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Composting of Turkey Brooder Litter in South Carolina: An On-Farm Demonstration Project

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Abstract

A composting demonstration project was conducted on a turkey brooder farm in one of the major turkey production areas of South Carolina. Litter was removed from the barns and was moved to a composting shed located on the farm. Data were collected to determine the content of plant nutrients, carbon, TS, VS, FS, and C:N in the litter before and after composting. Windrow temperatures were monitored to determine if the required temperature conditions were obtained for pathogen treatment. Turkey brooder litter composted well as indicated by an average windrow temperature of 59°C for 59 days. The final product was very stable as indicated by a very low CO_2 evolution rate (0.2 mg CO_2-C/g organic matter/day). The C:N of the brooder litter was 22 and the C:N of the compost product was 23. It was determined that N losses during composting (53%) caused the C:N to remain constant. Therefore, reduction in C:N was not found to be a good indicator of compost stability in this field study. Comparison of the composition of brooder litter with turkey grow-out litter indicated that brooder litter contained 29% less plant available nitrogen, and cost 47% more to spread on distant fields. As a result, composting may be a more desirable management option in such cases.

Keywords**:** composting, compost quality, poultry litter, nutrient management

Introduction

Turkey production involves two phases. The first phase occurs on brooder farms where young turkeys are placed at a few days of age and are kept in brooder barns until they are about 35 days old. The young turkeys are then transported to a grow-out farm where they are raised to market weight.

Turkey producers and litter brokers have observed that turkey brooder litter often has less fertilizer value as compared to grow-out turkey litter or broiler litter due to low nutrient content (N, P, and K). As a result, traditional land application is often undesirable or cost prohibitive if significant transportation distances are required.

Composting poultry litter has been suggested as a utilization alternative for years. One of the main deterrents for composting most types of poultry litter is the large amounts of additional carbon needed to raise the carbon to nitrogen ratio (C:N) from about 10 to 11 (Coloma, 2005; Henry, 1990) to the desirable range of 20 to 40 (Rynk et al., 1992).

It was a required company disease control practice to remove litter completely from turkey brooder barns after each flock, and then begin the next flock with fresh wood shavings. As a result, litter removed from barns on this farm contained a large amount of wood shavings relative to the amount of manure added by the young turkeys. Therefore, it was hypothesized that litter from turkey brooder barns would have a C:N ratio high enough to compost without adding additional carbonaceous material. If this is the case, composting turkey brooder litter may have the potential to become a profitable utilization option.

Purpose

A composting trial was conducted on a turkey brooder farm in Kershaw County, SC. The goal of the study was to demonstrate the efficacy of composting turkey brooder litter without addition of carbon amendments. The objectives to meet this goal were to: (1) measure the concentrations of major and selected minor plant nutrients, solids, and ash in turkey brooder litter as-removed from the building, (2) determine the C:N and moisture content of turkey brooder litter as-removed from the building, (3) compare and contrast the plant nutrient composition of turkey brooder and turkey grow-out litter, (4) observe the maximum, minimum, and average windrow temperatures during on-farm composting of turkey brooder litter, and (5) evaluate the quality of finished compost based on nutrient content, C:N ratio, CO_2 evolution rate, and color.

Information from this on-farm demonstration was used to develop extension classes for poultry producers on composting production and use. These classes were offered as part of the Confined Animal Manure Managers Program provided by Clemson University Extension.

Methods

This demonstration was conducted at a commercial turkey brooder farm located in Kershaw County, SC. The producer was interested in composting the litter from brooder barns on his farm and developing local markets for the finished product.

Description of the Composting Process

The composting trial began by removing brooder litter from a barn and transporting the litter by truck to an area beside the composting shed. A single large windrow was formed on one side of the shed. The moisture content of the brooder litter was increased by adding water to the litter as the windrow was constructed. Water was added to the litter using an overhead sprinkler system that was installed on the bottom cord of the trusses in the shed (Figure 1).

Moisture was added to the brooder litter as the windrow was built up in layers. The actual moisture content of the litter at the beginning of the composting trial was not measured. Instead, the moisture content of the litter was evaluated in the field using the ball squeeze method. The ball squeeze method has been recommended for in-field estimates of soil and compost moisture by many extension publications (*e.g.* Rynk et al., 1992). The ball squeeze method involves grabbing a handful of the material to be composted and squeezing the material to form a ball. If only a few drops of moisture come out of the material and it feels like a damp sponge the moisture content is in the desired range for composting (50% to 60%). If the ball of material falls apart the material is too dry. If a large amount of water is squeezed out the material is too wet.

