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Characteristics of Coco Peat as a Bulking Agent for Dairy Cow Manure Composting

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Abstract

In this paper, we describe the utilization of coco peat, commonly used in horticultural production, as a bulking agent for dairy cow manure composting. Coco peat has high water absorption and low moisture content, which are important factors for bulking agents; however, its utility in composting processes has not been clarified. Our objective of this study was to clarify the characteristics of coco peat as a bulking agent in composting material. Stainless fermenters with a volume of 430 L were used as an experimental device. The mixture of cow manure and coco peat was adjusted to 70%, 74%, 78%, and 82% moisture content, and cow manure and rice husks adjusted to 70% moisture content were used as control. As a result, the organic matter decomposition rate and compost temperature were low under the condition of mixing coco peat at the same moisture content as rice husk, and coco peat was not a significantly more effective bulking agent than rice husks. However, composting was possible even at high moisture contents above 75%, where fermentation stagnation can occur in rice husks. The higher moisture content using coco peat led to a higher temperature of the composting material and more organic matter decomposition because of more easily degraded organic matter content originating in manure. Moreover, ammonia emission and the decrease in fertilizer components were less in coco peat than in the control. Therefore, it can be concluded that coco peat can be used as an alternative bulking agent for dairy cow manure composting.

Discipline: Biomass Utilization
Additional key words: compost, crushed coco peat

Introduction

In Japan, 90% of animal solid manure is treated by composting. The composting process is organic matter decomposition by aerobic microorganisms, and keeping the environment of the composting material aerobic is essential for good composting. Animal manure, particularly dairy cow manure, has a high moisture content (MC) with low permeability for aeration. Therefore, bulking agents with low MC and the capability to improve permeability are mixed with animal manure. Woody materials, such as sawdust and bark, are used as bulking agents for composting materials in Japan. However, these materials are becoming scarce because of decreased timber production and competition with biomass power generation. Herbaceous materials such as rice husks (RH) are used as bulking agents to replace sawdust, but they require large stockyards because the production of rice husks is concentrated in autumn. Therefore, investigation of new bulking agents is needed for sustainable manure treatment.

Many researchers have previously investigated bulking agents. For example, biochar (Dias et al. 2010), spent mushroom compost, rockwool disposed from horticulture (Kojima & Abe 2011a), cornstalks (Yang et al. 2013), and ear corn residue (Hanajima 2014) have been examined as bulking agents. They are added to animal manure to adjust the MC or improve the physical properties of the mixture. Moreover, material that can mitigate gaseous odor from the composting process is

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also a subject for regional environments. Here, we focused on coco peat (CP), which is used in horticultural production. Coco peat is produced by crushing coconut shells and accounts for 23% of the total coconut fruit by mass. It is estimated that more than 10 million tons of CP is generated annually, mainly in Southeast Asian countries; Japan imports a large amount of CP from Sri Lanka (BFPRO 2016). Dried and compressed CP is commercially available in Japan. CP is used to improve the physical properties of soil, and it has high water absorption (Awang et al. 2009) and low MC. Water absorption is an important factor for bulking agents (Japan Livestock Industry Association 2000); therefore, CP could be used as a bulking agent in composting material. However, few reports have examined CP as a bulking agent for animal manure composting, and its effect on the composting process has not been clarified.

Therefore, our objective of this study was to verify CP as a bulking agent for composting material. Specifically, temperature change, organic matter decomposition, and ammonia gas emission under the condition of higher MC were investigated and compared to a conventional bulking agent.

Materials and methods

1. Experimental method and conditions

In this study, CP and RH were used as the targets for the bulking agent. RH was selected as a typical alternative bulking agent to sawdust. Table 1 shows the characteristics of the CP and RH. The CP had MC as low as that of RH and had water absorption five times higher than that of RH. In preliminary tests, the effect of the CP shape was investigated, comparing block-shaped 5 × 5 cm cubes or crushed particles under one cm in size. The shape of the CP did not affect organic matter decomposition (data not shown). The volume of the composting material of the block-shaped CP gradually increased because the blocks broke apart. Since the volume usually decreases with the progress of the composting process, it is difficult to calculate the scale of the facility and the necessary amount of block-shaped CP when assuming an actual utilization scenario. Therefore, crushed CP was used in this study. Figure 1 shows CP samples: a) a lump of CP before crushing, b) a crushed sample with a feed mixer (CM-15D, Hojitsu Plant, Japan) for 10 minutes, and c) what the CP looks like when mixing with dairy cow manure.

