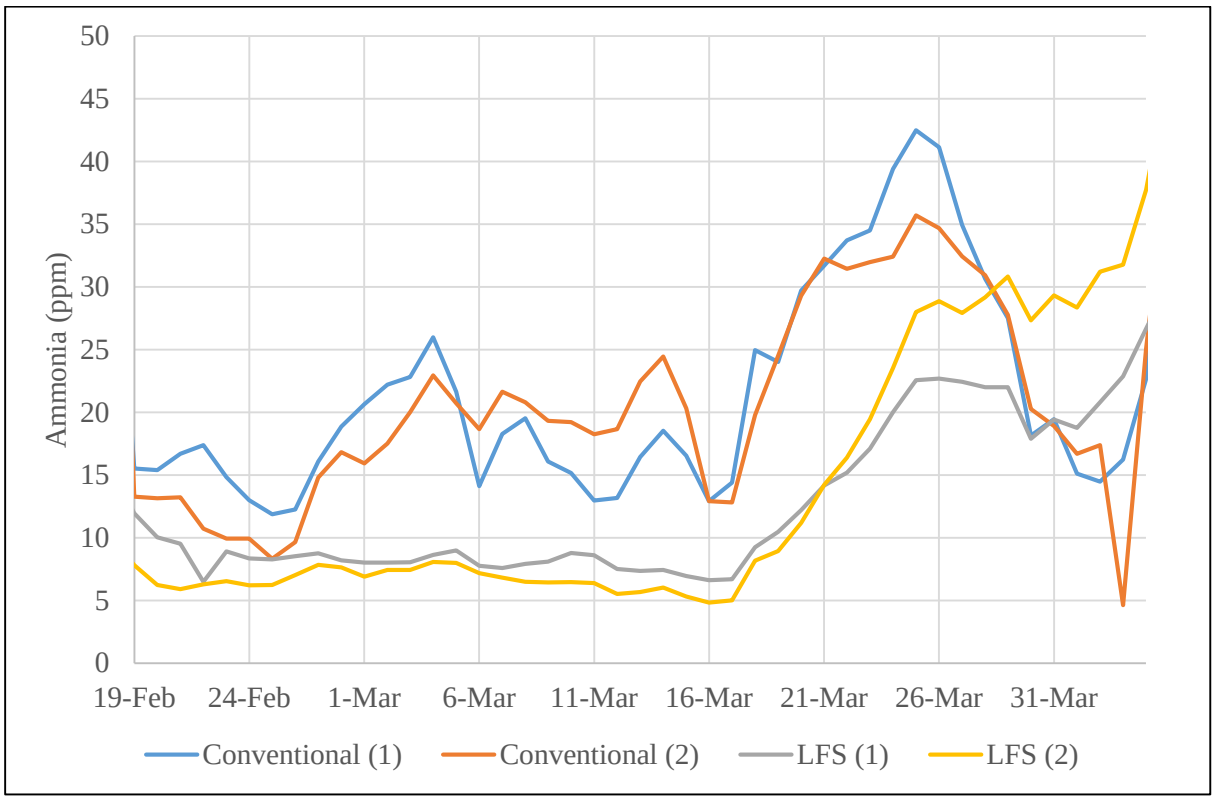

Figure 11. Comparison of pine shaving flooring (C1, C2) with the litter-less flooring system (T3, T4) on in-house ammonia concentration (ppm) for Flock 6.

Representative manure analyses from the study (Table 1) shows a slightly higher percentage of total nitrogen from samples in the LFS housing compared to the control. This is likely be due to the lack of carbon bedding material that promotes growth of bacterial populations that degrade manure nitrogen into NH_3. Phosphorus and potassium levels were not influenced by flooring type. Percent manure moisture was slightly elevated within the LFS housing while manure pH was reduced. Most broiler litter is land applied as a fertilizer. The minor increase in nitrogen noted in this study would not provide any increased financial benefit nor would it change litter application rates due to the limitations in the equipment used for typical land application of litter.

Table 1. Representative comparison of pine shaving flooring (Control) with the litter-less flooring system (LFS) on manure nutrient analysis, manure moisture and manure pH.