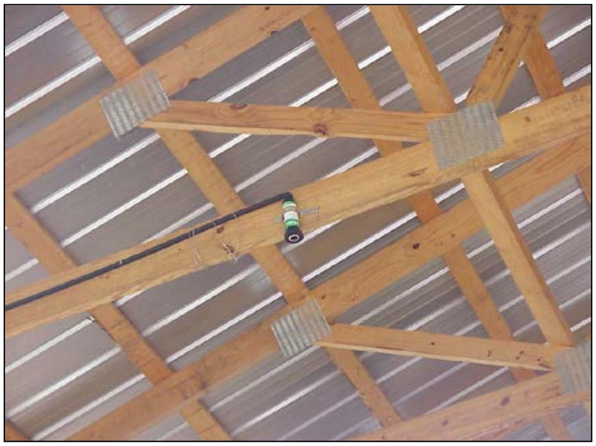

Figure 1. One of three sprinklers used to add water to the brooder litter as the windrow was formed in layers.

The windrow was built by spreading out a layer of litter, adding moisture, checking the moisture with the ball squeeze test, and then adding another layer. This procedure was continued until the top of the windrow was about 1.8 m high. The completed windrow is shown in Figure 2.

Figure 2. A completed windrow in the composting shed.

The windrow was turned periodically to provide aeration using a tractor and front-end loader. As the windrow was turned it was reformed on the opposite side of the shed. The windrow was turned approximately every week during the first 21 days. Following the 21st day the compost was turned whenever windrow temperatures near 71°C were observed, or when the temperatures began to decline. Windrow temperatures were measured using a long-stem (122 cm) thermometer and data were recorded by the turkey producer. Temperatures were taken in 12 to 16 locations within the pile during the composting process (Figure 3). Daily temperature measurements began on the 22nd day of composting. Temperature monitoring did not begin until the 22nd day due to a delay in receiving the long-stem thermometer at the farm.

After about two months of composting in the shed, the compost was removed and a windrow was formed in a nearby, grassy field (Figure 4). The producer continued to monitor windrow temperatures on a regular basis. The frequency of temperature measurements decreased to about every other day near the end of the active composting stage. Once the compost temperatures fell below 38°C, and additional turning did not result in additional heating, temperature measurements were suspended. The compost was allowed to cure for 40 days before samples were collected from several locations in the windrow for analyses.

Figure 3. Windrow temperature measurements using a long-stem thermometer.

Figure 4. Final curing of compost in an open windrow.

Sampling and Quantities Measured

Samples were collected to characterize the brooder litter before and after composting. Two samples of brooder litter were collected from each of several locations in the brooder houses. A large sample was collected from each of several locations in the windrow after composting and curing was completed.

All samples were well-mixed in a large container prior to sub-sampling for analyses. Two sub-samples of brooder litter and finished compost were analyzed for major and minor plant nutrients. Three sub-samples of litter and compost were used to determine solids and carbon content.

Two litter and compost sub-samples were sent to the Agricultural Services Laboratory at Clemson University to determine the concentrations of the following plant nutrients: total ammoniacal nitrogen (TAN = NH_4^+-N + NH_3-N), organic-N, nitrate-N, total P (expressed as P_2O_5), total K (expressed as K_2O), calcium, magnesium, sulfur, zinc, copper, manganese, and sodium. The laboratory at Clemson University also measured the moisture content.

Total solids (TS), volatile solids (VS), and fixed solids (FS) were measured in the Agricultural, Chemical, and Biological Research Laboratory in McAdams Hall at Clemson University according to standard techniques (APHA, 1995). Three sub-samples were taken from the brooder litter and the composted litter, placed in porcelain dishes, and dried in an oven at 105ºC for 24 hours. Total solids content were determined after the sample was allowed to cool in a desiccator. Fixed solids content (ash) was determined by incinerating the dried solids in a furnace at 550ºC for 2 to 3 hours, allowing the sample to cool in a desiccator, and determining the sample mass. Volatile solids were calculated as the difference between the total and fixed solids.

Characteristics Calculated from Measurements

The percent carbon of the brooder litter was calculated on a dry basis using the following equation (Rynk et al., 1992):

$$C_{DB\text{-}LITTER} = (100 - FS_{DB}) / 1.8 \qquad (1)$$

where:

$C_{DB\text{-}LITTER}$ = carbon content of litter on a dry basis, (%), and
FS_{DB} = fixed solids of litter on a dry basis, (%).