Dairy cow manure from a free-stall cow house of the National Institute of Livestock Grassland Science,

Table 1. Characteristics of coco peat and rice husks

	Moisture content ($\%_{,w.b.}$)	Volatile solid (%DM†)	pH (–)	EC (mS/cm)	Bulk density (g/L)	Water absorbency (g/g‡)
Coco peat	15.1	93.5	4.8	5.14	190	4.29
Rice husks	10.2	81.8	7.1	0.58	96	0.85

This table shows the characteristics of cocopeat and rice husks. Cocopeat had as low moisture content as rice husks and two times higher bulk density than rice husks. Moreover, the water absorption of cocopeat was almost five times higher than that of rice husks.
† DM: Dry matter.
‡ Water absorbency shows g of water/g of material.

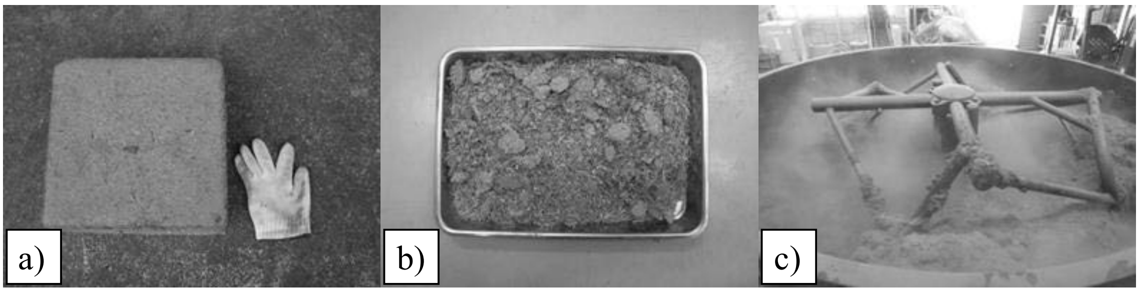

Fig. 1. Coco peat samples
a) Before crushing, b) after crushing, c) appearance of mixing with dairy cow manure

NARO, was used as the substrate. It was mixed with CP or RH using a mixer (A5 Type, Owaki-Kogyo, Japan). Dairy cow manure and crushed CP were measured for their moisture content, and they were mixed to meet predetermined MCs. The composting materials, which were a mixture of cow manure and CP, were adjusted to four different MCs: 70%, 74%, 78%, and 82% on a wet basis (w.b.). For the control, the mixture of cow manure and RH was adjusted to $70\%_{w.b.}$. These conditions were called CP_{70}, CP_{74}, CP_{78}, CP_{82}, and RH_{70}. The mixing ratio of dairy cow manure and CP or RH for each condition is shown in Table 2. Here, Abe et al. (2003b) reported that in composting using rice husks as a bulking agent, the higher moisture content resulted in a higher organic matter decomposition rate within the range of 60 to 75% moisture content. However, in the same report, when the compost had a 75% moisture content, no significant temperature increase was observed in the first week. Thus, the condition of using RH with a moisture content of 70% is regarded as the control in this study.

The mixture was composted in a pilot scale composting device at a volume of 430 L (diameter: 38 cm, height: 95 cm), the same as Abe et al. (2003a) and Saludes et al. (2008). Figure 2 shows a schematic representation of the device. This device can be aerated by a suction-type blower (VB-002-E, Hitachi Industrial Equipment Systems, Japan) at a set aeration rate. In contrast to the usual composting method, in which air is pumped from the bottom, the suction aeration composting implemented in this study promotes fermentation by sucking air from the bottom. This allows the recovery of ammonia generated during composting. It has also been reported that there was no difference in the temperature irregularity of compost and the organic matter decomposition between suction and pressure aeration composting (Abe et al. 2003a). Exhaust from the composting process was collected in a single pipe, from which temperature and gas concentration could be measured. The composting material temperature was measured at five depths: 6, 24, 42, and 60 cm from the bottom and 5 cm below the surface. Three load scales (LCN-A-5kN, KYOWA, Japan) were set under the device, and the weight of composting material was measured using the scales. Referring to Yakushido (2000), the aeration ratio was set at 56 L/(minute $m^3_{material}$) for the first seven days and then changed to 33 L/(minute $m^3_{material}$) until the end of the experiment, similar to Kojima & Abe (2011c). The composting period was 28 days under all conditions, and composting materials were turned over every 7 days. Sampling was performed during the turning operation.

