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Review

Considerations in selecting turkey bedding materials

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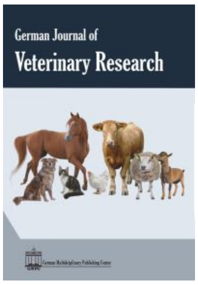

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Abstract

The commercial turkey of today is a descendant of wild, then domesticated, turkeys from North America originating in regions of old Mexico. The modern commercial turkey enjoys a wide range of acceptance in many countries. Turkey's production evolved rapidly from 1950 forward with many changes in production and management. It changed from range rearing to mostly total confinement. Rearing birds under increased density in confinement facilities has created both opportunities and challenges. Once confined, organic materials have been used as bedding (also referred to as litter). There have been many materials evaluated and used for bedding. Availability, cost, and bird performance were early key considerations. More recently, bird health and welfare are now important considerations as well. Optimal management programs for the modern turkey reared in confinement can be elusive and difficult to define. However, controlling litter moisture, which aids in reducing ammonia and footpad dermatitis, should be a key management component of confinement rearing. Therefore, bedding choice and litter management in turkey production require thoughtful consideration and active management.

Keywords: Turkey production, Bedding, Litter, Litter management, Litter moisture

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Introduction

The first use and then domestication of the turkey (*Meleagris gallopavo*) dates to as early as 800 BC in Mesoamerica (Speller et al., 2010). Domestication can be dated to at least AD 180, with possibly two centers of domestication. With Spanish contact, turkeys were transported to Europe. European settlers brought their domesticated turkeys with them to North America. Until the 1950s, turkey production in the U.S. was a secondary enterprise. However, turkey production in the U.S. increased significantly from 1950 forward (Lasley et al., 1985). Partial confinement replaced range rearing. As described by van Staaveren et al. (2020), for Canada most commercial turkeys today are reared in total confinement with some exceptions. As with broiler production, confinement rearing has brought many changes in production practices. For example, power ventilation to control moisture and gases, such as ammonia, is becoming more common for turkey production (Mendes et al., 2013). Another significant change is the use of organic floor coverings referred to as bedding when unused and then as litter once the birds have been reared on the material for some time. However, litter generally refers to bedding plus feces (with urine), feathers, uneaten feed, wastewater, and possibly other materials. Other flooring systems, such as slats or raised floors have been tested with some success (Noll et al., 1997; Farghly et al., 2018) but are not in common use for commercial flocks. Range rearing is still practiced but not on a large scale for commercial turkeys (Woolford, 2009). Therefore, this article addresses bedding and litter for turkey production with notes on quality.

Overview of the properties of poultry bedding materials

In most broiler and turkey production, the birds are always in contact with the bedding material, and hence, the bedding material plays an important role in bird health, air quality management, and worker safety. Ideal bedding serves multiple functions, including providing cushioning to the birds, serving as an insulator during the winter months, acting as an absorbent for urine, moist feces, and spillages from the drinkers, and most importantly, providing surface area for the decomposition of organic nitrogen and sulfur in the fecal matter (Munir et al., 2019). Therefore, diligence is needed for the selection and management of the bedding materials. All things considered, in addition to being inexpensive,

