Management of Slaughterhouse Bone Residual for Composting

Submitted by: Mark Hutchinson, University of Maine Cooperative Extension, 377 Manktown Rd Waldoboro, ME 04572 phone: 207-832-0343 email: **markh@umext.maine.edu**

AUTHORS: B.Seekins, N. Hallee, M.L. Hutchinson, M.A.King

I. Introduction

Beginning in the winter of 2001, the Maine slaughterhouse industry faced a crisis associated with disposal of the waste products (offal) from their facilities. As a response to that crisis, the Maine Department of Agriculture, in cooperation with the University of Maine Cooperative Extension and Maine Department of Environmental Protection undertook a program to assess composting as a viable approach to managing these wastes.
One of the significant technical difficulties encountered in the offal composting trials was the management of bones. Trials were developed to assess the adequacy of different types of grinding equipment for managing the bones from slaughterhouses. Equipment was assessed for safety, grinding performance and composting performance of material after grinding.

II. Materials and Methods

A tub grinder, wood chipper, hammer mill, ALLU bucket, and vertical mixer wagon were identified for evaluation. The wood chipper was ruled out because of serious safety issues. Bone grinding trials conducted at Highmoor Farm Agricultural Experimental Station, evaluated a Farmhand tub grinder and an ALLU bucket. Other identified equipment not tested was either unavailable or not operational at the time of the trials.

For each piece of equipment, a trial was conducted with a mixture of bones and horse bedding that had been composting for approximately six weeks and a second trial with each piece of equipment using fresh 'bones' and horse bedding. In all cases, the 'bones' actually consisted of a mixture of bones, fat, hides, heads, feet and animal parts other than entrails from a slaughterhouse.

In all cases, the blended materials were ground using the piece of equipment and then formed into a windrow (pile). The windrows were identified by equipment and bone condition (See Table 1).

Table 1. ID Numbers for Trial Windrows

ID #	Equipment Used	Material Used
A1	ALLU Bucket	Precomposted bones & bedding
A2	ALLU Bucket	Fresh bones & bedding
B1	Tub Grinder	Precomposted bones & bedding
B2	Tub Grinder	Fresh bones & bedding

Approximately 50 cubic yards of material was ground in each piece of equipment, 20-25% offal and 75-80% horse bedding. Windrows were left undisturbed except for data collection and sampling activities. In a normal compost operation, the windrows would have been turned on a schedule dictated by the age of the materials and pile temperatures. In this trial, however, it was felt that turning would compromise the results. It would not have been possible to separate the changes in size distribution created by the composting process from the mechanical reduction that would happen as a result of turning with a windrow turner or front loader. The only management activities during the process were taking pile temperatures and making observations on pile odors, vector activity, leachate, etc.

IV. Data Collection Methodology

Data collected from each of the trials included: equipment performance and safety, temperatures early in the process, distribution of particle size within the windrow, total weight of large pieces that rolled to the outside during pile formation (tailings) and a laboratory analysis that included compost quality parameters.
The equipment characteristics evaluated included: necessary supporting equipment, time to grind bones and build windrows and safety concerns.
Temperatures were taken at approximately one week intervals during the first month of the trials. Readings were taken at depths of one foot and three feet on both the north and south sides of each windrow each time temperatures were taken. (See Figures 1 – 4)
The determination of the distribution of particle size within the windrows was done by screening out the fine material and then sorting the larger pieces by hand. Four size categories were established, particles that would pass through a ½ inch screen, pieces between ½ inch and 1 x 3 inches, pieces between 1 x 3 inches and 1x 6 inches and pieces larger than 1 x 6 inches.

To determine the size distribution, a five gallon bucket of material was randomly collected from each side of each windrow. The sample from each side of each windrow was screened and recorded separately. The screened portions were each weighed. (See Table 2)

Even though the same volume of material was collected from each windrow (10 gallons), the total weight of material for each windrow varied from 40 to 59 lbs. This is because of variations in the amount of bone and other heavy tissue, the moisture content and the overall texture of the mixtures. To adjust for these differences, the percentage of the total weight was also calculated for each fraction to allow for comparison between different samples. These are also displayed in Table 2.