Equation 1 provides a reasonable estimate of the carbon content for un-composted manure and common carbon sources. Equation 1 assumes that 55.56% of the volatile solids are composed of carbon ($VS_{DB} = 100 - FS_{DB}$). However, carbon will be consumed during composting and will reduce the fraction of remaining VS that will be carbon. Therefore equation 1 does not provide a good estimate of the carbon content of composted materials.

The total nitrogen (TN) contained in brooder litter or finished compost was calculated as:

$$TN = TAN + Organic\text{-}N + Nitrate\text{-}N \qquad (2)$$

Aerobic microbes use a portion of the C and N during the composting process. A portion of the carbon is released as CO_2, and nitrogen can be lost by volatilization of ammonia or by leaching of nitrate. The remainder is retained as living or dead cell biomass. The reduction in total nitrogen (TN) was calculated as the difference between the TN in the litter and the TN in the finished compost on a dry matter basis. The volatile solids measurement contained all of the fixed carbon, organic carbon, and nitrogen in the sample. During the combustion process all of the nitrogen and organic carbon was burned off and was lost in exhaust gases. Therefore, a good estimate of the carbon used by the microbes was the difference in non-nitrogen volatile solids. The reduction in carbon was calculated from the reduction in non-nitrogen volatile solids as:

$$\Delta C_{DB} = (VS_{DB\text{-}LITTER} – TN_{DB\text{-}LITTER}) – (VS_{DB\text{-}COMP} – TN_{DB\text{-}COMP}) \tag{3}$$

where:
ΔC_{DB} = the reduction in carbon content during composting (dry basis),
$VS_{DB\text{-}LITTER}$ = the volatile solids content of litter (dry basis),
$TN_{DB\text{-}LITTER}$ = the total nitrogen content of litter (dry basis),
$VS_{DB\text{-}COMP}$ = the volatile solids content of compost (dry basis), and
$TN_{DB\text{-}COMP}$ = the total nitrogen content of compost (dry basis).

The carbon content of finished compost was calculated as:

$$C_{DB\text{-}COMP} = C_{DB\text{-}LITTER} - \Delta C_{DB} \tag{4}$$

The carbon to nitrogen ratio (C:N) of the litter and compost was calculated using the following relationship with the appropriate dry matter concentrations:

$$C:N = C_{DB}/TN_{DB} \tag{5}$$

Nitrogen can be present in manure as ammonium-N, ammonia-N, organic-N, and nitrate-N. Not all of the nitrogen in manure is immediately available for plant use. The nitrogen that is available for plant use is called the plant available nitrogen (PAN). The plant available nitrogen in animal manure can be estimated as (Chastain et al., 2001; Chastain, 2006):

$$\text{PAN} = A_f\,\text{TAN} + m_f\,\text{Organic-N} + \text{Nitrate-N} \tag{6}$$

where:
A_f = the ammonium-N availability factor, and
m_f = the organic-N mineralization factor.

Therefore, the plant available nitrogen is the sum of the TAN that is not lost by volatilization, the portion of the organic-N that is mineralized during the growing season, and all of the nitrate nitrogen.

The value of the ammonium-N availability factor varies from 0.5 to 1.0 depending on if the material is surface applied without incorporation ($A_f = 0.50$), incorporated on the day of application ($A_f = 0.80$), or incorporated immediately ($A_f = 1.0$; Chastain et al., 2001; Chastain, 2006). Compost and litter provide the most benefits to the soil if the material is incorporated on the day of application. It was assumed that the materials were incorporated for the comparisons in this study, and the value of A_f used was 0.80.

The value of the organic-N mineralization factor depends on the type of manure and type of biological treatment (Chastain, 2006). The recommended mineralization factor is 0.60 for poultry litter and 0.12 for compost (Chastain, 2006; Rynk et al., 1992).

The equations used to estimate the plant available nitrogen content of brooder litter and compost were:

$$\text{PAN}_{LITTER} = 0.80\ \text{TAN} + 0.60\ \text{Organic-N} + \text{Nitrate-N} \tag{7a}$$

$$\text{PAN}_{COMPOST} = 0.80\ \text{TAN} + 0.12\ \text{Organic-N} + \text{Nitrate-N} \tag{7b}$$

Carbon Dioxide Evolution Rate

The CO_2 evolution rate is a measure of the microbial activity in compost. Consequently, it is one of the primary methods used to evaluate the stability of the finished compost.