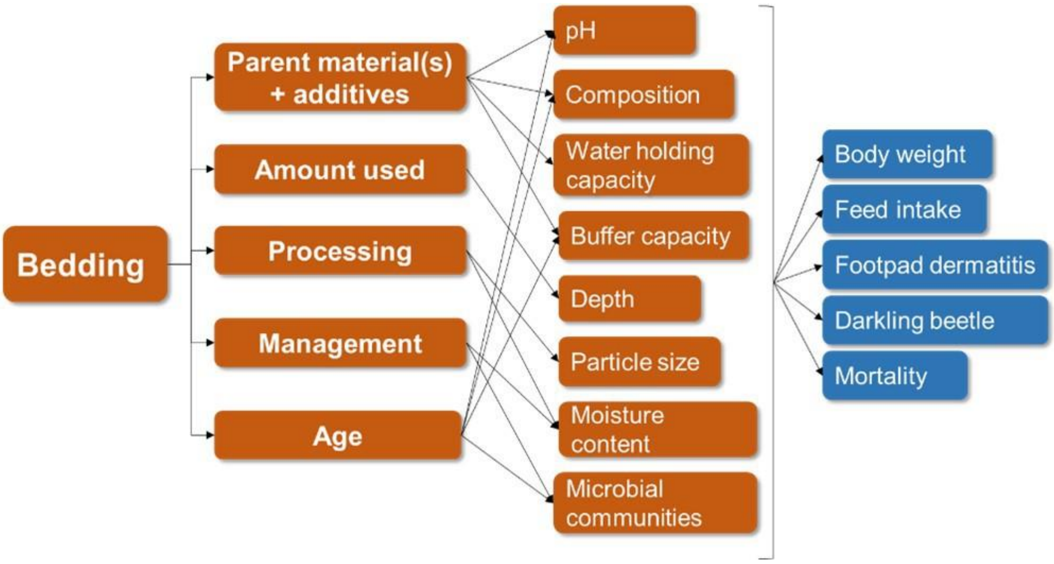

Figure 1: Bedding attributes and impacts on turkey production.

abundantly available and inert, all bedding materials are expected to have certain physical and chemical traits for optimum performance. This section provides an overview of some of the important factors that need to be considered while selecting an appropriate bedding material. In this paper, the terms "litter" and "bedding" are used interchangeably. Figure 1 summarizes key aspects of bedding management and how it impacts its properties and, in turn, turkey performance.

Particle size

In general, medium-sized litter particles (without sharp edges) are preferred, with an ideal average particle size ranging between 2-25 mm (Val-CO, 2021). Larger litter particles over 30 mm increase the caking of bedding material (Grimes et al., 2006) and can affect the movement of the birds and cause foot injuries (bumblefoot or plantar pododermatitis), resulting in lower-grade product (e.g., chicken feet). Also as suggested by Shepherd et al. (2017), smaller particles, due to high specific surface area, facilitate effective drying of material relative to larger particles. In addition, smaller particles also positively affect the chemical and microbial processes that will occur on the surface. However, it should be noted that certain finer bedding materials (e.g., saw-dust) may be associated with dust, and especially when mixed with airborne dried litter and feed, can impact the birds and human caretakers alike.

Litter depth

The depth of the litter can simultaneously impact the environmental quality in the barn and the health of the birds (Munir et al., 2019). Deeper beds have increased pore volumes and, therefore can hold/trap excess moisture and feces and can even provide pockets for microbial growth for degradation of urine and feces. In one of their studies, Cohuo-Colli et al. (2018) reported a 21% decrease in ammonia emissions when the density of litter was doubled from 1 kg/m^3. The thickness of the bedding also affects the moisture in the material, especially on the surface. Shepherd et al. (2017) reported that litter works similar to a sponge. They determined that deeper beds can absorb more water relative to shallower beds for fresh bedding of pine shavings and recycled litter bedding. However, no definite trend was observed by Cohuo-Colli et al. (2018) in beddings prepared with rice hulls. Most of the poultry barns in the U.S. have earthen floors, and some transfer of moisture through the earthen floor may be expected. In other locales, concrete floors are more common, which equates to greater concerns for moisture management. The depth of the litter also influences the overall heat transfer properties of the litter. The litter bed may be viewed as a packed bed of solids with air pockets between them. Considering that the thermal conductivity of air is only 0.02 W/m.K (vs. 0.1-0.2 W/m.K for wood), deeper beds can be effective in minimizing the heat loss through the floor. While the depth of the bedding will depend on the type of substrate (pine wood vs rice hulls), an average depth of 10 cm may be considered adequate and is not uncommon for turkey production (van Staaveren et al., 2020).

Water holding capacity (WHC)

The WHC of the bedding material is defined as the amount of water that a given mass of the bedding material can hold within its matrix. The WHC can be estimated on a percentage or a surface area basis. One approach described by Grimes et al. (2002) involves saturating 50 g bedding material for 30 min, followed by 30 min of draining and measuring the increase in the weight of the bedding material to estimate the WHC (%). Alternatively, (Dunlop et al., 2015) employed an Australian potting mix standard procedure described in AS 3743-2003 to determine the water holding capacity (L/m^2). The water-holding capacity of bedding material increases with the decrease in structural fiber content (Przybulinski et al., 2021). The WHC of litter will depend on the litter depth, porosity, and the amount of (non-litter) organic material. Therefore, the WHC will change continuously with time and the age of the birds.