The large pieces of bone, hide and soft tissue that rolled to the outside of the pile during pile formation (tailings) were quantified by collecting and weighing all the pieces that would not pass through the ½ inch screen from a five foot section in the center of windrow. Table 3 and Figure 6 show the total weights from each windrow.

At the conclusion of the project, random samples were taken from each pile for a complete compost analysis. The samples were collected by digging into the windrow approximately 12 to 15 inches and taking one shovel full at each location. The Plant and
Soil Analytical Lab at the University of Maine completed the analysis using standard lab techniques. This included tests for Nitrogen, Phosphorus, Potassium, Carbon, volatile solids, conductivity, moisture, bulk density, pH and C:N ratio.

V. Results

Equipment Performance

Normal safe operating considerations around front end loaders and agricultural implements are necessary. In addition, the following specific safety considerations were noted.

The ALLU bucket addition to the front end loader increased the weight on the front of the loader. The operator must take this weight increase into consideration during loader operation. The ALLU bucket appeared easier to use in bone grinding and windrow building and accomplished such in a minimum amount of time. There did appear to be more large bone particles mixed into the sample piles and more bone tailings accumulating at the base of the piles with the ALLU bucket. The ALLU bucket needs to process the same batch of material through the bucket more than once to achieve satisfactory bone particle size reduction.

The tub grinder produced a finer ground mixture within the sample pile with very few bone tailings accumulating at the base of the pile. The tub grinder needed much more time to process that equivalent amount of material. There appeared to be bone fragments that were thrown out of the tub grinder during operation. The tub grinder experienced difficulty handling wet material. Brush was added to the tub grinder to move the bone/bedding mixture into the grinder, otherwise bridging occurred.

The ALLU bucket was able to grind the materials much faster than the tub grinder. However, the resulting size distribution of the bone fragments was much greater for the ALLU bucket than for the tub grinder (Table 2).

Table 2. OFFAL GRINDER TRIALS- Screening Results					
Size Category	<1/2 inch	1/2 TO 1x3 in.	1x3 TO 1x6 in.	> 1x6 in.	TOTAL
ID #	Weight in Pounds				
A1-Nov02	44.25	4.25	0.375	3.25	52.125
A2-Nov02	36.5	5.5	0.125	10.25	52.375
B1-Nov02	39	1.5	0.125	0.125	40.75
B2-Nov02	38.5	4	0.375	1.5	44.375
A1_May03	41.75	2.5	0.5	1	45.75
A2-May03	53.25	4	1	1.125	59.375
B1-May03	41.25	0.625	0.25	0	42.125
B2_May03	45	4	0.875	0.125	50
	Percentage				
A1-Nov02	84.89	8.15	0.72	6.24	100
A2-Nov02	69.69	10.50	0.24	19.57	100
B1-Nov02	95.71	3.68	0.31	0.31	100
B2-Nov02	86.76	9.01	0.85	3.38	100
A1_May03	91.26	5.46	1.09	2.19	100
A2-May03	89.68	6.74	1.68	1.89	100
B1-May03	97.92	1.48	0.59	0.00	100
B2_May03	90.00	8.00	1.75	0.25	100

Windrow Temperatures. Figure 1 shows the temperatures taken at the one foot depth. Note that the two trials using fresh materials (A2 and B2) both started out at a lower temperature than the two that had precomposted materials (A1 and B1). The temperature in the precomposted material ground with the tub grinder (B2) rose much quicker than that ground with the ALLU bucket and maintained a higher temperature through the sampling period. The precomposted material that was ground with the tub grinder (B1) started out at a much higher temperature than any of the other trials (over 160°F). The temperature in this windrow then slowly declined to about 110°F over the next five weeks. Windrow A1, on the other hand, started out at about 140°F, rose gradually to about 150°F and then returned to the 140 °F. The one foot temperature in windrow A2 demonstrated a very similar pattern to that for A1 but was generally 30 to 40°F lower. The lower temperatures in the two fresh piles (A2 and B2) may have been due to the less uniform mix and because the preconditioned piles had a well established biological population at the outset.

