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Heat Treatment of Turkey Litter for Reuse as Bedding[1]

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Abstract: Local and national laws regulating poultry litter (PL) land application may require that PL be applied based on crop needs and PL nutrient content such as N and P. In addition, some may require monitoring of soil metals such as Cu and Zn. Even with efforts to decrease fecal nutrient excretion, there is also a need to extend the useful life of current bedding materials and to develop alternative uses of spent PL. Heat treatment of PL may extend bedding life and offer alternative uses of PL. The objective of this study was to determine if heat processed turkey litter (TL) can be reused as bedding for turkeys. Pine shavings (PS) which had been used as bedding to rear Large White male turkeys from hatch to 20 weeks of age was processed at 95 and 220 °C in an enclosed auger system. Four litter treatments (LT) were used: 1) control - new PS (T_1), 2) TL processed at 95 °C (T_2), 3) a 70:30 (w/w) mixture of TL processed at 95 or 220 °C (T_3) and 4) a 95:5 (w/w) mixture of TL processed at 95 or 220 °C (T_4). These bedding mixtures were placed in 36 floor pens in a randomized block design to provide 9 replicate pens per LT. Thirty Large White turkey hen poults were placed in each pen on day of hatch. The birds were reared to 14 wk. Mortality and feed consumption were monitored. Period and cumulative feed conversion (FC) ratios were calculated. Regression analysis of SAS, Inc. was used for data analysis. The LS Means procedure was used to separate treatment means ($P \leq 0.05$). At 6 wks, T_3 hens were heavier than T_1 (1.78 kg), T_2 (1.80 kg) or T_4 (1.81 kg) hens. There were no differences in BW at 10 (5.42 kg) or 14 wk (8.67 kg) among treatments. There were no differences in FC. The LT did not affect bird mortality. Litter treated by the heat process used for this study produces a bedding material suitable for rearing market turkeys.

Key words: Turkey litter, heat treatment, growth, feed conversion, litter nutrients

Introduction

Local and national laws regulating poultry litter (PL) land application may require that PL be applied based on crop need and PL nutrient content such as N and P (Gernat, 2003; Hansen, 2000; White, 2000). In addition, soil metal concentrations, such as Cu and Zn, have become a concern in areas of agriculture waste land application (Garlich, 1999; Tucker, 1997) with mandatory monitoring of soil Cu and Zn in some states such as North Carolina (Carter *et al*., 1999). In many locations, land application has historically been based on crop utilization of nitrogen. However, the passage of laws and regulations controlling land application of litter based on phosphorus is increasing (Gernat, 2003). Because crops normally use less P than N, this would potentially further restrict the use of PL for crops.

Even though efforts are under way to decrease fecal nutrient excretion, there is also a need to extend the useful life of current bedding materials and to develop alternative uses of poultry litter once its usefulness as bedding has ceased. Multiple flocks of birds are reared on litter before it is removed and the poultry house is cleaned and disinfected (Carpenter, 1992). Rearing broilers on old litter has not been considered to be a problem (Vieira and Moran, 1999; Kennard and Chamberland, 1951; McCartney, 1971; Jones and Hagler, 1983). However, turkeys are managed somewhat differently in that it is a common turkey industry practice for all turkey poults to be reared to five or six weeks on new, clean bedding. Growing the birds from five or six weeks old to market age on bedding used two to three flocks is also common. However, it is not unusual to observe turkey performance decrease as the number of flocks reared on a bedding material increases (personal communication).

Kelly *et al.* (1995) demonstrated that broiler litter could be stored for reuse in rearing broilers. Sweeten (1988) reported, that during composting, poultry litter reaches

[1]The use of trade names in this publication does not imply endorsement by the North Carolina Research Service or the North Carolina Cooperative Extension Service of the products mentioned or criticism of similar ones not mentioned.

temperatures (54 - 71 °C) to kill pathogens while Carter and Poore (1995) reported that deep stacking broiler litter creates enough heat to kill potential pathogens such as *Escherichia coli* and *Salmonella sp*. A more direct method of heat-treating PL may also extend bedding life. Therefore, the objective of this study was to determine if heat processed turkey litter could be reused as bedding for rearing commercial turkeys.