In their research, (Dunlop et al., 2015) noted that the WHC increased from 15 L/m^2 to 30 L/m^2 in 31 days of culture.

pH

The pH of the bedding material is perhaps one of the most important quality indicators. Typically, the pH (also called acid value) of solids is measured in a 1:10 bedding/deionized water mixture after equilibration over a few hours (Cassity-Duffey et al., 2015). The performance of the bedding material is strongly affected by its pH. Depending on its pH, the bedding material interacts with poultry feces, which typically ranges from neutral to slightly alkaline and can promote or inhibit the microbial decomposition of the manure. Neutral and alkaline bedding materials promote microbial processes associated with the degradation of uric acid into ammonia, while acidic bedding materials inhibit microbial activities (Blake and Hess, 2001). Typically, the nitrogenous content of the excreta is composed of uric acid (80%), minor portions of ammonia (10%), and urea (5%) (David et al., 2015). Under alkaline conditions and in the presence of water, oxygen, carbon dioxide and peroxide, and enzymes including uricase, allantoniase, allantoicase, and urease, uric acid is converted into urea and subsequently converted into ammonia (Naseem and King, 2018).

$$\text{Uric acid} \rightarrow \text{Urea} \rightarrow \text{Amonia}$$

The ammonia thus formed is hazardous to the birds and humans (Ritz et al., 2004; David et al., 2015). Because it is highly volatile and water-soluble, it can be deposited on the birds' mucus membranes (Beker et al., 2004). Higher ammonia concentrations (>50 ppm) have been shown to cause health conditions such as keratoconjunctivitis, tracheitis, and other diseases in birds (Estevez, 2002).

One practical approach to suppress the formation of ammonia from uric acid is to lower the pH of the reaction system. Lowering the pH can work in two ways. The main bacteria involved in the formation of ammonia, *Bacillus pasteurii*, is inactive at neutral and acidic pH, and therefore, ammonia production could be inhibited by lowering the pH (Elliott and Collins, 1982; Naseem and King, 2018). Secondly, acidic pH will also shift the ammonia-ammonium equilibrium towards ammonium and minimize the volatilization of ammonia away from the litter to the air (Lahav et al., 2008). Due to that combined effect, ammonia emissions are significantly reduced below pH 7. Naturally acidic materials (such as peat moss) are associated with a pH between 4.5 and 6.4 (Shepherd et al., 2017) and can readily suppress the volatilization of ammonia. However, with time, as feces and urine accumulate on the bedding, the pH of the bedding increases and stimulates microbial activities. Alternatively, acidifiers, such as aluminum sulfate (alum) and iron sulfate, can be used as litter additives to shift the equilibrium towards ammonium (Moore et al., 1995; Choi and Moore, 2008).

Moisture content and water activity

Mathematically, the moisture content is the total amount of water in the litter and is expressed on a wet basis (weight of water/total weight of litter) or a dry basis (weight of water/weight of solids). However, in the poultry industry, moisture content on a wet basis is commonly used. Moisture content directly influences other physical properties such as weight, bulk density, and, most importantly, the flowability of litter. Bernhart and Fasina (2009) found an increase in litter moisture content from 10.3% to 22% to shift the flow behavior of the litter from free-flowing to cohesive. In addition, moisture content also controls the quality of the litter (Fairchild and Czarick, 2011). Wet litter extends the microbiological processes, resulting in the formation of odorous compounds, and also strongly influences the ammonia transport processes within and out of the bedding material.

In addition, the birds raised on litter beds with higher moisture contents are prone to foot pad dermatitis, which can lead to acute inflammation and subsequent infections (Mayne, 2005; Bilgili et al., 2009; Shepherd and Fairchild, 2010) which can be a bird welfare concern (de Jong et al., 2012). In two studies, one in the US and one in Germany, the majority of observed commercial turkeys had some level of footpad dermatitis (Krautwald-Junghanns et al., 2011; Da Costa et al., 2014). Mayne (2005) reviewed the subject and described many reports of significant footpad dermatitis in commercial turkey flocks. Therefore, it appears that there are potential opportunities to improve turkey's health and welfare through improved litter moisture management (Wu and Hocking, 2011). An ideal bedding material should be dry with a moisture content of around 20-25% (Tabler et al., 2020). Before the arrival of the flock, the moisture content is usually low (15%).