Figure 2 shows the temperature readings at three feet for all four trials. Here again, the two piles with preconditioned material (A1 and B1) had higher temperatures throughout the period than those using fresh materials (A2 and B2).

Overall, the two windrows with the precomposted materials (A1 and B1) maintained higher internal temperatures than the two with fresh materials (A2 and B2).

Figure 1. Offal Grinder Trials - Temperatures at One Foot

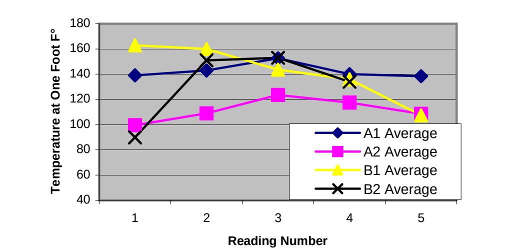


Figure 2. Offal Grinder Trials - Temperatures at Three Feet

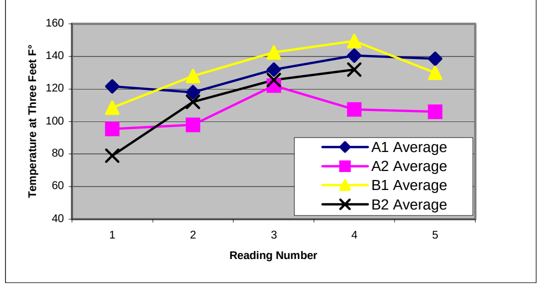
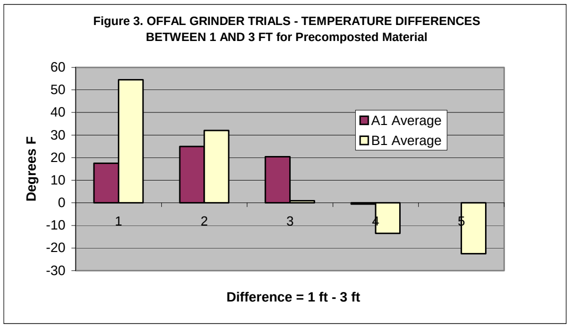
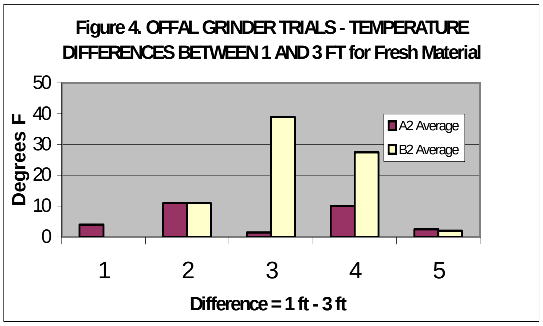


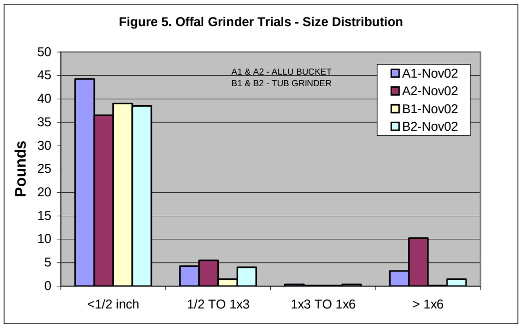
Figure 3 illustrates the differences in the one foot and three foot temperatures for the two piles using precomposted materials. Note that for both windrows, the one foot readings were consistently higher than the three foot readings for the first half of the sampling period. This difference indicates a high level of activity in the piles that results in reduced temperatures in the pile core as activity becomes limited by oxygen availability.