	% N	*% P (P_2O_5)*	*% K (K_2O)*	*% Moisture*	*pH*
Control	2.56	2.28	2.54	28	7.6
LFS	3.43	2.23	2.30	30	6.1

Particulate Concentrations

In-house particulate concentration (mg/m^3) was monitored using TSI Dust Trak DRX Aerosol Monitors. Particulate concentrations tended to be lower in the LFS houses than in the control houses (Table 2). Differences between the treatments tended to be greater early on in the flock when the variations in litter/manure depth were the greatest. Toward the end of the flock, the accumulation of manure in the LFS house facilitated the generation of more airborne particulates compared to the beginning of the flock when there was essentially no litter/manure in the house.

Particulate concentrations appeared to be influenced by both litter depth and ventilation rates. For instance, particulate concentrations were high in both the LFS and control houses toward the end of Flock 1 due to the fact that litter/manure depth was at its greatest and ventilation rates were minimal due to low outside temperatures. At the end of Flock 2, litter/manure depths were at their highest in both houses while ventilation rates were high due to fact that both houses were in tunnel ventilation mode due to high outside temperatures.

Table 2. Comparison of pine shaving flooring (control) with the litter-less flooring system (LFS) on in-house total (PM-1 to PM-10) aerosolized particulate concentration (mg/m^3).

Flock 1						
Age (days)	5	15	29	36	43	
Control	1.04	0.88	1.11	0.91	4.51	
LFS	1.47	0.93	0.97	0.87	4.12	
% Difference	34.3%	5.7%	-13.2%	-5.1%	-9.1%	
Flock 2						
Age (days)	8	15	22	29	35	42
Control	1.39	0.89	1.04	0.86	1.84	0.43
LFS	0.32	0.56	0.43	0.42	1.40	0.50
% Difference	-125.4%	-46.1%	-82.6%	-69.4%	-26.7%	13.5%
Flock 4						
Age (days)	31	45				
Control	2.05	3.00				
LFS	1.08	2.75				
% Difference	-62.50%	-8.5%				

Darkling Beetle Populations

Darkling beetles have been shown to be vectors for both viruses and bacteria. Poultry can be infected with these organisms by consuming the beetles that are carrying the pathogens. Beetles also cause damage to poultry housing as the larvae tend to burrow into the insulation and other materials to pupate. This damage can result in increased utility costs due to reduce insulation values. Darkling beetles, while present in the LFS houses, were present in much lower numbers as compared to the control houses (Table 3). The lack of bedding material, combined with the inability to access the dirt floor, reduced the area that beetles had to hide from the birds.

Table 3. Comparison of pine shaving flooring (Control) with the litter-less flooring system (LFS) on litter beetle populations. Data for each flock is the total number of adult beetles collected from within a treatment.

	Flock 1	*Flock 2*	*Flock 3*	*Flock 4*	*Flock 5*	*Flock 6*
Control	480	738	191	205	242	245
LFS	187	32	37	3	30	5
% Difference	88	184	135	194	157	192

4-B. **Litter-less Flooring System Component Performance**

As the flooring system was removed from each house at the termination of the study, the number of damaged tiles was calculated. On the primary test farm, approximately 11,110 tiles were used to cover the 25,000 ft^2 in each of the LFS houses. On this farm, there as a total of 54 broken tiles in the houses at the end of the study. At the end of each previous flock, the grower had to replace a number of damaged tiles resulting in time and effort not anticipated with the flooring system. On the second farm, the one treatment house had approximately 8,890 tiles covering 20,000 ft^2. Eighty-one broken tiles were counted at the end of the final flock. It should be noted that both farms had to get extra tiles shipped to them during the study for the growers to replace broken and crushed tiles after each flock. The edges of many of the tiles started to rise, causing these tiles to be caught by catching and house cleaning equipment. It was observed that as heavy equipment moved across the floor, the tiles would occasionally flex (possible due to uneven floor compaction/grading), allowing a very small amount of fine litter particles to get under the edge of the tiles. The amount to which the edges were raised appeared to increase over time. If the edge of the tile raised too much, it would be caught by a piece of equipment (scrape blade, transport coop, fork lift, etc.). This resulted in damage of that tile as well as adjacent tiles and even the bottom supporting component. In some cases the cone pegs which were part of the bottom tile were damaged. Examples of the damage are shown in Pictures 3-12. Both growers complained about the amount of time and labor involved with replacing tiles. The increasing incidence of the elevated tile edges raised serious concern among the growers and poultry companies about the longevity of the flooring system.