2. Measurement and analysis

The temperature was measured using T-type thermocouples. MC was measured at 105°C by the 24-hour method. VS was measured by weight before and after combustion at 600°C for four hours using crushed samples after measuring the MC. The pH was measured for the samples, which were diluted in 10 times the mass ratio of water and shaken at 200 rpm for 1 hour by a glass electrode method. EC was measured in the same sample as pH using an electrical conductivity meter according to standard methods of organic matter analysis (Incorporated Administrative Agency Food and Agricultural Materials Inspection Center 2013). Water absorption was measured after composting by calculating the MC after 24 hours of immersion and more than 30 minutes of draining in a room controlled at a temperature of 20°C (Samal & Sahoo 2009). The height of the composting material before and after turning was measured, and the volume

Table 2. Mixing ratio of manure and bulking agents under each condition

	Cow manure		Bulking agent		Mixture sample for experiment		Moisture content
	weight (kg)	volume (L)	weight (kg)	volume (L)	weight (kg)	volume (L)	at start ($\%_{w.b.}$)
CP_{70}	151	159	49 (0.33)	270 (1.70)	157.4	431	69.8
CP_{74}	178	200	42 (0.24)	225 (1.13)	180.6	431	73.1
CP_{78}	242	256	38 (0.16)	202 (0.79)	227.3	431	77.6
CP_{82}	275	311	25 (0.09)	134 (0.43)	277.5	382	80.9
RH_{70}	169	179	51 (0.30)	530 (2.96)	172.4	431	69.4

This table shows the mixing ratio of manure and coco peat or rice husks and the initial weight, volume, and moisture content under all conditions. The same conditions were used for rice husks as a control. Conditions using coco peat were adjusted to a higher moisture content than rice husks.
CP: Coco peat, RH: Rice husks.
The numbers in parentheses indicate the ratio of the mass and volume of the bulking agent to the mass and volume of the cow manure.

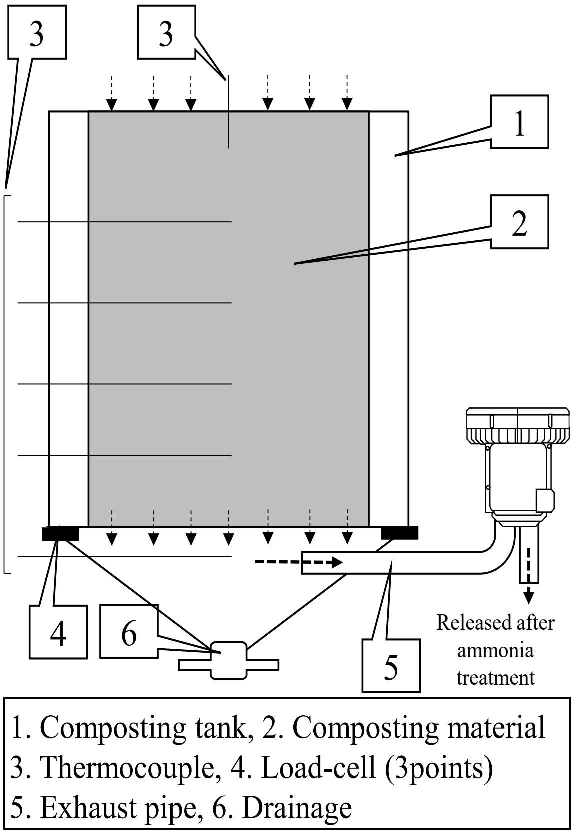

Fig. 2. A schematic representation of the device

was calculated from the height. NH_3 was measured by the detector tube method (tube No. 3HM, 3 M, 3La, and 3 L, GASTEC, Japan). The C/N ratio and fertilizer components (T-N, P_2O_5, K_2O) were analyzed by the Tokachi Federation of Agriculture Cooperatives.

