Beef Sessions

Moderator: Bob Larson

Carcass Disposal by Composting

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Abstract

Composting is an acceptable method of disposal of cattle carcasses. Composting requires appropriate carbon:nitrogen mix (~30:1), moisture (50-60%), porosity (35-45% open spaces), and temperature (130-150°F) to be successful. This paper describes a procedure used for approximately four years to successfully compost cattle. Adult (~1200 lb) intact cattle carcasses should be placed in a compost windrow for at least 60 days to assure adequate heat production and degradation of carcass before turning, mixing or grinding. Composted intact cattle can be ready for field application in approximately 12 months. Larger bones should be 'recycled' back into more compost for complete deterioration. Grinding of fresh carcasses or carcasses composted at least 60 days could reduce compost time to approximately 6 months and will eliminate major bone structure.

Introduction

The poultry industry has been composting carcasses since the 1980s[3] and the swine industry followed. Beef and dairy producers are beginning to consider alternatives to rendering carcasses because of increased expense of animal disposal. Prior to the 1990's, the renderer paid the producer for carcasses. During the 1990's, the renderers picked up carcasses at no charge to the producers. More recently, many renderers have begun charging cattle producers $12 to $80 per carcass.[8, 10]

Renderers are charging the producers for carcasses because of reduced demand for the render by-products and increased costs associated with rendering. Pet food demand for beef has been decreasing in favor of other protein sources such as poultry or non-animal ingredients.[8] Additionally, the cost of rendering has increased due to the increased regulations on the rendering process resulting from concerns associated with Bovine Spongiform Encephalopathy (BSE). Since August, 1997, the Food and Drug Administration established regulations that prohibited the feeding of ruminant protein to other ruminant animals.[2] Since the producer has begun to realize an additional expense for disposal, they are considering other alternatives for disposal. (Table 1)[9]

For most producers, the most acceptable alternatives for cattle carcass disposal are rendering or composting. Composting cattle carcasses has been shown to be successful.[7, 12]

Composting Process

Composting is a natural biological process of decomposition of organic materials in a predominately aerobic environment. The goal of composting animal carcasses is to speed the natural decaying process of an animal in a well-controlled, environmentally friendly system. The objectives of a successful animal carcass compost operation are to convert all soft tissues and bones to humus at a high temperature (130-160° F) to achieve pathogen kill without causing groundwater or air pollution. Keener[6] describes composting dead animals as "above ground burial in a biofilter with pathogen kill by high temperature".

The end product (i.e. mature compost) should be stable (i.e. low carbon dioxide and ammonia emission) to minimize competition with plants for soil nutrients and to minimize phytotoxic compounds eliminating negative effects on plant germination and growth.[1] The end product should also be ~25% less volume than the starting compost pile (Figure 1).

Phases of Composting

Composting consists of two main phases[6]: the **composting phase,** and the **curing phase** (Figure 2). Depending on the materials being composted and the uniformity of the compost pile, the composting phase lasts at least three weeks and up to seven months. The curing phase lasts at least one month and can continue for up to 18 months or longer if handled properly. When

Table 1. Alternatives for disposal of livestock mortalities (including poultry).[9]

*Composting
Rendering
*Traditional on-farm pickup
*Central pickup[a]
Freezing to extend on-farm storage[b]
Acid preservation followed by rendering[c]
*Landfill[d]
On-farm trench burial[e]
On-farm disposal pit[f]
Incineration[g]
Feed for animals (e.g. alligator farms)
Fermentation followed by rendering or use in mink or fox feed, extruded aquaculture feeds, or ruminant silage[h]
Extrusion[i]
Fluidized-bed drying and flash dehydration followed by extrusion[i]

*Reasonable and environmentally acceptable options for bovine carcasses >300 pounds depending on cost and biosecurity restrictions. Environmental restrictions are dependent on federal, state, and local regulations.
[a] Central pickup for delivery to a rendering plant must be incorporated with strict biosecurity measures.
[b] Poultry. Cost = ~$0.01 per pound of dead bird assuming $0.08 per kilowatt hour.
[c] Poultry. Cost=~$0.10/pound. Safety concerns with using sulfuric acid. Phosphoric acid preservation may be an option.
[d] Used as a backup if other options not available. Some landfills may refuse carcasses – may need to grind carcass. Cost=$10-30/ton (not including grinding costs). Concerns with groundwater pollution and predators.
[e] No longer generally accepted. Not likely to be an option in the future due to ground water contamination concerns. General guidelines: Minimum depth=3-4 ft; Maximum depth=6-8 ft; Cover depth=30-48 inches. Not acceptable in areas with light soil and high water table. Frozen ground may not allow burial.
[f] Poultry and swine. Anaerobic digestion but with aerobic activity at the top of pile. Safety concerns from hydrogen sulfide gas.
[g] Eliminates all pathogens. Highly regulated. Prone to public complaints. Capital, monitoring and permitting costs are high (500 lb/hour capacity: $230,000). Operating costs~$0.02-0.05/pound.
[h] Poultry. Non-corrosive container, sealed and vented for carbon dioxide. Ag bag may work. Grind carcasses to <1" size. Add fermentable CHOs. Most pathogens do not survive fermentation pH (4.3-4.5). Product is nutrient rich.
[i] Poultry. High capital costs.