Picture 3. Raised tile edges

Picture 4. Raised tile edges

Picture 5. Raise edges and broken tiles.

Picture 6. Raised tile edges

Picture 7. Broken tiles

Picture 8. Broken tiles

Picture 9. Broken tiles

Picture 10. Broken tiles

Picture 11. Damaged support cones

Picture 12. Damaged support cones

4-C. **Broiler Production Performance**

Bird performance data has been provided courtesy of Fieldale Farms, Inc., the company for the primary testing site.

Body Weight and Feed Conversion

Final bird body weight and feed conversion (Table 4.) are the main points which grower payments are made within the broiler industry. Any processes or practices that impact body weight and feed conversion will have a direct impact on farm profitability. Increases in bird mortality directly impact total body weight of the flock with a corresponding reduction in salable product. First week mortality within the LFS houses was consistently higher due to the difficulty experienced with heating of the houses for bird comfort during the critical 10-14 day brooding period. The plastic flooring is a better conductor of heat where pine shavings is a better insulator. The result is that the LFS floors were colder to birds as they were often found huddling throughout the house. The grower adjusted the house temperature based on observations of bird behavior to provide warmer conditions and to prevent the chicks from huddling. Average body weight and feed conversion were similar between the control and treatment.

Table 4. Comparison of pine shaving flooring (Control) with the litter-less flooring system (LFS) on broiler production performance.

Flock 1

Houses	Head started	PCT liv	1 wk Mort	AVG Wt.	Feed Conv.	Conv. 6.00	Pct Cndm	Gain/day
Control	59600	97.88	0.95	6.25	1.88	1.86	0.49	0.131
LFS	59600	95.91	1.4	6.11	1.89	1.88	0.64	0.128

Flock 2

Houses	Head started	PCT liv	1 wk Mort	AVG Wt.	Feed Conv.	Conv. 6.00	Pct Cndm	Gain/day
Control	59600	96.48	1.6	6.06	1.94	1.93	0.41	0.127
LFS	59600	97.53	2.3	5.73	1.95	1.97	0.54	0.120

Flock 3

Houses	Head started	PCT liv	1 wk Mort	AVG Wt.	Feed Conv.	Conv. 6.00	Pct Cndm	Gain/day
Control	59600	95.49	1.7	6.35	1.94	1.94	0.44	0.127
LFS	59600	95.94	1.6	6.39	1.90	1.89	0.66	0.128

Flock 4

Houses	Head started	PCT liv	1 wk Mort	AVG Wt.	Feed Conv.	Conv. 6.00	Pct Cndm	Gain/day
Control	59600	96.45	1.2	6.89	1.84	1.77	0.56	0.144
LFS	59600	95.47	1.7	6.87	1.86	1.79	0.51	0.144

Flock 5

Houses	Head started	PCT liv	1 wk Mort	AVG Wt.	Feed Conv.	Conv. 6.00	Pct Cndm	Gain/day
Control	59600	95.89	1.0	6.35	1.92	1.89	1.62	0.128
LFS	59600	95.93	2.0	6.52	1.88	1.83	1.04	0.133

Flock 6

Houses	Head started	PCT liv	1 wk Mort	AVG Wt.	Feed Conv.	Conv. 6.00	Pct Cndm	Gain/day
Control	59600	94.90	0.7	5.76	1.95	1.97	10.12	0.125
LFS	59600	95.57	1.1	5.79	1.89	1.91	1.03	0.126

Key:

PCT liv	Livability
1 wk Mort	1st week mortality
Avg Wt.	Average body weight
Feed Conv	Feed conversion
Conv. 6.00	Feed conversion adjusted to 6 lbs
Pct Cndm	Percent condemnation
Gain/day	Gain per day in lbs

Bird Footpad/Paw Scores

Paw scores, an indicator factor of house environmental conditions for animal welfare audits, was significantly impaired within the LFS houses, as shown in Figure 12 where the percent of Grade "A" feet is represented. This is not only an indicator of poor house conditions for the birds, but it is an economical loss for poultry companies due to less salable pounds of Grade A feet. Foot

pad lesions, also referred to as footpad dermatitis or pododermatitis, were exacerbated by the wet, slick condition of the manure on the LFS flooring during the first weeks of the flock. As a result, the manure adhered to the chicks' feet, increasing the incidence and severity of footpad dermatitis. Flock 4 reversal can be attributed to the placement of fresh pine shavings onto the LFS flooring prior to brooding.