A sample of finished compost was sent to the Agricultural Analytical Services Laboratory at The Pennsylvania State University (University Park, PA 16802) for measurement of the CO_2 evolution rate. The mean CO_2 evolution rate (mg CO_2-C/g organic matter/day) was the mean of two sub-samples. This laboratory was selected since it was federally approved for testing compost quality.

Results and Discussion

Nutrient and Moisture Content of Turkey Brooder and Grow-Out Litter

Two turkey brooder litter samples were taken from each of the houses on this farm prior to composting. The average nutrient contents on a wet and dry basis for these two samples are compared with the nutrient content of turkey grow-out litter that was obtained in a previous study (Chastain et al., 2001) in Table 1.

Nutrient contents were compared on a dry matter basis since the moisture content of the two samples was different. The nutrient contents were converted from percent wet basis to percent dry basis by dividing the as-sampled concentration by the dry matter fraction (F_{DM}).

The data shown in Table 1 indicates that brooder litter on this farm had lower moisture content, nutrient content, and density than a typical turkey grow-out litter. The brooder litter contained 36% less TN, 61% less P_2O_5, and 55% less K_2O, and about half as much Mg, and S as turkey grow-out litter. The dry matter concentrations of Cu, Zn, Mn, and Na were also much lower in brooder litter than grow-out litter.

Estimates of the plant available nitrogen (PAN) are also given in Table 1. The brooder litter on this farm contained 29% less plant available N (PAN) than turkey grow-out litter. Application of turkey grow-out litter to provide 100 kg PAN/ha would require spreading 5.68 metric tons (1000 kg/MT) per hectare. Whereas, application of 6.85 MT of brooder litter per hectare would be required to provide the same amount of PAN/ha. As a result, 1.2 times as much brooder litter would be required per hectare to provide the equivalent amount of PAN.

In most regions of the U.S., the only litter utilization option that is included in manure or comprehensive nutrient management plans is land application to cropland. Land application can be environmentally responsible and cost effective if a sufficient amount of cropland is available close to the turkey farm. If litter must be transported to distant fields for utilization the nutrient content and density become controlling variables in the transportation costs.

The lower bulk density of brooder litter as compared to grow-out litter (481 kg/m^3 versus 353 kg/m^3) results in greater transportation and application costs. The transportation cost for grow-out litter in Kershaw County was about $14 per metric ton for modest distances. The density of brooder litter was 27% lower than for grow-out litter. Therefore, a truck used to transport grow-out litter would hold 27% less brooder litter by weight, and the transportation cost would increase to $18/1000 kg for brooder litter. The cost to land apply litter can range from $2.79 to $5.60 per metric ton with an average of $4.20/MT based on estimates that include fuel, labor, and equipment costs.

Table 1. Comparison of nutrient content of turkey brooder litter with turkey grow-out litter on a wet and dry basis (F_{DM} = dry matter fraction).

	Brooder Litter		Grow-Out Litter[1]	
Moisture	14.53%		26.5%	
F_{DM}	0.8548		0.735	
Bulk Density[2]	353 kg/m^3		481 kg/m^3	
	(% wet basis)	(% dry basis)	(% wet basis)	(% dry basis)
TAN	0.13	0.15	0.60	0.82
Organic-N	1.86	2.18	2.10	2.86
Nitrate-N	0.03	0.03	0.02	0.02
Total-N	2.02	2.36	2.72	3.69
PAN – Incorp.[3]	1.25	1.46	1.76	2.39
P_2O_5	1.47	1.72	3.20	4.36
K_2O	1.02	1.19	1.95	2.66
Calcium	1.06	1.24	1.85	2.52
Magnesium	0.18	0.20	0.35	0.47
Sulfur	0.21	0.25	0.44	0.59
Zinc	0.024	0.028	0.031	0.042
Copper	0.014	0.017	0.026	0.036

[1] Data from Chastain et al., 2001).

[2] Litter Density (lb/cu. ft.) = 77.29 - 0.643 TS (%), r^2 = 0.9751, multiply by 16.018463 to convert to kg/m^3 (Chastain et al., 2001).

[3] PAN – incorp.= plant available N if litter is incorporated on the day of application, equation 7a.

The cost to transport and land apply litter was estimated as:

$$ATC = (CT + CA) \times LAR \tag{8}$$

where:

ATC = application and transportation cost per hectare,
CT = transportation cost, \$/1000 kg,
CA= application cost, \$4.20/1000 kg, and
LAR = litter application rate, metric tons per hectare.