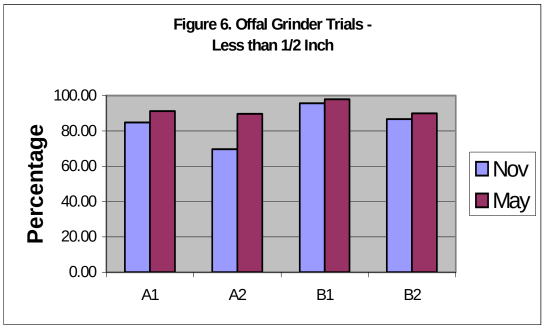
Figure 4 shows the differences between the one foot and three foot temperatures for the piles with fresh materials (A2 and B2). The temperature difference between the one foot and three foot readings rapidly increased and then declined over time. Because it contained fresh rather than precomposted material, the decline in activity occurred much later in the process. Windrow A2 (ALLU bucket) also had temperatures at one foot higher than at three feet throughout the sampling period, but these differences were relatively small throughout the period and did not display a consistent pattern. Again, this was probably because of the less uniform particle size and less adequate mixing in this windrow which slowed the activity in the pile.



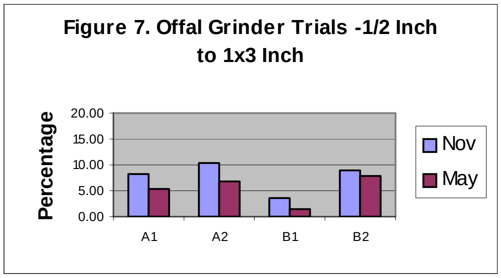


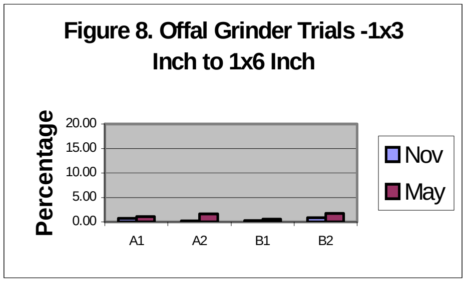
The results of the screening trials done in November 2002 and May 2003 are displayed in Tables 2 and 3 and in Figures 5 through 10. Figures 5 and 6 show that most of the material in all four trials was small enough initially to pass through a ½ inch screen. Only windrow A2 (fresh material ground with the ALLU bucket) had more than 15 lbs (30%) of material that did not pass through the ½ inch screen. Figure 6 shows that for all four trials, the percentage of the material that passed a ½ inch screen was greater in May than in the previous November. This is consistent with what would be expected in a normal composting process. The largest increase in this fraction occurred in windrow A2 which originally had a very high percentage of the particles over ½ inch.





Figures 7 through 9 look at the percentages of the materials that fell into different size categories over ½ inch. The most dramatic differences in the initial weights were in the 'over 1x 6 inches' size category. The two trials done with the ALLU bucket had a much larger percentage of the material in this size category than either of the tub grinder trials. Also, the trials with fresh material had noticeably larger percentages of large pieces than the trials with precomposted material. The large pieces in the fresh material included hides and other soft tissue in addition to the bones, while the precomposted material was primarily bones and bedding since the soft tissue had already decomposed prior to grinding.





By the end of the trials in May 2003, however, the differences in the large category had reduced considerably. This was a result of a reduction of large pieces during the compost process. Trial A2, in particular, had a dramatic reduction of material in the large size category, dropping from about 20% of the total weight to about 2%. Trial A1 also had an impressive reduction from about 6% to about 2%. Trials B1 and B2 started out with a relatively small volume of large pieces and these had reduced to almost zero by the end of the trial.
The only size category over ½ inch that saw an increase was the next to largest category (1x3 to 1x6 inch). In this category, there were slight increases in each of the trials. This was probably because some of the material that was in the largest category at the start of the trials being reduced to this size, but not decomposing completely.