Materials and Methods

All birds used in this study were handled in accordance with the University Institutional Animal Care and Use Committee. Pine shavings, which had been used as turkey bedding for one growth period, were used in this study. A previous flock of Large White male turkeys had been reared on the bedding for 20 weeks. This litter was removed from the pens and stock piled for approximately two weeks. Portions of the litter were heat processed at either 204 or 220 °C for re-use as bedding material. Four treatments were used: 1) control - new pine shavings, 2) turkey litter heat treated at 95 °C, 3) a 70:30 mixture of turkey litter processed at 95 or 220 °C, respectively and 4) a 95:5 mixture of turkey litter processed at 95 or 220 °C, respectively. The litter processing took place at the North Carolina State University Animal and Poultry Waste Management Center waste processing facility and utilized a proprietary method of heating litter as it passed through closed auger systems (Adherent Technologies, Inc., Raleigh, NC, USA) .

The litter treatments were placed in 36 floor pens in a randomized block design to provide 9 replicate pens per treatment. There were 3 rows of pens with 12 pens per row. Each row of pens served as a block. There were 3 replicates for each treatment in each block (4 treatments x 3 blocks x 3 replicates per block = 36 pens). Each pen was approximately 6 m^2. There was one tube feeder and one bell-type waterer in each pen. Additional temporary feeders and waterers were used during the first two weeks.

Thirty Nicholas Large White turkey hen poults were placed in each pen on day of hatch. Typical rearing techniques were used to rear the birds for a 14 week growth period. During this period standard industry type rations were provided. The feed (Table 1) was formulated initially by the principle investigators and then modified in consultation with a commercial feed manufacturer (Southern States, Inc., Richmond, VA, USA). Monensin was used for coccidiosis prevention up to six weeks of age. No other growth promotants, antibiotics, or feed additives were used. Feed consumption, by pen and mortality were monitored. Birds were weighed individually at 6, 10 and 14, weeks of age. Period and cumulative feed conversion ratios were calculated.

Litter was sampled for nutrient content (N, P, Cu, & Zn) at the beginning of the study and at 6 and 14 wk of age. At wk 6 and 14 the litter was sampled from each pen while at the beginning of the study the litters were sampled before placement into the pens. Litter was analyzed for total hetertrophs and coliform bacteria at the beginning of the study and at wk 6 and 14. The litter treatments were also sampled for *Salmonella sp* and *Campylobacter sp* at the beginning of the study and at wk 14. At wk 6 and 14, litter from pens in each block were combined by treatment into one composite sample providing 3 composite samples per treatment. At the beginning of the study, the litters were sampled before placement into the pens. Ammonia levels were determined in 3 pens per treatment at the beginning of the study and at weeks 6 and 14. Overturned 5 gallon buckets were used to trap air in each sample pen for 1 minute before measuring for ammonia content using Drager tubes (Dragerwerk Ag Lubeck, Germany).

Regression analysis of SAS (SAS, Inc., Cary NC, USA, 1992) was used to analyze all data. The LS Means procedure was used to separate treatment means ($P \leq 0.05$).

Results and Discussion

Body weights for the study are presented in Table 2. At wk 6, treatment 3 (1.86 kg) hens were heavier than hens of treatment 1 (1.78 kg), 2 (1.80 kg) or 4 (1.81 kg). There were no differences in treatment body weights at weeks 10 or 14. There were no differences in cumulative or period feed conversions (Table 3) or mortality (Table 4). The performance of these birds on heat treated litter agrees with other reports where litter or bedding material was stored or composted before us or reuse. Malone *et al.* (1983) used a cellulose fiber based, composted municipal garbage (CMG) to rear broilers compared to broilers reared on new wood shavings. In three experiments using two sources of CMG, broilers reared on CMG had statistically or numerically improved body weights and improved feed conversion (Malone *et al.*,1983). Vieira and Moran (1999) compared rearing broilers on new shavings or previously used, but untreated, litter. The birds reared on the used litter had reduced weight gain at 3 wk of age but had compensated by the end of the trial at 7 wk of age with no differences in feed conversion. Others have reported increased levels of micro-organisms in used litter which may be a stressor for young birds (Schefferle, 1965; Collins *et al.*, 1989; Kelly *et al.*, 1995). It is not uncommon for turkey poults to experience stress and intestinal challenges during the brooding period (Grimes and Jesse, 1995). Exposure to increased levels of litter borne micro-organisms might be expected to lead to decreased performance of turkeys during the brooding or growing periods.