However, the moisture content increases to about 35% over time due to spillage, respiration, and accumulation of urine and feces. Litter tilling is not an uncommon management practice for commercial turkey flocks (van Staaveren et al., 2020). However, when practiced in naturally ventilated houses, moisture loss is dependent on ambient conditions. Therefore, power ventilation is useful, and ventilation rates should be correctly determined to maintain a moisture content of less than 25%. Ideally, the ventilation rates should be adjusted to maintain relative humidity in the house in the range of 50-60% so that the litter remains dry (Czarick and Fairchild, 2012). Similar results were reported by Weaver and Meijerhof (1991), who also observed decreased litter moisture contents at a lower relative humidity of 45% when compared to 75% relative humidity, while higher bird body weights and lower incidences of bird infections were found at a lower relative humidity of 45% (compared to 75%).

Besides its impact on bird performance, the moisture content influences nitrogen transformation during litter storage. Cabrera and Chiang (1994) reported significant increases in both NH_3 and N_2O emissions from stockpiled poultry litter, with increases in moisture content from 12% to 24%.

While moisture content represents the total water present in a bedding/litter sample, water activity (aW) describes the proportion of free (unbound) water present in the litter sample. This free water facilitates chemical and microbial activity within the litter and, therefore, is one of the important quality indicators of the litter. It is expressed as the ratio of the partial pressure of water above litter to the partial pressure of pure water (litter/water). Typically, no microbial activity occurs below a water activity of 0.6 (region 2 of the isotherm). For the litter, as suggested by Dunlop et al. (2016), water activity in the range of 0.84-0.91 is recommended to minimize the growth of pathogenic bacteria, mitigate malodors, and minimize personnel health risks.

Moisture content and water activity

Freshly obtained wood-based bedding materials are not microbially dense, and some of them (e.g., oak) may even have certain antimicrobial properties due to low pH (Munir et al., 2019). However, upon the arrival of the birds, followed by the continuous deposition of urine, feces, and unconsumed feed coupled with moisture and warm temperature provides ideal conditions for microbial growth within the bedding. Terzich et al. (2000) performed an extensive analysis of litter samples collected from broiler facilities all across the United States and reported an average count of 2.5×10^{11} CFU/g. Interestingly, the litter samples from the Delmarva region (DE, MD, and VA) were associated with the highest counts (4.6×10^{11} CFU/g), while the litter from the Pennsylvania region possessed the least (9.3×10^{9} CFU g-1). The *E. coli* loading, on the other hand, was found to be highest in the Texas region, and the lowest numbers of *E. coli* were detected in the Carolina region. Overall, the pH was found to be somewhat correlated to the overall microbial load. In a different study, Lu et al. (2003) analyzed litter samples via DNA sequencing and estimated that aerobic bacteria had around 10^{9} CFU/g, of which *Staphylococci* alone was estimated to be around 13% while *Enterococci* were found to be at 0.1%.

Similarly, Dumas et al. (2011) also reported microbial counts of 10^{10}/g dry weight and observed that the environmental conditions, especially the moisture content of the litter, impacted the microbial diversity and load. Considering the potential of the litter as animal feed, the litter microbiome plays an important role in the future. In evaluating the potential of poultry litter as a feed ingredient, Ghaly and MacDonald (2012) showed that thin-layer drying of litter at 60°C achieves approximately 99% reduction in bacteria, yeast, and *E. coli* cell counts.

Commonly used bedding materials and comparison of their performances

Historically, the poultry industry has used wood-based products such as shavings or sawdust as the preferred material. However, due to cost and availability considerations, many types of substrates of organic and inorganic origin have been evaluated, tested, and used as poultry bedding, as summarized in Table 1 (Veltmann et al., 1984; Grimes et al., 2002; Atencio et al., 2010; Toghyani et al., 2010; Garcˆes et al., 2013; Kaukonen et al., 2017; Shepherd et al., 2017; Munir et al., 2019). Most research has been directed toward broilers, justifiably so, since broiler production is the primary poultry commodity in most countries. Less research has been directed toward turkey production, which is the subject of this article. It may be assumed that materials successfully used as bedding for broiler production can also be used for turkey production. This is justified in most cases but possibly not all. A recent study evaluating the motivation for broilers and turkeys to access different bedding and litter materials, compared to feed, showed no variation in bedding preference within or between species (Monckton, 2020).