The influence of the differences in bulk density and PAN content can be demonstrated assuming that litter was applied to provide 100 kg PAN/ha. For both materials, the application cost was assumed to be \$4.20 per metric ton. Using a transportation cost of \$14 per metric ton for grow-out litter and a litter application rate of 5.68 MT/ha, total transportation and application cost would be \$103.38/ha (equation 8). The amount of brooder litter needed to provide the same amount of plant available N was 6.85 MT/ha with a transportation cost of \$18 per metric ton. The total application and transportation cost for brooder litter would be \$152.07/ha. Therefore, it would cost 47% more to utilize brooder litter than grow-out litter for the same transportation distance and PAN application rate. The low nutrient content and higher transportation costs places turkey brooder producers at an economic disadvantage if the waste management plan requires transportation of litter long distances.

Composting Temperature History

The trial began immediately after the windrow was formed in the composting shed, day zero. For the first 21 days of composting, the long-stem thermometer was not on-site and no temperature data were taken. However, the windrow was turned weekly during the first three weeks. The windrow was turned on the 21st day and temperature measurements began on day 22. Temperature measurements continued till day 96 when the average compost temperature fell to 38°C. The average, maximum, and minimum temperatures are shown in Figure 5.

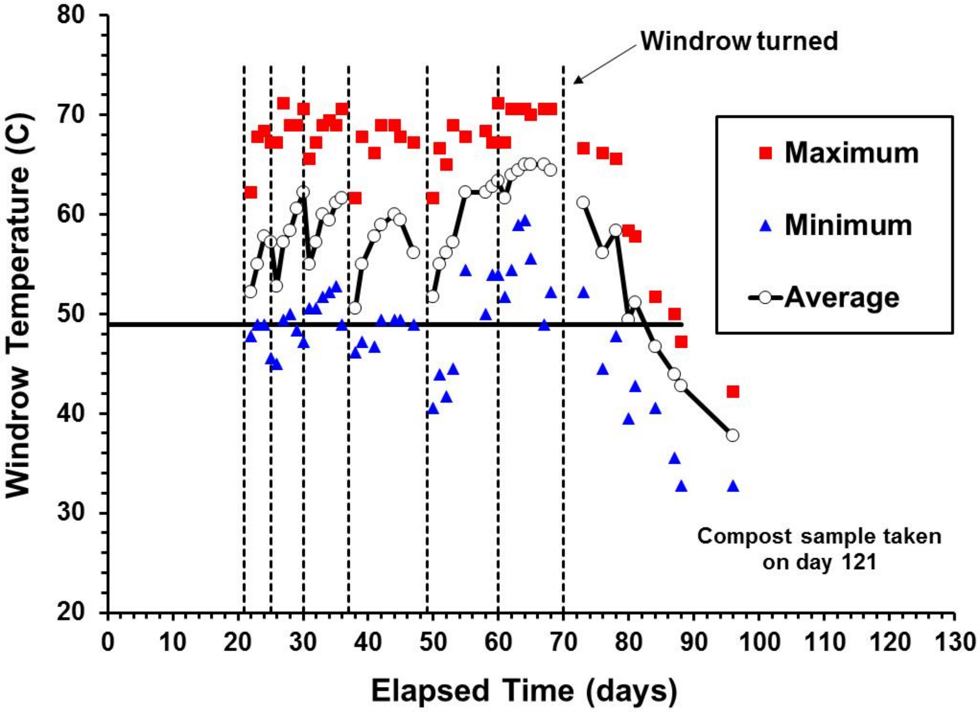

Figure 5. Average, maximum, and minimum temperatures (°C) during composting of turkey brooder litter.

Composting litter must be maintained at sufficiently high temperature to provide adequate lethality for pathogens. In addition, composting is most efficient at temperatures in the range of 40°C to 60°C, and the optimum temperature is about 55°C (Finstein, 1981; Willson, et al., 1980 as cited by Henry, 1990).

The compost windrow was turned 7 times after temperature monitoring was initiated. The first 6 times the windrow was turned the average windrow temperatures followed a similar pattern: the temperature fell after turning and then increased to 53°C or more. The seventh time the windrow was turned (on day 70) the windrow temperatures declined at a steady rate. The producer turned the compost a few more times, but the windrow temperatures never increased again. Therefore, it was concluded that active composting was completed on day 81. The compost was allowed to cure in an uncovered windrow until the 121st day.