The weight and temperature were measured every 5 minutes and recorded using a computer. NH_3 was measured every day. Material volume, MC, VS, pH, and EC were measured at each sampling time. The C/N ratio and fertilizer components were measured before and after composting.

The dry matter decomposition ratio (%) and organic matter decomposition ratio (%) were determined from the change in total mass before and after composting following formulas 1-2.

$$dry\ mater\ decomposition\ ratio = \frac{M_0(100-MC_0)-M_f(100-MC_f)}{M_0(100-MC_0)} \times 100 \quad (1)$$

$$organic\ matter\ decomposition\ ratio = \frac{M_0VS_0(100-MC_0)-M_fVS_f(100-MC_f)}{M_0VS_0(100-MC_0)} \times 100 \quad (2)$$

where M_0 is the weight of composting material at the start (kg), M_f is the weight of composting material at the finish (%w.b.), MC_0 is the moisture content of composting material at start (%TS), MC_f is the moisture content of composting material at finish (kg), VS_0 is the volatile solid of composting material at start (%w.b.), and VS_f is the volatile solid of composting material at finish (%TS).

Results

Figure 3 shows the change in temperature at all depths and the average in the composting material under each condition. The numbers in the legend indicate the distance from the bottom, and “top” indicates 5 cm below the surface of the compost. The material temperature of the RH_{70} increased rapidly after the start of composting, reaching the first temperature peak in reached in 1.6 days. Subsequently, the temperature of RH_{70} gradually decreased, and the average temperature did not reach 60°C after the first turning. The temperature of the top was low throughout the experiment and never exceeded 50°C. The temperature increased in all CP mixed conditions later than in the control but reached above 60°C by the first week. CP_{70}, which had the same MC as RH_{70}, reached its first temperature peak at 3.8 days. Under the conditions of mixed CP, the material temperature increased more, and those high temperatures were maintained longer as the MC increased. The periods of temperature over 55°C, which is used as quality assurance of compost (EPA, 2019), were 0.3 days (CP_{70}), 5.8 days (CP_{74}), 11.9 days (CP_{78}), 13.8 days (CP_{82}), and 2.3 days (RH_{70}). Under CP_{82} conditions, the temperature of the deepest point (6 cm) was lower than other points in the first week.

Figure 4 shows the change in the moisture content of compost material. In RH_{70}, the moisture content decreased with the progress of composting, finally reaching 60.2%. On the other hand, under CP mixed conditions, moisture content changed by as little as 3% or lower in the composting process. Figure 5 shows the change in pH of compost material. Under the CP mixed condition, the pH was below 6.5 at the beginning of composting. Subsequently, pH increased as composting proceeded, but under all conditions except for CP_{82}, pH did not reach above 7.0. In RH_{70}, the pH exceeded 7.5 on the seventh day and eventually remained around 8.0.

Table 3 shows the changes in the properties of the composting material before and after composting. Under the conditions of mixed CP, weight, volume, dry matter, and organic matter decreased or decomposed more as MC increased. Although the conditions of mixed CP had lower weight-decreasing ratios than the control, they also had a higher decomposition ratio for dry matter and organic matter. CP_{78} had a similar dry matter or organic matter decomposition as RH_{70}. Under mixed CP