Due to basic economics, bedding materials are generally by-products of another industry or process. Some examples are pelleted newspaper, processed or pelleted cardboard, corn stover, rice hulls, peanut hulls, wheat straw, pelleted wheat straw, hay, grasses, and pine lumber by-products (shavings and saw-dust). Some materials are grown, harvested, and/or processed specifically for use as bedding. Some examples are fast-growing willow trees, miscanthus grass, and peat moss. In some cases, materials have been tested and used as a “top-dress” material such as peat moss or char products. There are a few materials that do not fit into these categories, such as slatted floors or sand. In many, if not most, cases, the evaluation process compares the performance of birds on the bedding chosen as the alternative material to the performance of birds reared on the preferred material, such as pine shavings (saw-dust).

Pine-based bedding has become the preferred material in many locales, such as the southeastern and mid-Atlantic U.S., because of availability, cost, and bird performance. However, pine by-products have become more difficult to obtain in some areas serving as motivation for researchers and producers to seek other materials. In other locales, other bedding materials serve as the preferred bedding; for example, wood-based materials and straw in Europe and Canada, peat moss in Finland, and sugar cane bagasse in regions of Brazil (Teixeira et al., 2015; Kaukonen et al., 2017; Munir et al., 2019; van Staaveren et al., 2020). The “preferred” bedding tends to be what is available and cost-effective as long as bird performance is acceptable (Swain and Sundaram, 2000). The acceptability factor includes performance as well as bird health. In most studies, footpad quality is used as an indicator of bird health. Footpad quality is closely linked to litter moisture and litter moisture management (Kaukonen et al., 2017; Shepherd et al., 2017). Turkey producers tend not to carry their used bedding forward as much as broiler producers. In addition, most turkey poults are brooded to approximately five weeks of age and then moved to another facility for rearing to market age. For brooding, it is common for the brooding chamber or facility to be cleaned out after every brood cycle, with new material placed for the next group of finding suitable bedding for turkey production.

Miscanthus grass

Miscanthus grass is an example of an alternative bedding material that is of interest as a replacement for pine by-product bedding in the U.S. (Davis and Purswell, 2017; Dunkley et al., 2017). The growing, harvesting, and handling of this grass has been developed for broiler production to the point that it is becoming a common bedding in some broiler-producing areas. Advantages that this material has include it can be reared in broiler areas, near or on-site to a broiler farm, it is a perennial and can be harvested yearly, it can be reared on less than ideal cropland, and it can be harvested at a moisture level of 12 to 15% and then applied directly into broiler houses.

Little to no further processing is needed. Evans et al. (2019) tested this material for rearing tom turkeys to 19 weeks of age. They found that using miscanthus grass as bedding resulted in similar, if not superior, bird performance compared to birds reared on pine shavings. Furo (2019) reared turkey hens on either pine shaving or miscanthus grass at three stocking densities. At market age, 14 weeks, there were no differences in bird performance (body weight, feed intake, and feed conversion) due to bedding. Birds reared on lower density (more space per bird) had improved performance. Bedding and density affected footpad scores at 14 weeks. Birds reared on miscanthus grass and higher density had greater footpad scores, equating to increased footpad dermatitis. Litter moisture was correlated with the increased footpad scores. These results demonstrate that the bedding material can share in the effects of management and environment on bird health and performance. In addition, this work further demonstrates that litter moisture management is critical and that litter moisture management plans may be different for different bedding materials.