compost is in the curing phase, the compost can be tested for maturity to confirm the compost process is complete. Testing for compost maturity can be done with a Compost Maturity test using the Solivta™ procedure by Woods End, Research.[5]

The composting phase is divided into three subphases: **initial, high rate,** and **stabilization phases** (Figure 2). The **initial phase** lasts one to three days and internal temperature in the compost pile increases from ambient temperature to approximately 110°F. Mesophilic microorganisms degrade sugars, starches and proteins. Chilled carcasses added to compost windrows in winter environments can successfully initiate composting. Frozen carcasses may not begin composting, depending on amount of frozen carcass added to a compost windrow and microbial activity level of the windrow.

The **high rate phase** lasts 10 to 100 days and internal temperatures in the compost pile are above 110°F and below 160°F. Thermophilic microorganisms degrade fats, hemicellulose, cellulose and some lignin. The compost operator's goal should be to achieve consistent temperatures of 130-150°F.

The **stabilization phase** lasts 10 to 100 days and internal temperatures in the compost pile begin to decline. Mesophilic microorganisms recolonize and further degradation of cellulose, hemicellulose and lignin occurs. As temperature drops below 130°F, the compost pile should be turned, mixed, or ground unless the compost is mature.

Basic Elements of Successful Composting

There are over 20 controllable factors to consider when composting. Four major factors are:

1. Material mix (carbon to nitrogen ratio)
2. Water content
3. Porosity (i.e. air spaces)
4. Temperature

Other factors include:

1. Particle size (target=1/8 to 1/2 inch)
2. Bulk density (target=1100 lb/cu yd)
3. pH (target=6.5 to 8.0)
4. Oxygen concentration (target=greater than 10%)

A proper **carbon:nitrogen (C:N) ratio** is important to achieve optimum growth of microorganisms. The

Table 2. Carbon:Nitrogen ratios of common amendments.

Sawdust	450:1	
Wheat straw	125:1	
Rice hulls	120:1	
Corn cobs	100:1	
Corn stalks	70:1	
Soy hulls	70:1	(estimated)
Oat straw	60:1	
Corn silage	40:1	
Grass hay	30:1	
Paunch manure	25:1	
Cattle manure	20:1	
Alfalfa hay	15:1	
Slaughter waste	3:1	
Blood waste	3:1	
Dead cattle	3:1	(estimated)

starting mixture of carcass, manure and a carbon source should achieve C:N ratio of approximately 30-40:1. As the compost matures, CO_2 gas is released thereby lowering the C:N ratio of the compost. The C:N ratio of mature compost should be approximately 10-25:1. A mixture of one ton of cattle manure (50% dry matter) and a 1000 lb carcass will result in a C:N ratio of approximately 15:1. This ratio is too low to achieve an optimal compost environment. Table 2 lists the C:N ratios of some common amendments.[11] An example of a spreadsheet developed to calculate moisture and C:N ratios is included in Table 3. Sawdust is considered the 'gold standard' for carbon source. Sawdust is especially good as a top cover due to the ability of sawdust to filter odors emitting from the compost pile.

The ideal **water content** of a compost mixture is 50-60 % with an acceptable outside range of 45-65 %. In conditions when moisture levels are above 60 %, the small pores where oxygen resides is displaced with water, thereby inhibiting aerobic organism activity. Anaerobic organisms take over resulting in highly odorous organic acids and hydrogen sulfide. The compost should be moist, but not soggy. If moisture can be squeezed from a handful of compost material, the compost is too wet. Finally, compost mixtures above 60-65 % moisture are prone to leaching. Leaching can potentially cause surface and ground water contamination and is highly odoriferous.

