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Composting characteristics of bovine manure produced by conventional stacked processing and an experimental small-scale apparatus

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Introduction

Southern Kyushu is an important center of beef production in Japan and the large amounts of bovine waste that are produced in the region need to be utilized in a way that is not harmful to the environment. One such method is to use the manure to produce organic fertilizer, which can then be used to replace the chemical fertilizer that is used for forage production (Hasyim *et al.*, 2014). The composting of bovine manure involves co-digestion of cow manure with substrates such as sawdust and hay. The composting characteristics of these mixtures are influenced by the relative amounts of manure and the substrate used, and by external and internal composting conditions (Guo *et al.*, 2012). Conventional stacked composting requires large volumes of materials, and repeating the composting procedure to produce compost with uniform characteristics is difficult (Kajiya *et al.*, 2013). However, optimization of bovine manure composting has been established using a small-scale apparatus that can be operated by hand (Kajiya *et al.*, 2014). However, the composting characteristics of the apparatus have not yet been compared with those associated with conventional stacked processing. The present study therefore compared the composting characteristics of these two methods in terms of the temperature profile during the composting process, physicochemical properties of composted manure, and percentage germination of plants; all of these methods have been advocated for use as safety indices for compost intended for application to cultivated crops (Cobo *et al.*, 2002).

Materials and Methods

Conventional stacked composting: Beef manure was produced by beef cows put to pasture on bahiagrass (*Paspalum notatum* Flügge) supplemented with Italian ryegrass (*Lolium multiflorum* Lam.) hay when herbage was in short supply. Beef manure, consisting of feces and urine from adult beef cows, was obtained from concrete pens, and was amended with sawdust (Japanese cedar, *Cryptomeria japonica*) or rhodesgrass (*Chloris gayana* Kunth) hay as a co-digestion substrate. Water was added to the manure-substrate mixture (hereafter referred to simply as "manure") to maintain a water content of 55%, and the manure was stacked without ventilation in a conical pile under a plastic cover; the pile had a height of approximately 1 m and a mass of approximately 18 kg. Manure-sawdust and manure-rhodesgrass mixtures were turned every 7 days for 28 to 53 days until no further increases in temperature were observed.

Processing with a small-scale apparatus: Beef manure was obtained using the same feeding system employed for the assessment of the conventional stacked processing method reported previously (Kajiya *et al*., 2014). Seven kg (fresh weight; FW) of beef manure and 0.1 kg (FW) of Japanese cedar sawdust or 3.5 kg of rhodesgrass hay were used to adjust the water content of the mixture to 65.9% (<70%). Three manure-sawdust replicates were set up to test the small-scale manure composting apparatus (Kaguyahime, Fujihira Co. Ltd., Tokyo). Manure was turned every 4 days until no further increases in temperature were observed at 20 days after composting. A description of the apparatus and details of the composting procedure were provided previously (Kajiya *et al*., 2014).

Physicochemical properties: The moisture content, temperature, pH, electric conductivity (EC), and carbon (C) and nitrogen (N) contents of the composted manure were determined as described previously (Kajiya *et al*., 2014). As in Kajiya *et al*., (2014), percentage germination was assessed using Japanese mustard (*Brassica rapa* var. *perviridis*) seeds incubated in the dark for 7 days at 20°C after the addition of 10 ml of composted manure extract or distilled water.

Results and Discussion

Temperature profile: Temperature profiles of the composted mixtures were monitored for 29 to 98 days and 20 days in the conventional stacked and small-scale apparatus composting experiments, respectively (Fig. 1). Maximum

temperatures exceeding 60°C were observed for 18.0 and 103.0 hr, and for 46 hr in the conventional stacked and small-scale apparatus experiments, respectively (Table 1).

