**Systematic Evaluation of In-House Broiler Litter Windrowing Effects on Production Benefits and Environmental Impact**

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**ABSTRACT**

In-house windrow composting of built-up broiler litter between flocks is being adopted in some production complexes in the US. Although the composting process is accepted to dry and stabilize organic materials, decrease mass and volume, and reduce pathogens, there are challenges and uncertainty when used in the typically short downtime of broiler production. Producers’ good management practices in achieving drier litter during growout are in conflict with establishing a fast windrowing process, because most litter materials are drier than needed, so water is added to allow fast heating in some cases. High temperatures achieved due to increased microbial activity may encourage nitrogen mineralization and lead to higher ammonia volatilization. The associated time and cost to run ventilation fans after windrowing to exhaust ammonia and dry out litter, as well as the net impact on cumulative ammonia and other greenhouse gas (GHG) emission is not clearly defined. Additionally, high mineralization rates may lead to the nutrient transformation, including phosphorous (P). Research showed that P runoff after field application was affected by the soluble (water extractable) P in the fertilizer source, including poultry litter. Once again, the extent of any potential change in soluble P from this practice, which draws great attention in the nutrient sensitive watersheds in certain poultry production regions, is also unknown.

The objective of this proposed study are to investigate the best management practice for litter windrowing between broiler flocks that will reduce pathogens, and to systematically evaluate the environmental impact and production performance associated with in-house windrowing on a commercial scale broiler farm.

We will accomplish the objective by conducting windrowing trials for four flocks on reused litter. The production benefits will be quantified by evaluating the effect on pathogen reduction, including *E. coli*, *Salmonella*, and *Clostridium* spp., under two different litter moisture conditions, and by assessing bird performance of each subsequent flock. The potential cost and environmental impact will include gaseous emission and nutrient composition in the windrowed and non-windrowed litter. Cumulative ammonia and GHG emissions will be quantified during the downtime litter management and subsequent growout periods. Electricity used by ventilation fans to vent ammonia, litter nutrient contents, prior to and after windrowing, or without windrowing in a comparison house will be evaluated.

It is anticipated that this study will add practical guidelines and recommendations to in-house windrowing management in improving production benefits and reducing environmental impact. It will help the poultry industry in sustaining production efficiency while complying with environmental regulations.

**Project Title: Systematic Evaluation of In-House Broiler Litter Windrowing Effects on**

**Objectives:**

1. To experimentally investigate the best management practice for litter windrowing between broiler flocks that will lead to lower pathogenic challenge, effective darkling beetle control and acceptable in-house ammonia level prior to flock placement for increased flock performance; and
2. To quantitatively monitor and compare the organic matter stabilization, cumulative ammonia emission, and nutrient transformation from the litter windrowing and litter conditioning process.

**Justification**

Windrowing litter between flocks has recently been adopted by broiler growers in the US to manage reused litter as an attempt to reduce disease susceptibility and increase bird performance. Although composting is known to stabilize and dry organic materials, kill weed seeds and reduce pathogen populations, the criteria of attaining sufficiently high temperature for an extended period are critical. The nature of a relatively short downtime between flocks of broiler production creates challenges for successful adoption of windrowing as in-house composting. For example, growers’ good management practices in achieving drier litter during grow-out are in conflict with establishing a fast yet successful windrowing process, because most litter materials are drier than what is needed for successful windrowing. It is uncertain under what litter condition that water is to be added, and if so, whether windrowing can eventually reduce the litter moisture content.

Recent interest has centered around the implementation of on-farm pathogen reduction strategies by poultry integrators (i.e., hatchery, feed mill, and breeder and grow-out operations) to successfully control foodborne pathogens and comply with federal in-plant standards (Payne et al., 2007). Pathogenic microorganisms such as *Salmonella*, *Campylobacter*, *Clostridium*, and fecal indicator bacteria such as *Escherichia coli* are commonly found in the poultry house environment and in or on the bird. If found on the final processed product, pathogens can cause human foodborne illness. It is estimated that foodborne pathogens cause millions of illnesses and thousands of deaths annually in the United States (Mead et al., 1999). *Clostridium* is also associated with poultry diseases such as necrotic enteritis and gangrenous dermatitis causing loss of performance and mortality in birds. This spore forming organism is considered heat tolerant, therefore, making it somewhat resistant to heat treated processes such as composting. Questions exist regarding whether windrowing litter can effectively control *Clostridium* spp. and other pathogens.