Porosity is important to assure adequate oxygen is maintained in the pile by allowing air to penetrate and move through the pile. Ideally, a compost pile should have 35-45% porosity (open spaces). Optimum porosity is achieved by balancing particle size, water content and pile size. Piles greater than six foot in height can cause compaction and reduce porosity. If porosity is inadequate, one potential solution is to place perforated aera-

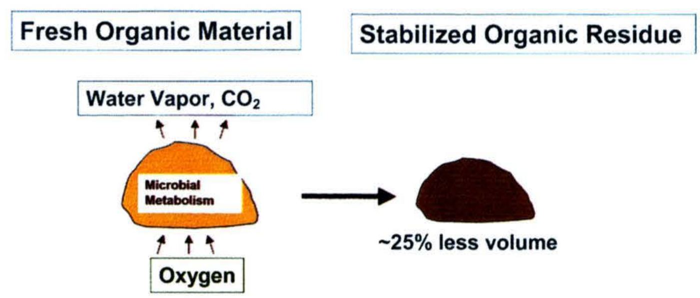


Figure 1. Simplified overview of the composting process

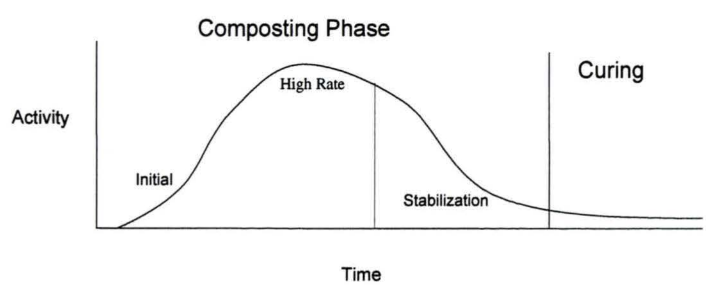


Figure 2. Phases of composting

Table 3. Moisture and C:N Calculation.

Worksheet to calculate moisture and C:N content of compost mix.

	Total wt.	Water content	Water content	Dry matter	C:N ratio		Total C:N	
Item	(lb)	(%)	(lb)	(lb)	C	N	C units	N units
Wh straw	400	15	60	340	125	1	42500	340
Carcass	1000	60	600	400	3	1	1200	400
Manure	2000	50	1000	1000	20	1	20000	1000
Total	3400	48.8	1660	1740	36.6	1	63700	1740

Estimated water content of a fresh carcass (including gut contests) is ~60%.

Temperature Probe Suppliers

- •Atkins, 3401 Southwest Fortiers Drive, Gainsville, FL 32608, 904-378-5555
- •Camx Scientific, Box 747, Rochester, NY 14603, 716-482-1300
- •MAC Associates, 2532 Zollinger Road, Columbus, OH 43221, 614-459-0223
- •Meriden Cooper Corp., 112 Golden Street Park, Box 692, Meriden, CT 06450, 800-466-8448
- •Omega Engineering, Inc., One Omega Drive, Box 4Q47, Stamford, CT 06907, 203-359-1660
- •Reotemp Instrument Corp., 11568 Sorrento Valley Rd. #10, San Diego, CA 92121, 619-481-7737
- •Walden Instrument Supply Co., 910 Main Street, Wakefield, MA 01880, 617-245-2944

Photograph 1. Temperature probes and a list of temperature probe suppliers.

tion tubes in the base of the compost pile. Air can be forced into the perforated tubes via aeration fan(s).

Optimal **temperature** in a compost pile is primarily achieved by adhering to the three previous discussed controllable factors. Temperature is easily monitored with three to five foot temperature probes (Photograph 1). The compost pile must be sized properly to assure adequate heat generation and retention. The ideal temperature range for a compost pile is 130-140°F with an outside acceptable range of 110-150°F. Microbial activity declines rapidly when temperatures exceed 150°F. Figure 3 illustrates the effect of temperature on carbon dioxide emission rate (measure of microbial activity).[6]

Biosecurity Risks Associated with Composting Cattle

Composting will **NOT** destroy all disease causing organisms.[4] Most viruses are inactived at 122-140°F. Foot and mouth disease virus can withstand temperatures of 203°F for 15 seconds.

Bacillus anthracis (vegetative form) and *Mycobacterium tuberculosis* are inactivated at 140°F. Anthrax spores are **not** inactivated at temperatures achieved in the compost process. Clostridia (e.g. *C. chauveoi, C. novyi, and C. tetani*) are resistant to heat inactivation. Some clostridia can survive boiling for two or more hours. Generally, bacterial spores can be inactivated at 250°F for 15 minutes. Autoclaving (moist heat at 250°F in a pressurized container) for five hours is recommended to inactivate prions, such as bovine spongiform encephalopathy.