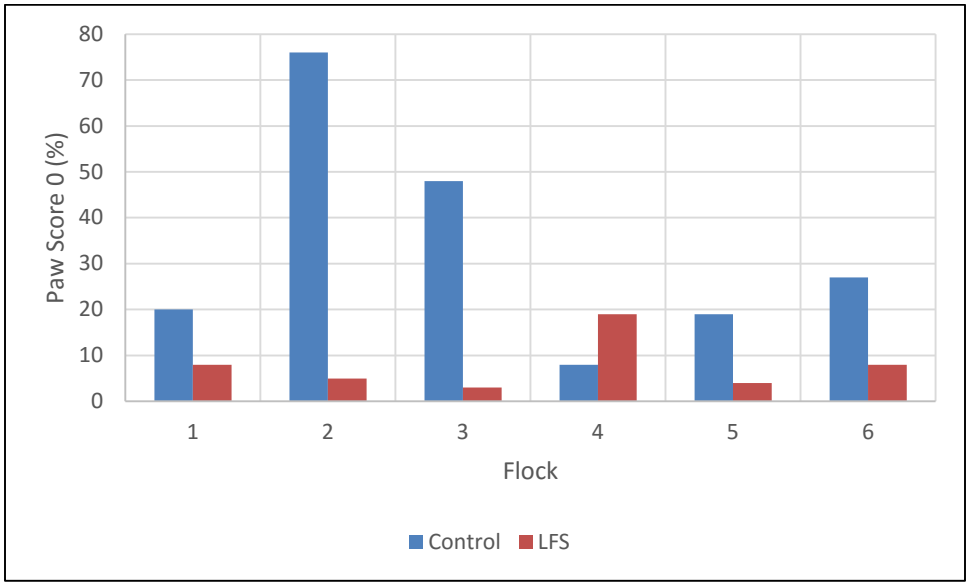

Figure 12. Comparison of pine shaving flooring (Control) with the litter-less flooring system (LFS) on broiler paw scoring. Paw scores are based on a visual ranking system used to score footpad lesions, with a score of "0" for no lesion present, or grade "A".

5. Conclusions

1. Ammonia concentrations were lower in the LFS houses. The difference in ammonia concentrations between the LFS and Control houses decreased with bird age.

2. Particulate concentrations tended to be lower in the LFS houses. The difference in particulate concentrations between the LFS and Control houses decreased with bird age.

3. Energy usage was higher in the LFS houses than control houses. Higher heating costs were in part due to the higher house temperatures maintained during brooding in order to keep the chicks comfortable in the LFS houses. Heating and electricity usage were also higher due to the farm managers efforts to dry the wet manure as quickly as possible by increasing the minimum ventilation rates during the first few weeks of each flock.

4. Darkling beetle populations were significantly reduced with the use of the LFS flooring system. The lack of bedding material likely disrupted their life cycle habitat.

5. Issues related to the lifting or displacement of the flooring system components over time and the associated damage caused by house cleaning and catch equipment raises concerns as to the longevity of the LFS system.

6. Paw quality, as an animal welfare evaluation standard, was significantly decreased with the LFS system.

7. No appreciable differences in final body weight, feed conversion or livability were noted between the LFS system and traditional bedded flooring. First week mortality tended to be higher with the LFS flooring system.

The LFS project was terminated at the end of the first year of a scheduled two-year study at request of the poultry growers and companies, and the flooring system was removed. No further interest in the flooring system has been expressed by either the poultry growers or the poultry companies.

Though the LFS system did show promise in the areas of ammonia and particulate matter concentration reductions, issues with bird welfare and mortality, energy usage, labor, and longevity of the system components indicate that further significant research and development would be required before the system could be considered as a commercially viable product.

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