Recent interest has also centered on air emissions from poultry operations. Microbial degradation of nitrogenous compounds such as uric acid, which is excreted by the bird, leads to the release of ammonia, a colorless, highly irritating gas. Poultry litter pH, moisture content and temperature all play an important role in the rate of ammonia volatilization with an increase in volatilization observed by increasing any of these variables. The cumulative ammonia emissions from both downtime and grow-out time may be different from windrowing or other commonly used litter management methods.

The increased temperatures created by windrowing litter can lead to increased ammonia volatilization during and following the windrowing process. Upon pile disturbance (turning and re-spread), ammonia is to be volatilized to the ambient environment, together with moisture vaporization. If not managed properly, unexpected high ammonia concentrations could sustain for extended periods after windrowing and negatively affect the subsequent flock. The dynamics of ammonia release as affected by air exchange (a result of building ventilation rate) is not well understood. The time and/or the cost necessary to run ventilation fans to exhaust gaseous products are not clearly defined.

Nitrous oxide (N2O) is produced through two biochemical reactions: nitrification and denitrification. Nitrous oxide, methane and carbon dioxide (CO 2) emissions from broiler growout periods and downtime periods using conventional litter management were reported (Burns et al., 2008). Composting animal manure has been shown to contribute to greenhouse gas emissions, thereby potentially contributing to global warming and acid rain (Tiquia and Tam, 2002; Sommer and Moller, 2000). During composting, N2O can be produced early in the composting process and during the maturation phase (Peigne and Girardin, 2003). There is unlikely production of N2O during the thermophilic phase because nitrifying bacteria cannot grow when the temperature is too high (Hellmann et al., 1997). The cumulative amount of gases released by windrowing may impact air quality in a different manner than the conventional management practices, which largely unknown.

Windrowing built-up litter may offer opportunities to poultry growers. Cake removal, which is typically recommended for non-windrow litter management, is not necessary, due to the relatively high moisture contents in the cake being beneficial for fast self-heating. Darkling beetles, one of the pests that is constantly dealt with by poultry growers, will surface and concentrate on top of the litter as piles heat up and offers prime time for efficient chemical treatments. However, little research has been done to quantify the efficacy of such treatments which can provide practical recommendations to growers.

Considerable attention has been drawn lately with regard to the impact of poultry operations on water quality as well. Higher mineralization as a result of increased microbial activities may change the nutrient composition of the litter, including phosphorus (P). Research showed that P runoff after field application was affected by the soluble (water extractable) P in the fertilizer source, including poultry litter. Once again, the extent of any potential change in soluble P from this practice, which draws great attention in the nutrient sensitive watersheds in certain poultry production regions, is largely unknown.

Methods to best implement litter windrowing in broiler production will have immense implications for the broiler industry as it strives to succeed in pathogen control, increase production efficiency, and at the same time address public concerns and comply with environmental regulations.

**Procedures**

Field experiments will be conducted in the Applied Broiler Research Farm (ABRF) of University of Arkansas. The farm consists of four commercial-scale broiler houses each measuring 40×400 ft. All houses are equipped with solid-side walls, dropped ceiling, tunnel ventilation and evaporative cooling systems. The farm operates under a standard broiler contract with a local company to raise medium size chickens (5 to 6 lb), and typically rest for 2 weeks between flocks. The facility is equipped with bird scales and load cells on feed bins in all houses that are recorded every day. Electricity use by lights and ventilation are metered separately from each house. All houses have a packed dirt floor underneath the bedding materials, which consist of a wood shaving and rice hull mixture. Litter is reused for multi-flocks and cleanout usually occurs once a year.