The average windrow temperature was above 49°C for 59 days (day 22 to 81). The average temperature during this period was 59°C with a maximum of 71°C and a minimum of 39°C. Based on EPA standards for pathogen reduction (EPA, 2003), the core temperature of a windrow must be 55°C or more for 3 days with a minimum number 5 turnings. Therefore, the temperatures observed from day 22 to 81 satisfied pathogen reduction requirements.

Concentrations of Plant Nutrients, Volatile Solids, Ash, and Carbon Before and After Composting

A composite sample of composted brooder litter was collected from several locations in the outdoor windrow on the 121st day. The composition of the finished compost, based on the mean of two sub-samples, is compared with the untreated brooder litter in Table 2.

The constituents of the un-composted and composted litter were compared using a concentration factor defined as:

$$CF = C_{COMP\text{-}DB} / C_{LITTER\text{-}DB} \quad (9)$$

where:

CF = the concentration factor for the constituent,
$C_{COMP\text{-}DB}$ = the dry basis concentration of the constituent in the compost, and
$C_{LITTER\text{-}DB}$ = the dry basis concentration of the constituent in the brooder litter.

Nitrogen, Carbon, C:N, and Moisture Content of Turkey Brooder Litter

One of the objectives was to determine if turkey brooder litter was suitable for composting without the addition of carbonaceous material. The carbon content of the litter was not determined until after the composting trial was initiated. It was determined that turkey brooder litter on this farm was 51.3% carbon on a dry basis (Table 2). The total nitrogen content was 2.36% on a dry basis. The C:N for turkey brooder litter as-removed from the house was 22, and was within the acceptable range of C:N for composting (20 to 40, Rynk et al., 1992).

The other major factor for composting performance is the moisture content. The moisture content of turkey brooder litter averaged 14.5%. Therefore, water was added to achieve a moisture content that would facilitate composting (50% to 60%) as the windrow was constructed. The actual moisture content of the litter at the beginning of the composting trial was not measured. Instead, the moisture was estimated using the ball squeeze method. The amount of moisture added proved to be adequate as evidenced by the composting temperatures achieved (Figure 5), and a final compost moisture content of 51.0%.

Influence of Composting on Nitrogen, Carbon, and C:N

During the composting process, a portion of the nitrogen in the windrow can be lost and a portion of the organic-N will be mineralized. Microbes convert organic-N first to ammonium-N and then nitrifying bacteria convert a portion of the ammonium-N to nitrate nitrogen. A portion of the ammonium-N will be converted to ammonia gas that can be lost from the composting material by volatilization. In addition, a portion of the nitrate nitrogen can be lost from an uncovered compost windrow by leaching.

At lower values of C:N, carbon is often the limiting energy component for the microbes and ammonium-N is generated at a faster rate than can be utilized by microbes. Consequently, a greater fraction of the total nitrogen (TN) can be lost as ammonia. Under ideal conditions (optimal C:N, temperature, pH, moisture), and if leaching and volatilization losses are controlled, all of the degradable organic nitrogen would be converted to soluble forms and would be used to build microbial biomass. The nitrogen in the finished, stable compost would be predominantly in organic form. However, such ideal conditions are very difficult to obtain on-farm in a turned windrow.

Table 2. Comparison of the plant nutrient, volatile solids, carbon, and ash content of turkey brooder litter before and after composting.

	Before Composting[1]		After Composting[2]		
Moisture	14.53%		50.99%		
F_{DM}	0.8548		0.4902		
	(% wet basis)	(% dry basis)	(% wet basis)	(% dry basis)	*CF*[3]
TAN	0.13	0.15	0.11	0.22	1.47
Organic-N	1.86	2.18	0.40	0.81	0.37
Nitrate-N	0.03	0.03	0.03	0.06	2.00
Total-N	2.02	2.36	0.54	1.10	0.47
PAN – Incorp.[4]	1.25	1.46	0.17	0.33	0.23
Total Carbon	43.88	51.34	12.25	25.00	0.49
P_2O_5	1.47	1.72	0.53	1.09	0.63
K_2O	1.02	1.19	0.34	0.69	0.58
Calcium	1.06	1.24	0.40	0.82	0.66
Magnesium	0.17	0.20	0.06	0.12	0.60
Sulfur	0.21	0.25	0.06	0.13	0.52
Zinc	0.024	0.028	0.009	0.018	0.64
Copper	0.014	0.016	0.004	0.009	0.56
Manganese	0.024	0.028	0.010	0.020	0.71
Sodium	0.084	0.099	0.027	0.055	0.56
VS	78.99	92.41	31.77	64.81	0.70
FS (ash)	6.49	7.59	17.25	35.19	4.64
C:N		22		23	
C/TS		0.513		0.250	
C/VS		0.556		0.386	
TN/TS		0.024		0.011	
VS/TS		0.924		0.648	
PAN/P_2O_5		0.849		0.303	

[1] Before sample is based on the average of two samples of brooder litter before composting.