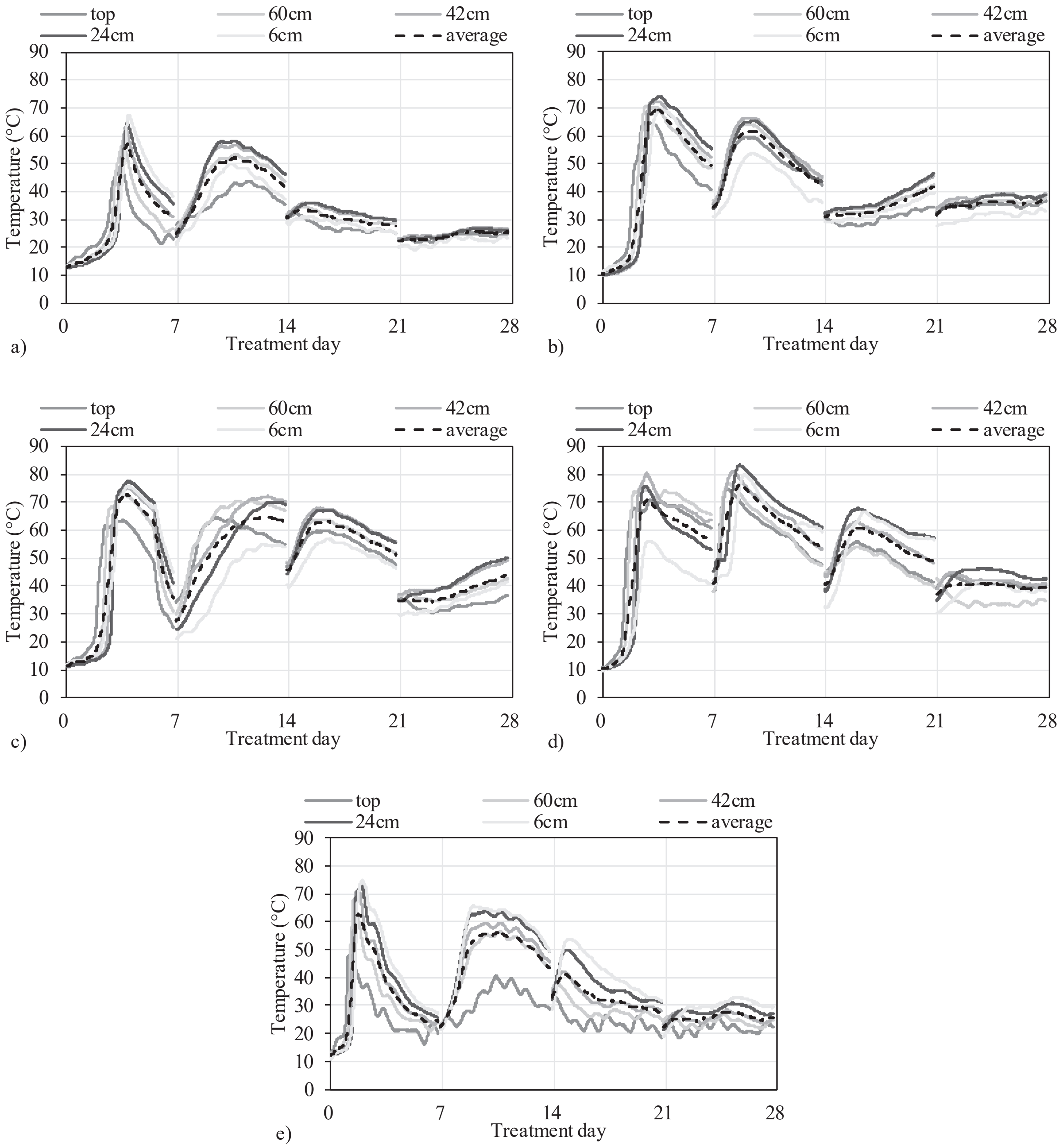

Fig. 3. Changes in temperature at all composting material heights and average at all heights
a) CP_{70}, b) CP_{74}, c) CP_{78}, d) CP_{82}, e) RH_{70}

conditions, the pH decreased as the MC decreased. The pH of CP_{78} after composting remained lower than 7.0. Moreover, the water absorption of the material after composting of CP_{82} was the same as that of RH_{70}. Lower MCs of mixed CP had higher water absorption.

Figure 6 shows the changes in ammonia concentration in the exhaust gas. The maximum concentrations of ammonia gas under each condition were 15 ppm (CP_{70}), 8 ppm (CP_{74}), 18 ppm (CP_{78}), 26 ppm (CP_{82}), and 310 ppm (RH_{70}). Moreover, the average ammonia gas concentrations for 2 weeks after composting were 1.5 ppm (CP_{70}), 2.0 ppm (CP_{74}), 3.2 ppm (CP_{78}), 12.5 ppm (CP_{82}), and 89 ppm (RH_{70}). During the first two weeks of composting, the ammonia gas concentration of