Windrowing experiments will be conducted in two of the four houses, with the other two using traditional methods to prepare litter during downtime. De-caking will be performed in the litter conditioning houses, but not the windrowing houses. Two initial litter moisture contents, high and low, will be used, one in each windrowing house. The target high and low moisture contents of each trial will be 34% and 30%, respectively. This means water will be added in drier seasons (winter) even for low moisture treatment. Litter moisture content will be determined two days prior to harvest day to allow calculation of water addition to each treatment. Windrows will be formed on the same day when birds are harvested, to allow the process to start as soon as possible. We plan to conduct each trial for 9 to 10 days before windrows are spread out for subsequent house preparation. During the 9 to 10 day period, windrows will be turned once (broken and reformed) to reintroduce oxygen into the piles and allow homogenous results to occur.

Windrow trials will be conducted on four consecutive flocks with built-up litter. Temperature of ambient air, surface and core of the windrows will be continuously recorded using data loggers for all four trials.

***Microbiological Sampling Procedures***

Six composite litter samples will be aseptically taken within established windrows in each house after the second and fourth flocks on the same litter. Of the six composite samples, 3 will be collected from the pile core and 3 will be collected from the pile surface. Samples will be taken pre (time 0) and post (day 10) windrowing. For the control house, 3 composite samples will be aseptically collected following a zigzag pattern throughout the house. Composite samples will consist of 10 collection points each weighing approximately 10g. Each composite sample will be pooled in a Ziploc bag, stored on ice and transported to theLeland Tollett Veterinary Diagnostic Laboratory in Fayetteville, AR for sample analysis. Upon arrival, samples will be analyzed for *Clostridium* spp., *Salmonella* spp. and *E. coli* populations.

***Gas Monitoring Procedures***

Aerial emission from a windrowing and a litter conditioning house will be monitored to compare cumulative ammonia, CO2, and N2O emissions from both downtime and immediately afterwards. Gas concentrations will be continuously monitored by a multi-gas photoaccoustic infrared analyzer (Innova 1412, Innova AirTech Instruments A/S, Denmark). Fan operation status from the two houses will be monitored. Gaseous emissions will be calculated by multiplying concentrations and corresponding ventilation rates. From the time that windrows are formed, the houses will be closed except for one load-out door, to allow machinery operations. Sufficient fans will operate to allow machine operations and air emissions continuously monitored by instrumentation. After windrows are spread out, ammonia concentration will be continuously monitored and sufficient ventilation fans activated accordingly to ensure interior environment is acceptable prior to chick arrival. Ventilation electricity use that’s needed to exhaust excessive ammonia will be documented from each house.

***Litter Nutrient Analysis***

Litter samples will be collected from the two windrowing houses and one litter conditioning house pre (time 0) and post (day 10) for nutrient analysis.

***Flock Performance Evaluation***

Flock performance from all houses including feed efficiency, live weight and livability will be collected for the four flocks after the windrow trials.

**Literature Review**

Composting of poultry litter after it has been removed from a broiler house has been performed for years. The compost product contains less bacteria than uncomposted litter and is safe to use as a soil amendment (Hartel et al., 2000). Given the length of time of in-house windrowing and relatively low initial moisture contents of litter, this in-house process may not be as effective in destroying bacteria as traditional composting. Macklin et al. (2008) reported no difference in *Clostridium* populations recovered from litter windrow composted vs. uncomposted; however, they observed a significant reduction in *Salmonella* populations. The researchers windrowed the litter for a 7-day duration without turning or initial moisture content adjustment.

On-farm trials conducted in Louisiana (Lavergne et al., 2006) provided mixed results using variable moisture contents. Litter moisture contents used in different trials were in general between 25 to 37%. Elevated initial moisture contents led to excessive moisture in the completed windrowed litter, which was less desirable for new flock placement.

The results of this proposed study will be used to develop a management guideline to achieve better production efficiency from in-house litter management, and at the same time generate scientific data in assessing environmental impact of different litter management practices.

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