[2] Analysis of 2 sub-samples from a large composite sample collected on day 121 from several locations in the composted windrow.

[3] Concentration factor calculated using equation 9.

[4] PAN – incorp.= plant available N if litter is incorporated on the day of application, equation 7a and 7b.

Carbon provides energy for the composting microbes. A portion of the carbon will be converted into microbial biomass and a large portion of the carbon will be lost as CO_2 as a result of cellular respiration. Like organic-N, not all of the carbon is available for use by the microorganisms. Wood shavings used in turkey brooder houses for bedding contain a large amount of carbon as cellulose and lignin. Lignin and cellulose degrade very slowly and are not readily available to composting microbes.

Composting microbes can only use a fraction of the organic-N. Organic nitrogen accounted for 92% of the total nitrogen in un-composted turkey brooder litter (Table 2). The reduction in organic-N was believed to be the best indicator of the consumption of N by composting microbes since organic-N is converted to soluble forms of N that can be lost. The concentration factor for organic-N (Table 2) was 0.37. Therefore, composting reduced the organic-N concentration by 63% on a dry basis in 121 days.

Composting of brooder litter greatly altered the nitrogen composition and reduced the amount of nitrogen that could be used to replace fertilizer-N to grow a crop. After composting, the ammonium-N content was increased by 47% and the nitrate-N concentration was doubled. However, the total-N content was reduced by 53% and the plant available N was reduced by 77%. As a result, a substantial amount of nitrogen was lost from the compost by ammonia volatilization and possibly leaching of nitrate during the uncovered curing phase.

The carbon content of the dry matter was reduced by 51%, however the value of C:N was not changed for all practical purposes. It was estimated that after composting, 38.6% of the VS were carbon (equation 4). The C:N value did not change significantly with composting. This was due to the fact that 53% of the TN was lost. If only 25% of the TN had been lost during composting the final C:N would have been 14.

The volatile solids fraction (VS/TS) fell from 0.924 before composting to 0.648 after composting. This was equivalent to a 30% reduction in volatile dry matter concentration. The volatile fraction of the dry matter was the only portion of the solid material that was reduced by composting.

Fixed solids or ash cannot be utilized in any biological treatment process. Therefore, an increase in the fixed solids was expected during composting. The ash content of the compost was 4.64 greater than the brooder litter.

The results of this trial point out that reduction in C:N is not a reliable indicator of compost quality and stability under field conditions since nitrogen losses raise the C:N value of finished compost. Quantification of the reduction in organic-N, TN, C, VS, and an adequate temperature history provides a more complete description of the quality of finished compost. In addition, the fact that the composting mix would not re-heat with additional turning provided good indication that the composting microbes had used the majority of the available N and C.

Reductions in P, K, Minor Plant Nutrients and Minerals

The composting process does not reduce the amount of P_2O_5, K_2O, calcium, magnesium, sulfur, zinc, copper, manganese or sodium in a composting mixture. Composting microbes will use small amounts of these components, but these nutrients and minerals will remain in the microbial biomass.

A significant portion of the P, K, and the defined minor nutrients or minerals are either in a soluble form or would most likely be converted to soluble forms during the composting process. In Table 2, the concentration factors for each of these components were less than one indicating a reduction in dry matter concentration. These reductions are believed to be due to leaching losses that occurred while the compost was being finished and cured in an uncovered windrow. A biological or porous geotextile cover could be used to greatly reduce these losses.

The data provided in Table 2 indicate that the compost produced during this trial had significant amounts of S, Mg, Mn, and other minor plant nutrients. Therefore, this compost could be used as a minor nutrient supplement for many crops (Jones, 1998).