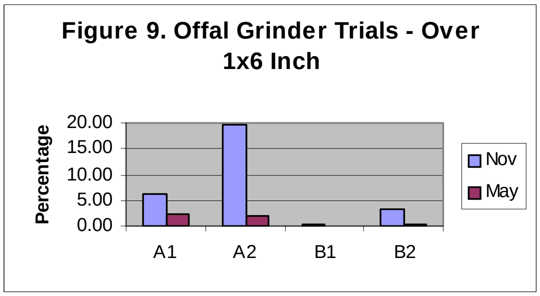


Figure 9. Offal Grinder Trials - Over 1x6 Inch

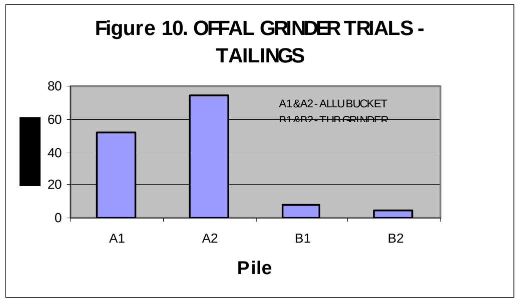


Figure 10. OFFAL GRINDER TRIALS - TAILINGS

Some of the greatest differences between the trials were the quantities of larger pieces that rolled out of the pile during the pile formation (tailings). Table 3 and Figure 10 display these differences. The windrows formed with the ALLU bucket had much more material along the outside than the two built with the tub grinder. The windrow of precomposted material had over 50 lbs from the ALLU bucket (A1) compared to only 8 lbs from the tub grinder for the same material (B1) while the windrow of fresh material ground with the ALLU bucket (A2) had over 70 lbs as compared to less than 5 lbs from the tub grinder (B2). However this did not significantly affect the compost analysis.

There were very few differences of any significance between the characteristics of the compost produced in the trials. The one difference uncovered was the soluble nitrogen content of the precomposted (preconditioned) material compared to the piles that started with fresh bone material. The soluble nitrogen (ammonium and nitrate) was considerably higher in Trials A1 and B1 than in A2 and B2. This means that the compost from the preconditioned piles would have more plant available nitrogen than the compost made from fresh bone material.

Table 3. OFFAL GRINDER TRIALS - Tailings from Each Pile

ID #	Pounds Along Ten Feet of Windrow
A1-Nov02	51.5
A2-Nov02	74
B1-Nov02	8
B2-Nov02	4.75

VI. Discussion and Conclusions

Precomposting works better. The first conclusion drawn from these trials is that precomposting the material before grinding is preferable to grinding it fresh. The temperature response in the windrows showed that the process was working more efficiently. There was also far less odor and potential for vector attraction with the precomposted material and so less likelihood of causing a nuisance or environmental problem. The more uniform particle size after grinding meant that it was possible to get a more uniform mix. In addition, precomposting the material would mean less management would be needed on the site. With the precomposted material, all the putrescible portions have decomposed before grinding so the only thing that might be exposed during or after the grinding would be clean bone pieces.

Side by side comparison of nutrient values and several other compost quality parameters suggests that most of these factors in the final compost product are not affected much by the choice of grinding equipment. Levels of ammonium and nitrate N were 4 to 5 times higher in the trials using precomposted materials compared to the trials using fresh bone material.

Tub grinder gave better composting performance. Both the fresh and precomposted materials ground with the tub grinder demonstrated better composting performance than their counterparts ground with the ALLU bucket. This was most likely related to the overall finer grind achieved and the smaller volume of large pieces in the mix. Because of the preferable texture, there was also a generally more uniform mixture that allowed the tub grinder piles to perform in the way that would indicate a well made compost pile. The tub grinder also resulted in far fewer tailings with both materials than the ALLU bucket, meaning that there would be less site clean up needed after each batch of material had been ground and formed into windrows.

ALLU bucket was quicker and easier to use. The use of the ALLU bucket was a two step process to build the windrow. The ease of the operation would allow the operator to come back to a windrow periodically and regrind as part of the turning process. If this piece of equipment was available on site as a regular part of the operation and could be used to regrind and mix piles, better results would be achieved.

The tub grinder, on the other hand, required some additional steps that slowed the process down. Wet heavy material slowed the tub and caused bridging inside so that the material did not get fed into the grinder uniformly. This was particularly a problem with the fresh material. Adding an occasional bucket load of brush (tree limbs and twigs) to the tub, kept the wet clumping material moving into the grinder blades and sped up the process. Having to add the brush, however, made another step for the operator.