Good Litter Management Improves Broiler Performance, Health, and Welfare

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How litter is managed before, during, and after each flock is a key factor for improved broiler performance, health, and welfare. Successful growers understand that **good litter management during and between flocks is critical**, particularly in today's "No Antibiotics Ever" (NAE) environment. Litter management starts with the previous flock, not the current flock. If you wait until a new flock of chicks arrives to begin a litter-management program, you are already behind, and it will likely be the next flock before you and your birds can benefit from the fruits of your labor. Litter conditions do not change overnight. Litter management is an ongoing, time-consuming process that requires frequent and consistent effort on the part of the grower. Good litter management involves **reducing the amount of water going into the litter and increasing the amount of water evaporation from the litter** (Liang and Tabler, 2020).

Built-Up Litter and Moisture

Reusing litter over multiple flocks is a **common practice across the U.S. broiler industry,** but it comes with potential risks:

- High ammonia levels during early brooding;
- Moisture challenges that must managed to prevent wet litter/poor welfare issues;
- Increased energy (gas and electricity) use to maintain proper air quality; and
- Pathogen carryover that could result in birds breaking with the same disease flock after flock.

Moisture is a key factor influencing litter quality in broiler houses (Tabler et al., 2012). Litter moisture is associated with a multitude of factors such as broiler-house environment (temperature, ventilation rate, humidity, etc.) and litter properties (bedding material, new vs. built-up litter, litter depth, etc.). Wet litter in the poultry house has been a known problem for almost 100 years (Dann, 1923). Litter moisture concerns and wet litter conditions continue to plague the poultry industry despite well over 90 years of advancement in terms of selective breeding, housing design, ventilation systems, and production methods (Dunlop and Stuetz, 2016).

How much litter moisture in a broiler house is too much? Tabler et al. (2015) found the average moisture content of litter in Mississippi broiler houses to be approximately 27 percent. Collett (2012) suggested that moisture content above 25 percent can cause litter cushioning, insulating, and water holding capacity to become compromised. Abd El-Wahab et al. (2012) reported that the critical moisture content for onset of footpad dermatitis was approximately 35 percent. In truth, there is **no single percent moisture content that describes conditions that initiate problems associated with wet litter** (Dunlop and Stuetz, 2016). Similarly, there is no single source of moisture that contributes to wet litter.

Numerous multidimensional factors contribute to wet litter, including bedding material properties, litter conditions (moisture content, friability, stickiness), manure deposition rates, bird activity, house environment, litter type, and ventilation program (Dunlop, 2017). Dunlop et al. (2015) estimated that the amount of water added to litter from manure deposition is 1.5 to 3.2 liters per square meter per day (0.04 to 0.08 gallons per square foot per day). Over the course of a grow-out flock, the total amount of water added to the litter is more than 100 liters per square meter (2.4 gallons per square foot). This amounts to 60,000 gallons in a 25,000-square-foot house, which is **several times more water than the litter can hold** (Dunlop and Stuetz, 2016). These numbers highlight the importance and necessity of evaporation and moisture removal by proper ventilation. While fresh air exchange is important, the most critical role of the fans is moisture removal. In essence, the fans are simply water pumps.

Ammonia (NH_3) generation is a major issue with reused or built-up litter, particularly if the litter gets wet. **High ammonia levels in broiler houses is an animal-welfare concern** and often results in poor bird performance and flock health conditions, as well as a loss in profits to the grower and the integrator. Levels should be kept to 20 parts per million (ppm) or less to prevent production problems. Reducing stress throughout the grow-out period is critical to maintaining welfare standards and crucial for achieving a low cost per pound of live weight at harvest time. Various litter amendments are available to lower litter pH and help reduce ammonia early in a flock. Ammonia volatilization depends on four factors: (1) temperature, (2) litter pH, (3) litter moisture, and (4) air movement. Water evaporation rate depends on litter moisture content and airflow/ventilation over the litter.

Moisture Control

Moisture control **depends largely on management practices**—continuous ventilation monitoring and regular checks on water systems to prevent and repair leaks. Adjusting drinker height and water pressure appropriately as birds grow is also critical to avoid excessive spillage into the litter. Increasing ventilation as the flock ages is a necessity to meet moisture-removal requirements. As water consumption increases, ventilation should increase accordingly. A **uniform bird density** throughout the house is also important to moisture control. This means timely movement of birds from half to full house and uniform bird numbers in both the brood and nonbrood ends. Separate water meters for the brood and off ends can help determine when bird numbers are uniform throughout the house. Or, with practice, it becomes easier to "eyeball" each end and determine when numbers are uniform. Once numbers are uniform, migration fences should be used to maintain uniform flock distribution.

Use of **circulation fans in the ceiling can help remove moisture** from the litter. These fans may run continuously during the flock or be programed to run whenever the minimum ventilation or tunnel fans are not running. They provide a gentle air movement (not a draft; chickens don't like drafts) that helps break up air temperature stratification in the house and assists with litter drying. It's also important to divert storm water away from the house and pad. Standing water can seep into the pad and wick up from the bottom into the litter inside the house.