Composting will destroy many common pathogens. During composting, pathogens are subjected to at least three adverse conditions: 1) heat, 2) toxicity caused by products of decomposition, and 3) microbial antagonism.

More research is needed to determine effectiveness of composting on selected pathogens.

Description of a Successful Livestock Composting Operation

Cattle have been successfully composted for approximately four years at the Elanco Animal Health research facility in Greenfield, IN. Selecting a site for composting cattle is very important to the overall success of the project. Due to the size of cattle carcasses and accessibility of equipment, an un-roofed compost system using the windrow method is recommended. A schematic of a compost windrow is shown in Figure 4.

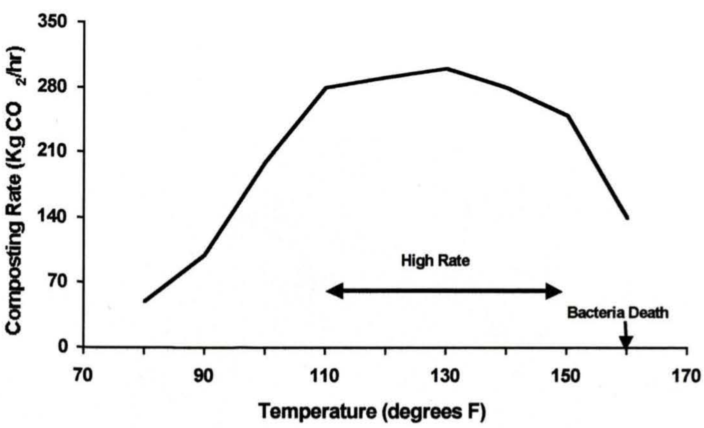


Figure 3. The effect of temperature on rate of CO_2 emission.[6]

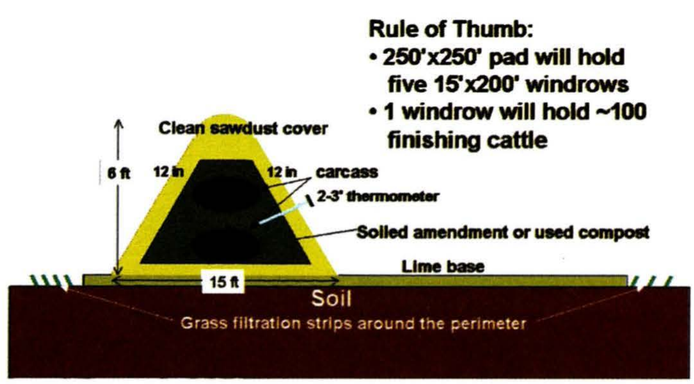


Figure 4. Schematic of composting window (intact carcass)

Here is a list of factors to consider when selecting a site:

1. The facility should be large enough to handle 1-2 years of cattle mortalities to accommodate a field application program. A 250'x250' area is sufficient to compost approximately 500 cattle depending on composting methods used.
2. It should be accessible to equipment used to deliver carcasses to site, other compost maintenance equipment, and compost amendment materials (e.g. soiled bedding, manure, carbon source).
3. The facility should be isolated from other farm traffic and public areas to reduce risk of biosecurity breakdown and negative public perception.
4. It should be at least 300 feet from streams, lakes, waterways, wells and flood plains to eliminate risk of surface water contamination.
5. The base of the compost facility should be at least three feet above the high-water table and made of low permeability material (e.g. heavy clay soil, crushed rock overlaying a geo-textile cloth or concrete on high permeability soil).
6. Provisions in place for run-on and run-off control. The base of the compost facility should prevent precipitation accumulation in the pile and should be sloped ~0.5 to 2% to prevent leachate run-off during heavy rain events.
7. The surface run-off from the compost base should be directed through properly designed vegetative filter strips.
8. Comply with local and state regulations.

Options for Handling Carcasses

Carcasses can be handled for composting in one of three ways:

- **Method A** - *Intact (whole) carcass.* Leave carcass intact and cover with appropriate amendments. Requires mixing (e.g. turning) at least three times at approximately 2-3 month intervals. Major bones may need to be 'recycled' or ground separately if a concern.
- **Method B** - *Intact carcasses followed by grinding 2-6 months after placement.* Grinding eliminates bone concerns. May need to be turned 2-4 months after grinding.
- **Method C** - *Grind fresh carcasses.* May need to be turned 2-4 months after grinding.