Biochar

Biochar is a term used to encompass a broad array of carbonaceous compounds treated by pyrolysis. The feedstock for biochar can be varied, as well as the actual pyrolysis process (Spokas et al., 2012). Biochar has numerous potential uses in agriculture, especially as a soil amendment. The properties of biochar include a larger surface area with a potentially greater water-holding capacity. Poultry researchers have evaluated and tested biochar as a litter amendment for rearing broilers and turkeys. Ritz et al. (2011) evaluated three biochar materials as litter amendments for rearing broilers. Two of the biochar materials, pine chips and coir (coconut husk), were acidified, while another, peanut hulls, was used unacidified. Broiler performance was unaffected by the biochars compared to pine shavings. The acidified biochar reduced ammonia volatilization, whereas the unacidified biochar had no effect. Linhoss et al. (2019) also evaluated biochar as a litter amendment for rearing broilers. Biochar was added over pine shavings at a rate of 0.97 kg/m^2 and compared to plain pine shavings serving as the control. At 35 days, neither bird performance, bird health (footpad quality), nor litter nutrient content was affected by bedding; however, body weight gain of the birds reared on biochar plus pine shavings tended to be greater than for birds reared on plain pine shavings (1.825 versus 1.727±29 g, p=0.064).

Water holding capacity was increased by 21.6 and 32.2% when added to pine shavings at 10 and 20%. Biochar water holding capacity was increased for biochar with greater particle size. In addition, litter moisture was reduced by biochar addition (26.1 vs. 29.1±1.9%, p=0.011). Flores et al. (2021) compared four bedding treatments for rearing tom turkeys at 19 weeks of age. The base bedding for all four treatments was 70% (by weight) of the once-used turkey brooder house litter. For the four treatments, biochar (from miscanthus grass) at 0, 5, 10, and 20% was combined with miscanthus grass at 30, 25, 20, and 10% to the 70% used litter. Two levels of pellet quality were also used to provide a 4×2 arrangement of treatments. Birds reared on 20% biochar had a greater mean body weight at 20 weeks of age compared to the birds reared on 0% biochar in the bedding. The birds reared on the other two bedding treatments were intermediate in body weight. Birds reared on 10 and 20% biochar also had greater feed intake than the control birds reared on 0% biochar. Feed conversion was not affected by bedding treatment. While not measured, it was observed by the authors when the caked litter was removed from the pens of birds at 11 weeks of age the pens with 20% biochar in the bedding had less caked litter.

Peat moss

Peat moss is a potential alternative bedding for some areas (Shepherd et al., 2017) but is a common bedding material in other locales, such as Finland (Kaukonen et al., 2017). Shepherd et al. (2017) compared peat moss as bedding to several materials used as bedding for rearing broilers, including both used and fresh pine shavings. They found that peat moss was an acceptable bedding material providing good broiler performance with commercial use dependent upon local availability and cost. Kaukonen et al. (2017) compared broilers reared on sphagnum peat moss as a bedding to broilers reared on wood shavings and wheat straw in a commercial broiler setting in Finland. Birds reared on the sphagnum peat moss had better footpad health than birds reared on the other two beddings. In addition, the authors noted that peat moss seemed to be a more "forgiving" bedding, especially for new producers, and that management of the litter is important for litter conditions.

All peat moss materials are not the same. Enueme et al. (1987) found that turkeys reared on a reed-sedge type peat moss experienced greater footpad issues than turkeys reared on pine shavings, especially when the peat moss had a coarser consistency. Grimes (unpublished) reared commercial turkey hens on sphagnum peat moss compared to new and used pine shavings. Birds reared on the peat moss performed as well as birds reared on the other bedding materials.

Table 1: Characteristics and relative performance of different bedding materials.