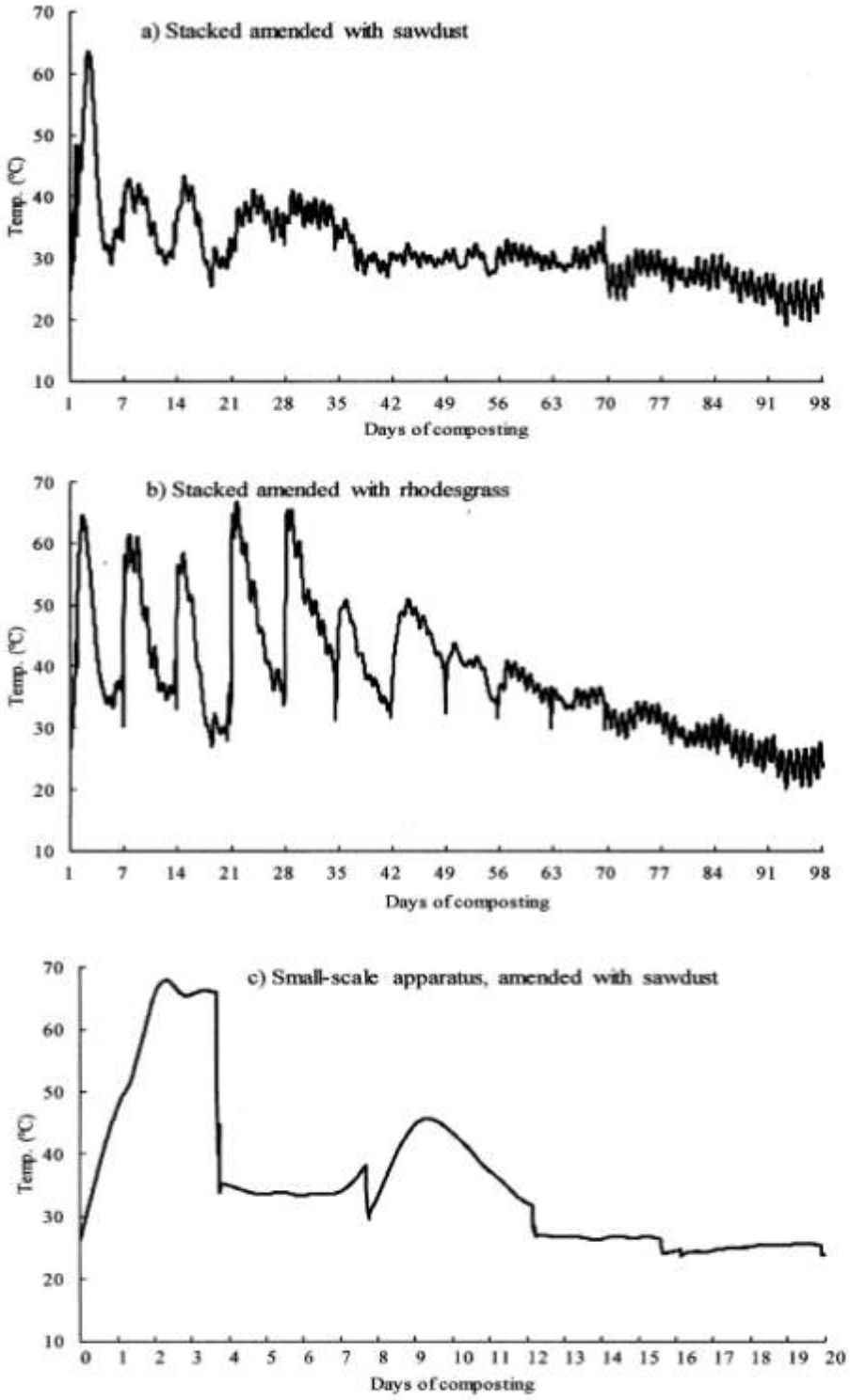

Fig. 1. Temperature profiles observed in beef manure amended with (a) sawdust and composted by stacked processing, (b) rhodesgrass hay and composted by stacked processing, and (c) sawdust and composted by the small-scale apparatus.

Physicochemical properties: The physicochemical characteristics of sawdust- and rhodesgrass-amended manure are shown in Table 1. In both processing methods, the pH and EC values ranged between 7.5 and 8.4, and 1.3 to 2.3 mS cm^{-1}, respectively. The moisture content of the manure and the percentage germination of Japanese mustard seeds ranged from 55 to 65% and 94 to 98%, respectively (Table 1).

Table 1. Physicochemical and biological parameters obtained using conventional stacked and small-scale apparatus composting methods.

Property	Conventional stacked processing		Small-scale apparatus
	Amended with sawdust	Amended with rhodesgrass hay	
Maximum temperature (°C)	63.6	66.9	67.9
Time above 60 °C (hr)	18.0	103.0	46.0
Time above 55 °C (hr)	28.5	239.5	51.5
pH (H_2O)	7.5	8.4	8.1
EC (mS m^{-1})	1.3	2.0	2.3
Germination (%)	94.0	98.0	94.7

Conclusion

The temperature and physicochemical profiles obtained using both the conventional stacked and the small-scale processing methods corresponded very closely with each other. Thus, beef manure composting using the small-scale apparatus is considered to be as effective as conventional stacked processing.

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