Photograph 2 illustrates a compost site. Photographs 3 and 4 illustrate carcasses on a compost base and covering carcasses with amendment (Method A), Photographs 5 and 6 show the remains of carcasses after composting for two months (Methods A or B), Pho-

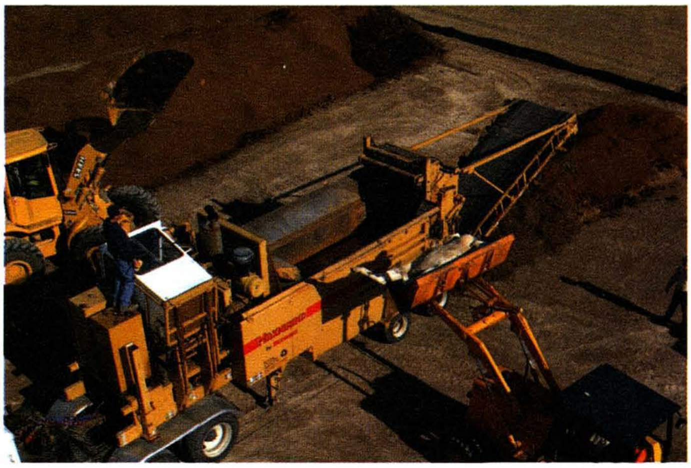
Photograph 2. Compost site.

Photograph 3. Carcasses on top of windrow base – Method A.

Photograph 4. Carcasses covered with soiled amendments – Method A.

Photograph 5. Remains of cattle carcasses after composting two months (Method A or B).

Photograph 6. Major bones remaining after composting two months (Method A or B).



Photograph 7. Grinding operation with large scale grinder (Method C).

Photograph 8. Compost windrow after grinding (Method B or C).

Photograph 9. Finished compost.

tographs 7 (Method C) and 8 (Methods B or C) show the grinding operation with a large-scale grinder and Photograph 9 shows finished compost.

Economics of Composting

Estimated Cost of Composting

Depending on the option selected for handling carcasses, the estimated cost of composting is \$25-52 per ~1000 lb carcass (Table 4.) This estimate includes cost of a lime base, equipment rental, sawdust amendment and land application. This estimate does not include initial site preparation, which can vary greatly depending on location.

Compost Value

The density of finished compost is approximately 1,100 lb/cubic yard. Approximately 3.5 cubic yards of compost is generated from each carcass (roughly 1 cubic yard from a full size carcass and 2.5 cubic yards of amendment). Approximately two ton (wet basis) of compost is generated from each carcass (~1000 lb carcass + ~3000 lb amendments). Based on these assumptions and estimated nutrient content in compost (Table 5), the estimated value of finished compost is \$10-30 per carcass or \$5-15 per ton. Based on the estimated cost of composting (\$25-52 per carcass) and value of compost (\$10-30 per carcass), the net cost per carcass is approximately +\$5 to -\$42. No dollar amount is assigned to the value of organic matter from the compost.

Troubleshooting

A list of factors to consider when troubleshooting a cattle compost process is included in Table 6.

Environmental Recommendations

Most states have not developed regulations for large scale composting of cattle outside a building. Here is a list of general environmental recommendations:

- Cover carcasses within 24 hours of death
- Minimize leachate and run-off
- Compost process must be complete (mature) before land application

Table 4. Estimated costs of composting.

Item	No Grind	Grind Compost	Grind Deads
Lime base	$20/hd initial base preparation $5-8/hd after removal of a cured windrow		
Payloader	$3-8/hd		
Grinder	$0	$3/hd	$6/hd
Sawdust	$10-15/hd		
Time	12 months	9 months	6 months
Turns or grinds	3	2	1
Area (sq ft)	60-120/hd/yr	45-90/hd/yr	30-60/hd/yr
Cost of land application	$7-15/hd		
Total cost (excluding site preparation)	$25-52/hd		

Table 5. Compost volume and value.

- ~1100 lb/cubic yard
- ~3.5 cubic yards of compost from each carcass
- ~2 tons of compost from each carcass
- Pounds of nutrient/ton of compost (assume 50% moisture):
- Total Kjeldahl Nitrogen: 10-25
  - Potentially available nitrogen: 5-15
  - Phosphorus: 2-20
  - Potassium: 4-20
- Value of compost from nutrients: $5-15/ton
- Nutrient value of compost per head: $10-30
- Net per head: +$5 to -$42
- Value of compost for organic matter: $??/ton

Table 6. Factors to consider when troubleshooting a cattle compost process.