Floor moisture from the pad or the hardpan (if one exists) may play an important role in creating high ammonia levels. **Sufficient bedding depth** is also important. A minimum of 3 inches should be maintained all the time. A depth of 4 to 6 inches appears to be ideal. Litter depth needs to be uniform throughout the house, as variability can be problematic to maintaining proper feeder and drinker height. **Litter must be level** to help ensure proper feeder and drinker height throughout the house. Additionally, areas with limited litter will cake over and develop wet spots, leading to higher ammonia levels and increased footpad lesions.

Quality litter is about more than just maintaining the proper moisture content. It is also about friability, which has health implications as well as certain behavioral advantages for the birds. When litter is friable (easily crumbled or pulverized), it helps keep litter dry and enables birds to "work" the litter when they scratch, walk, dust bathe, preen, and forage (Dunlop and Stuetz, 2016). Bernhart and Fasina (2009) reported that litter moisture affects the amount of cohesion (stickiness) between litter particles. Bernhart et al. (2010) indicated that, as litter moisture **increases above 20 to 30 percent, litter particles begin sticking together** and form "clumps" because water acts as a natural binder. Clumps and caked, wet litter increase the risks of footpad damage, which can lead to footpad dermatitis.

Ventilation rate helps manage litter moisture, and seasonal changes in temperature require the right ventilation adjustments to maintain the proper house environment and help birds maintain appropriate body temperature (Tabler et al., 2020). However, growers often significantly **reduce winter ventilation rates to conserve fuel** and lessen heating costs (Gates et al., 1997). Unfortunately, decreased winter ventilation often leads to wet litter and increased ammonia levels that can threaten flock health. As a result, flock welfare status may be compromised, and increased ventilation rates and additional gas usage are often required to maintain acceptable ammonia levels, which are generally higher than rates required for moisture removal alone (Xin et al., 1996).

Water Activity

While the amount of water (moisture content) in litter is an important factor, Dunlop et al. (2016) argues that availability and freedom of water (as opposed to water that is bound and unavailable) is even more important. This idea requires discussion of the **water activity (A_W) concept**, otherwise known as the equilibrium relative humidity. Moisture content is a measure of how much water is present. Water activity tells us about the energy of that water and how (or if) it can be used by microorganisms. Van der Hoeven-Hangoor et al. (2014) indicated A_W is a better measure of water in litter than moisture content since it is more closely related to microbial, chemical, and physical properties of litter. It is also relatable to relative humidity and therefore can be used to explain how much water is absorbed by litter or evaporated from litter depending on relative humidity at the litter surface (Dunlop and Stuetz, 2016). Water will migrate from higher A_W to lower A_W until equilibrium is achieved and A_W is constant throughout the system (Dunlop et al., 2016).

Water activity is a measure of **available or "free" water in the litter**. It describes the degree to which water is "bound" in the litter, and its availability to contribute to chemical/biochemical reactions and growth of microorganisms. The A_W of pure water is 1.00. Water activity is measured in a range from 0.03 to 1.00. The closer litter's A_W value is to 1.00, the more "free" or available water litter contains to participate in various chemical and physical reactions. **Water activity better predicts growth of microorganisms** because microorganisms can only use available water to grow.

Numerous authors have demonstrated that microbiological properties of poultry litter are directly related to A_W and that maintaining litter below a critical A_W value corresponds with reduced growth of pathogens, including *Salmonella* and *E. coli* and other microorganisms (Carr et al., 1995; Chinivasagam et al., 2012; Eriksson De Rezende et al., 2001; Hayes et al., 2000; Himathongkham et al., 1999; Macklin et al., 2006; Payne et al., 2007). Physical handling properties such as stickiness, friability, cohesion, adhesion, compressibility, and flowability of litter are also directly related to A_W because water needs to be available on the surface of particles for interparticle bonds to form (Bernhart and Fasina, 2009; Dunlop and Stuetz, 2016; Reed and McCartney, 1970; Roudaut, 2007).

Once litter reaches a critical hydration level, particle surfaces merge with neighboring particles (Roudaut, 2007), resulting in clumps and cake rather than friable material. Bernhart and Fasina (2009) found that this reduction in friability occurred at A_W of approximately 0.80 to 0.85 (which corresponds to a moisture content of 18 to 22 percent). In general, **A_W is greatest with fresh bedding materials and decreases during the grow-out** with the addition of poultry manure and the natural breakdown of organic materials (Dunlop et al., 2016). This happens because bedding materials such as shavings and sawdust are cellulose in nature, and cellulosic materials hold water by simple bonds. Adding manure (which contains proteins, carbohydrates, and salts) creates more complex molecular bonds that more strongly bind water in the litter.

Summary

Good litter management is key to producing healthy broilers and providing proper welfare conditions, particularly if broilers are produced in some version of an NAE program. **Reusing litter for multiple flocks is common practice but comes with multiple risks** that must be adequately addressed. Moisture and ammonia are two of the greatest risks associated with built-up litter use. Management practices that control litter moisture and thus help reduce ammonia levels play a large role in creating good litter conditions and promoting animal welfare. Use of circulation fans, proper litter depth, and adequate ventilation rate are all management tools that can assist with litter management, as is use of litter amendments to control ammonia early in the flock. Litter **moisture content is a valuable tool** in assessing litter quality, but **water activity may be even more important** and should receive greater attention in the future where litter management is concerned as it can affect microbial litter populations.

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