Bedding material	Properties				Performance as bedding	Reference
Rice hulls (RH) (Whole, ground, and mixed)	MC=21.8 (±2.8) to 26.6 (± 2.1) [0-3 weeks; all inclusive).				Whole and ground RH were compared with wood shavings as bedding material.	Veltmann et al., 1984
					The bird health indicators did not statistically differ from wood shavings-raised birds.	
					Ground rice hulls adhered to poults' toes and somewhat impacted mobility and resulted in 2% mortality.	
RH, river-bed sand (RBS), Coconut husks (CH), Guinea grass (GG), Corn cob (CC), newspaper and Wood shavings (NWS)	Bed	WHC	WR	MC	RH, CH, GG, CC, and Newspaper-WS were compared with WS as bedding materials.	Garces et al., 2013
	WS	2.55-2.64	21.3-16.3	33.3		
	RH	1.83-2.34	32.1-26.4	34.5	The pH of all the bedding materials increased by at least 1.1.	
	CH	2.74-2.15	33.8-20.7	50	RBS, CH, and NWS beddings resulted in the highest release of ammonia.	
	GG	2.54-0.35	33.7-13.9	30.8	CH was found to be least effective as bedding materials relative to other materials tested.	
	NWS	3.39-2.97	21.5-16.3	25.5		
	RBS	0.17-0.28	8.6-12.1	7.2		
WS, sand, RH, recycled paper, and no litter	Bed	BW	Mortality (%)		Birds raised on RH exhibited lower weights than those reared on other materials.	Toghyani et al., 2010
	WS	2091	2		The WS, sand, and recycled paper were found to be the same with respect to bird performance.	
	Sand	2116	1.8			
	RH	2017	2.8		The birds preferred to remain on sand bedding over others.	
	Paper	2072	2.3			
	No litter	2.12	2.4			
PS, RH, and RBS.	MC_{PS} = 10.12-24.62 (7-42 d)				PS, RH, RBS, and PS-RBS were compared as bedding materials.	Atencio et al., 2010
	MC_{RH}= 9-24.5 (7-42 d)				RBS retained 15% less moisture than other treatments.	
	MC_{RBS} = 0.1-9.37 (7-42 d)				RBS bedding resulted in higher body weights.	

MC= Moisture content (%); MR= Moisture Retention (%); AD =Apparent Density (g/ cm3); WHC: water holding capacity (cm3/g); BW = Body Weight (Kg).

Litter management

While selecting suitable bedding material is critical to ensure an optimal environment for birds, litter management practices during and between flocks can significantly impact bedding characteristics and, in turn, bird welfare. Most importantly, the frequency of cleanout can affect the quality of bedding material in terms of bacterial count, pH, moisture content, and particle size.

For turkeys, the litter is typically cleaned out after each cycle in brooding facilities, while in turkey grow-out facilities, the litter may be used for just one flock or for multiple flocks (van Staaveren et al., 2020). The increased cost of bedding materials has led to an increase in the interval between cleanouts. Top dressing of reused litter with a layer of fresh bedding is not uncommon (van Staaveren et al., 2020). Raising more flocks on the same litter increases its moisture content, leading to packed litter depth and diminished capacity to absorb and release moisture, both negatively impacting footpad quality and bird health (Kaukonen et al., 2017; Munir et al., 2019).

The impact of extended litter use on microbial populations is less evident. In a study assessing the impact of the number of raised broiler flocks (4 to 28 flocks) on the microbial population of the litter, Vizzier Thaxton et al. (2003) reported no significant changes in counts of coliforms, Staphylococcus, aerobes, or anaerobes between flocks. In another study, Salmonella count in broiler litter was found to steadily decrease with litter reuse (Roll et al., 2011).

To overcome the challenges of prolonged litter use, producers remove caked litter from high-use areas and apply a small layer of fresh dry bedding, typically around 2 cm deep (known as top-dressing) (Malone, 1992). Coufal et al. (2006) studied the impact of top-dressing litter using fresh rice hulls on broiler performance (body weight and mortality rate) and nitrogen emissions. They reported that top-dressing had no beneficial effect on broiler performance and no reduction in N volatilization. The use of litter amendments is common in broiler production to improve litter quality and to temporarily reduce litter ammonia when litter is reused for multiple broiler flocks (Ritz et al., 2017). However, the use of litter amendments is not common for turkey production, probably because of the shorter use time of litter in turkey grow-out facilities. Turkey brooder chambers are generally cleaned out after each flock, resulting in little need for litter amendments for ammonia control. Windrowing, especially on broiler farms, is a useful practice to control litter-borne pathogens, improve subsequent broiler flocks, and extend the useful life of litter (Barker et al., 2013; Liang et al., 2014). While this method is available for any organic litter, it is not common on turkey farms, per the experience of the authors herein. However, this litter management practice may be useful on turkey farms with disease problems in conjunction with multiple flock use of litter, especially where antibiotic-free production is practiced or with limited antibiotic availability.

Conclusions

Turkey bedding choice and litter management will continue to be challenges for turkey producers. While no one bedding or management method has proven to be optimal, litter moisture management is critical. Decisions on litter selection and use must be integrated into the ongoing changes and evolution of turkey production, with the constant goal of improving production efficiency and bird performance, health, and welfare.

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