- **Excessive odors**
  Not enough carbon
  Not enough insulating cover
  Not composted long enough
  Too much moisture
- **Flies/insects**
  Not enough cover
  Standing water or effluent
- **Effluent**
  Not enough amendment base
  Not enough amendment cover
  Too much moisture (rains)
- **Vermin**
  Not enough cover
  Not covered soon enough
- **Temperatures too low**
  Not enough moisture
  Too much moisture
  Not enough porosity
  Not enough oxygen
  Not enough carbon
  Pile too big or too small
- **Temperatures too high**
  Not enough moisture
- **Bones**
  Not enough cover
  Not ground
  Not composted long enough
  Not enough heat

- Maximum storage time of cured compost should not exceed 18 months
- Surface should be relatively impermeable
- Avoid flood plains and wetlands

Results from a 63 Day Compost Study

Study Description. Twelve Holstein steers (approximately 1000 lb) were euthanized and placed in a compost windrow without grinding. The steers were placed approximately five feet apart (hooves to topline) in two layers (six steers per layer). Within each layer, alternate carcasses remained intact (closed) or were opened by cutting into the abdominal cavity and major muscle sections on the top side of the carcass (open). **Temperature probes were placed in each carcass to monitor the internal carcass temperature during composting.**

Study Results. The carcasses in the top row increased to 130°F within two weeks and maintained temperatures between 140-150°F from 4 to 9 weeks after placement in the windrow (Figure 5). Carcasses in the bottom row maintained temperatures between approximately 110-120°F for the duration of the 9-week study. Additionally, there was no difference in temperatures between the open and closed carcasses (Figure 6).

Study Conclusions. Due to heavy rainfall before and during this study, the amendments used to compost these carcasses were too moist. The moisture

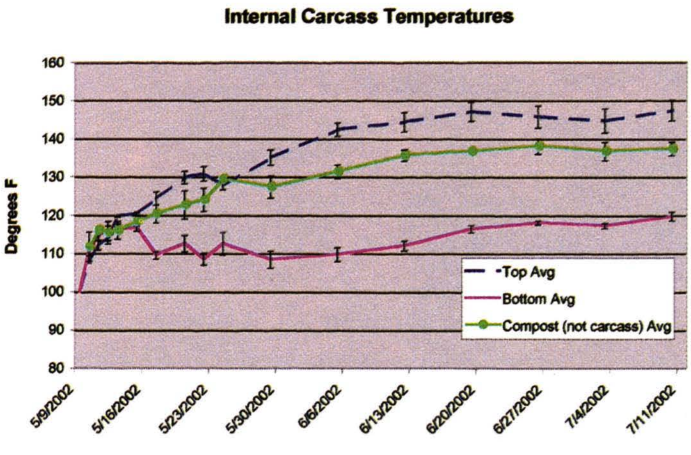


Figure 5. Internal carcass temperatures during 63 days after placement of carcass in compost windrow.

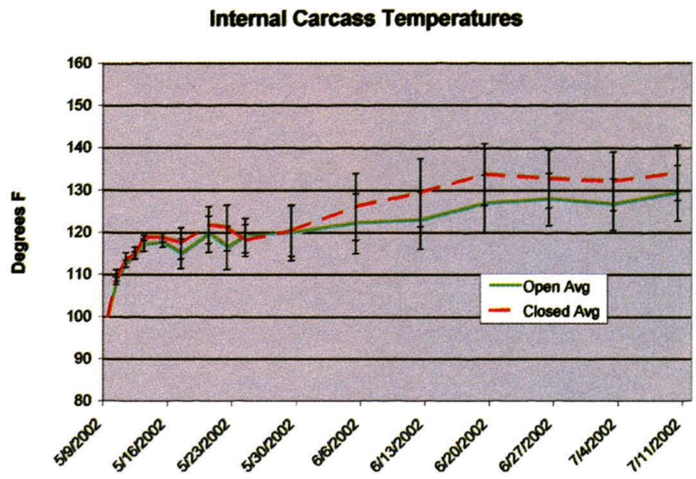


Figure 6. Internal carcass temperatures during 63 days after placement of carcass in compost windrow.

content of the pile was approximately 60-65%. Because the moisture of the compost was high, the carcasses in the bottom row did not heat as much because of lack of oxygen. There is no advantage to cutting open the carcasses at time of compost.

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