Nutrient analysis for wk 0, 6 and 14 are presented in Table 5. No statistical analysis was performed on the baseline litter values; however, as expected, the pine

Table 1: Composition of feeds used for rearing hens to 14 weeks of age

Ingredient	Starter 1	Starter 2	Grower 1	Grower 2	Finisher 1	Finisher 2
	---------- % ----------					
Corn	45.10	47.60	57.50	57.90	63.60	66.80
Soybean Meal (48%)	43.20	40.50	31.20	29.80	23.80	20.00
Meat & Bone Meal	6.00	5.00	5.00	5.00	5.00	5.00
Fat	1.00	2.25	2.00	3.80	4.10	5.00
Limestone	1.25	1.25	1.25	1.00	1.00	1.00
Phosphate	2.00	2.25	1.80	1.50	1.50	1.25
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Mineral Premix	0.10	0.10	0.10	0.10	0.10	0.10
Vitamin Premix	0.20	0.15	0.15	0.15	0.15	0.20
Choline	0.20	0.15	0.10	0.05	---	---
Lysine	0.15	0.08	0.25	0.18	0.13	0.12
D.L. Methionine	0.26	0.22	0.18	0.16	0.16	0.10
Selenium Premix	0.05	0.05	0.05	0.05	0.05	0.05
Monensin	0.075	0.075	---	---	---	---
Total	100	100	100	100	100	100
Calculated Analysis						
Crude Protein (%)	28.0	26.0	22.6	21.8	19.3	17.6
ME (Kcal/kg.)	2864	2952	3040	3161	3241	3224
Calcium (%)	1.44	1.40	1.28	1.13	1.12	1.07
Available P (%)	0.74	0.76	0.64	0.57	0.58	0.52
Methionine (%)	0.72	0.65	0.57	0.53	0.50	0.42
TSAA (%)	1.16	1.07	0.94	0.89	0.83	0.73
Lysine (%)	1.83	1.66	1.52	1.43	1.21	1.09
Sodium (%)	0.19	0.18	0.19	0.19	0.19	0.19
Feeding Schedule (Wk)	0-4	4-6	6-8	8-10	10-12	12-14
Feed Form	C	C	P	P	P	P

C- Crumble, P- Pellet

Table 2: Body weights of turkey hens reared to 14 weeks of age on different litter treatments

Treatment	Week 0	Week 6	Week 10	Week 14
	---gm---	---------- kg ----------		
1	60	1.78[b]	5.39	8.76
2	59	1.80[b]	5.41	8.69
3	59	1.86[a]	5.52	8.68
4	59	1.81[b]	5.43	8.56
SEM*	0.5	0.02	0.04	0.07

[a]Different superscripts denote statistical significance (P<0.05) within each week. *Pooled standard error of the mean.

Table 3: Feed Conversions of turkey hens reared to 14 weeks of age on different litter treatments

Treatment	Week 6	Week 10	Week 14	Weeks 6-10	Weeks 10-14
1	1.44	1.79	2.19	1.23	3.66
2	1.45	1.78	2.22	1.22	3.80
3	1.43	1.77	2.28	1.21	4.24
4	1.45	1.77	2.21	1.20	3.80
SEM*	0.02	0.12	0.04	0.04	0.19

*Pooled standard error of the mean.

shavings was noticeably lower in all nutrients surveyed. The heat treated litter had been used as bedding in a previous trial and it was expected that the treatment would eliminate some of the accumulated nutrients (i.e. N loss due to volatilization). The pine shavings litter had less total, ammonium, nitrate and organic nitrogen as well as less phosphorus, copper and zinc than any of the other treatments at week 6. There were no differences for ammonium nitrogen, phosphorus, copper, or zinc among treatments 2-4 for week 6.

Table 4: Mortality (%) of turkey hens reared to 14 weeks of age on different litter treatments

Treatment	Weeks 06	Weeks 6-10	Weeks 10-14	Total Mortality
1	5.83	2.92	0.83	9.58
2	5.19	2.59	0.74	8.52
3	2.08	1.67	3.33	7.08
4	4.07	2.59	1.85	8.52
SEM*	1.15	0.94	0.76	1.62

*Pooled standard error of the mean.

Table 5: Nutrient assessment for litter treatments sampled at Weeks 0, 6 and 14

Treatment	Total N	NH_4	NO_3	Organic N	P	Cu	Zn
	ppm						
(Week 0)*							
1	6944	1213	70.2	5661	1479	6.9	46.3
2	41308	3106	365	37837	14947	70.7	500
3	41117	2079	192	38846	18142	77.2	595
4	40795	3037	346	37412	15995	74.2	551
SEM**	-	-	-	-	-	-	-
(Week 6)							
1	26596^{c}	605^{b}	150^{c}	25842^{c}	5872^{b}	50.0^{b}	311.8^{b}
2	38418^{ab}	1536^{a}	270^{ab}	36612^{ab}	10849^{a}	74.5^{a}	456.6^{a}
3	39197^{a}	1280^{a}	250^{b}	37667^{a}	11043^{a}	77.4^{a}	482.4^{a}
4	36892^{b}	1395^{a}	300^{a}	35197^{b}	10914^{a}	76.8^{a}	462.1^{a}
SEM**	808.1	103.0	12.3	810.3	637.1	2.1	11.7
(Week 14)							
1	56610	7421	20.0	49170	14555	91.3	561
2	52086	5810	49.2	46229	15781	84.8	580
3	50622	5874	23.5	44724	15447	85.4	576
4	53219	6268	35.8	46915	15514	88.0	583
SEM**	2363.6				649.4	4.5	26.7