Change in N, P_2O_5, and K_2O Content on an As Sampled Basis

The nutrient content of fertilizer and some composted materials are often given in percent on an as sampled or wet basis. Using the PAN estimates in Table 2, it was determined that un-composted brooder litter was a 1.25-1.47-1.02 fertilizer, and composted turkey brooder litter was a 0.17-0.53-0.34 fertilizer. These results indicate that composting reduced the fertilizer value of the brooder litter. Therefore, composting is not a good option if nitrogen is the major plant nutrient needed by the crop to be grown.

Carbon Dioxide Evolution Rate

A respirometry test was performed on a sample of finished brooder litter compost by the Agricultural Analytical Services Laboratory at The Pennsylvania State University to measure the CO_2 evolution rate. The compost sample had a moisture content of 54.1% when it was received at the laboratory. Water was added to bring the sample to a moisture content of 63.4%. The amount of carbon dioxide released by two sub-samples was measured over 2 days. The mean CO_2 evolution rate was found to be 0.1 mg CO_2-C/g solids/day or 0.2 mg CO_2-C/g organic matter/day.

The compost stability and quality criteria used to interpret the results are given in Table 3. The brooder litter compost was rated as very stable with no potential for phytotoxicity from volatile fatty acids. The potential for odor, and impact on soil carbon was also rated very low. That is, the compost would not be expected to be a net immobilizer of available nitrogen in soil.

Table 3. Use of CO_2 evolution rate as an interpretive index for compost quality[1].

CO_2 Evolution Rate (mg CO_2-C/g organic matter/day)	Stability Rating	General Characteristics
< 2	Very Stable	Well cured compost; no continued decomposition; no odors; no potential for volatile fatty acid phytotoxicity.
2 - 8	Stable	Cured compost; odor production not likely; limited potential for volatile fatty acid phytotoxicity; minimal impact on soil carbon and nitrogen dynamics.
8 - 15	Moderately Unstable	Uncured compost, minimal odor production, moderate to high potential for volatile fatty acid phytotoxicity, moderate potential for negative impact on soil carbon and nitrogen dynamics.
15 - 40	Raw Compost	Green, uncured compost; Odor production likely; high potential for volatile fatty acid phytotoxicity; high potential for negative impact on soil carbon and nitrogen dynamics.
> 40	Raw Feedstocks	Raw, extremely unstable material; odor expected; probably high volatile fatty acid phytotoxicity with most materials; negative impact on soil carbon and nitrogen dynamics; not recommended for use as compost.

[1] Source: U.S. Composting Council Test Methods for the Examination of Composting and Compost as cited by the Agricultural Analytical Services Laboratory at The Pennsylvania State University.

Visual Comparison of Turkey Brooder Litter Before and After Composting

High quality compost should have a dark brown to black color, be free of undesirable solid matter, and should emit no objectionable odor. Before composting the turkey brooder litter was light brown in color, and feathers and manure particles were evident as indicated in Figure 6. The un-composted litter also emitted foul odor. After active composting and curing was completed the composted brooder litter had a dark brown color, did not emit objectionable odors, and feathers and manure particles were not evident (Figure 6).

Figure 6. Visual comparison of turkey brooder litter before and after composting.

Conclusions

- The C:N value of turkey brooder litter as removed from the house was 22 and was suitable for composting without addition of additional carbon containing materials
- Comparison of the composition and characteristics of brooder litter with grow-out litter indicated brooder litter was less dense than grow-out litter and contained 29% less plant available nitrogen. The low plant nutrient content, and higher transportation and application costs associated with brooder litter made it less desirable to use in situations that require moving litter long distances for utilization.
- Turkey brooder litter composted well as indicated by the temperature history, reduction in carbon and organic-N, dark brown color, and low odor emitted by the final product.
- The compost windrow was turned 9 times and the average temperature was 59°C for 59 days. Therefore, adequate treatment was provided for pathogens.
- The CO_2 evolution rate of the finished compost was 0.2 mg CO_2 – C/ g organic matter – day. Therefore, the compost product was very stable, well cured, with no potential for volatile fatty acid phytotoxicity or unpleasant odor.
- Composting reduced the carbon content by 51%, total-N by 53%, and plant available-N by77%.
- A significant amount of N was lost during the composting and curing process by ammonia volatilization and leaching of nitrate.
- The final C:N was about the same as the initial C:N. Therefore, change in C:N was determined to be a poor indicator of compost quality under field conditions.
- Composting significantly reduced the N, P, and K content of the litter. Therefore, the final compost product would make a good soil amendment to add organic matter, P, K, magnesium, sulfur, and other minor plant nutrients.

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