[a]Different superscripts denote statistical significance ($P<0.05$) for each of the parameters listed.*Only one sample taken for baseline (Week 0) per treatment, therefore, no statistical analysis performed. **Pooled standard error of the mean.

Table 6: Microbial results for litter treatments sampled at Weeks 0, 6 and 14

Treatment	Total Heterotrophs	Coliforms	Salmonella	Campylobacter
	CFU			
(Week 0)				
litter - house	$8.38e+06^{a}$	$1.50e+04^{a}$	-	-
litter - stockpiled	$5.05e+06^{b}$	$0.00e+00^{b}$	-	-
pine shavings	$2.70e+04^{c}$	$0.00e+00^{b}$	0	0
litter - low temp.	$4.50e+04^{c}$	$0.00e+00^{b}$	0	0
litter - high temp.	$9.00e+03^{c}$	$0.00e+00^{b}$	0	0
SEM*	6.32e+05	2.24e+03	-	-
(Week 6)				
1	1.52e+06	$2.68e+05^{a}$	-	-
2	9.17e+05	$5.80e+04^{c}$	-	-
3	3.63e+06	$1.69e+05^{b}$	-	-
4	1.27e+06	$7.47e+04^{c}$	-	-
SEM*	1.60e+06	5.59e+04	-	-
(Week 14)				
1	1.24e+07	$8.09e+04^{a}$	0	2.50e+03
2	1.38e+07	$1.97e+04^{b}$	0	1.17e+03
3	1.35e+07	$1.49e+04^{b}$	1.67e+02	1.17e+03
4	1.39e+07	$1.07e+04^{b}$	0	3.33e+02
SEM*	7.12e+05	2.82e+04	83.3	1.07e+03

[a]Different superscripts denote statistical significance ($P<0.05$) for each of the parameters listed. *Pooled standard error of the mean.

However, at week 6, treatment 4 litter had less total nitrogen, nitrate nitrogen and organic nitrogen than treatments 2 and 3. At wk 14, there were no differences in any of the litter treatments for any nutrient surveyed. There were no differences in aerial ammonia levels among treatments at 0, 6 or 14 weeks of age (data not shown). At 14 wk of age the mean aerial ammonia level measured was 5.4 ppm.

Litter bacterial analysis is presented in Table 6. As expected, previously used litter had significantly higher numbers of total hetertrophs and coliforms than stock-piled or heat treated litter or new pine shavings. The stock-piled litter also had significantly higher levels of total hetertrophs than heat treated litter or new pine shavings. There were no coliforms detected in the stock-piled litter, new pine shavings or heat treated litter at the beginning of the study. In addition, there was no *Salmonella sp*. or *Campylobacter sp*. detected in the new pine shavings or heat treated litter. At week 6, there were no differences in any of the litter treatments for total heterotrophs. However, treatment 1 (new pine shavings) had significantly higher levels of coliforms than any of the heat treated treatments. Treatment 3, which was the 70:30 mixture of turkey litter processed at 95° or 220° C, respectively, had higher levels of coliforms than treatments 2 or 4. At wk 14, there no differences in total hetertrophs for any treatment. However, as observed during week 6, the new pine shavings had significantly higher levels of coliforms than any of the heat treated litter treatments. It may be possible that the heat-treated litters were providing some type of microbial inhibition. There were also no differences among treatments for levels of *Campylobacter sp*. at wk 14. Also at wk 14, there was one composite sample for treatment 3 which had detectable levels of *Salmonella sp*. None of the other samples for treatment 3 or any other treatment had detectable *Salmonella sp*. levels.

This heat treatment process has the potential to provide a product with potential advantages to the poultry industry: 1) a product of potentially greater value than litter, 2) a product that does not have to be land applied which eliminates land application of excess nutrients and 3) a product that could be moved out of the area where it is produced. Therefore, the authors recommend studies to explore the economic and environmental costs or benefits of the heat treatment of turkey or broiler litter.

In summary, the results of this study demonstrate that the heat treatment of previously used turkey litter, as processed in this study, produces a bedding equal to new pine shavings as a litter material for the rearing of commercial market turkeys.

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