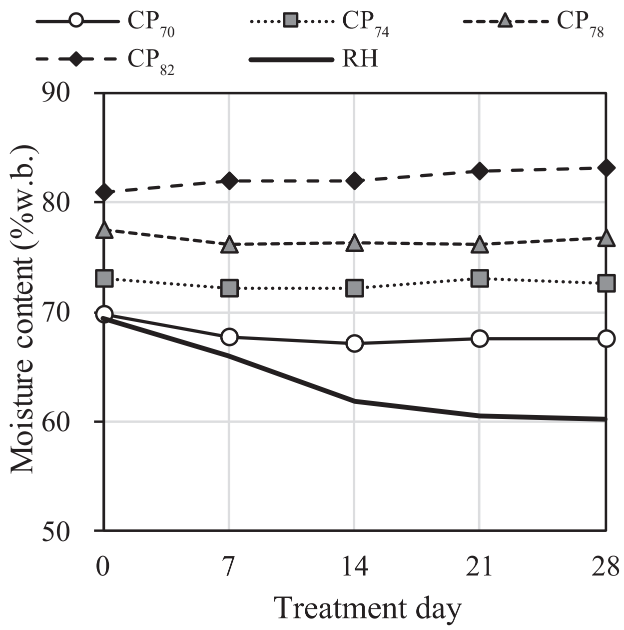

Fig. 4. Changes in moisture content of compost material

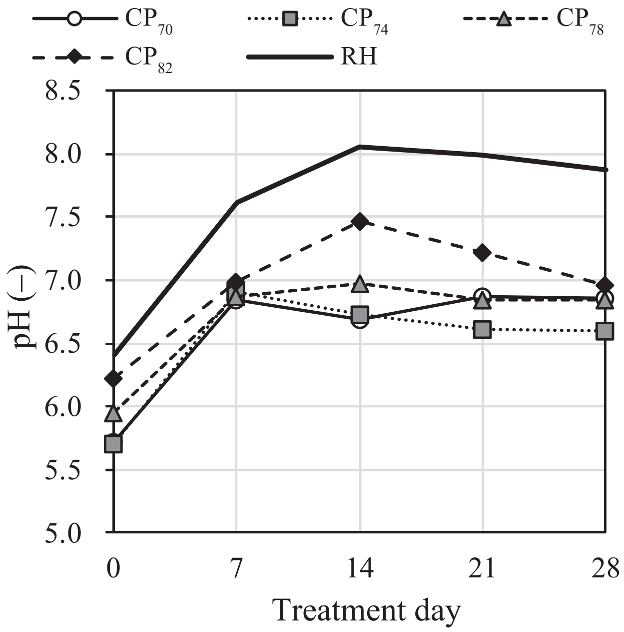

Fig. 5. Changes in pH of compost material

the mixed CP conditions was in the range of one-seventh to one-sixtieth that of RH_{70}. The mitigation effect of ammonia emission was the greatest in the conditions for CP_{78}. Table 4 shows the changes in the concentrations of nitrogen, phosphoric acid, and potassium oxide in the composting material before and after composting. In all conditions with mixed CP ($CP_{70\text{-}82}$), the concentrations of T-N, P_2O_5, and K_2O increased before and after composting. On the other hand, the concentration of T-N increased, but the concentrations of P_2O_5 and K_2O decreased before and after composting in RH_{70}. Drainage occurs during suction-type aeration composting. The amount of drainage of CP_{70}, CP_{74}, CP_{78}, CP_{82}, and RH_{70} were 4.2, 4.2, 6.4, 16.2 kg, and 19.5 kg, respectively; the drainage proved range from 2.68 to 5.82% of the initial mass for CP_{70} to CP_{82}, while it was 11.3% for RH_{70}. Thus, it was concluded that P_2O_5 and K_2O, which are soluble materials, leached into the drainage and were released from the composting material, reducing the amount of drainage. Since drainage is particularly likely to be generated with suction aeration composting (Abe et al. 2003a), it is considered that pressure aeration composting might suppress the decline in fertilizer components caused by drainage.

Figure 7 shows the relationship between the initial MC and initial bulk density and organic matter decomposition. The dark color range shows the recommended initial bulk density (500 kg/m^3-700 kg/m^3; Abe et al. 2009). The bulk density of RH_{70} was 400 kg/m^3, and the organic matter decomposition rate was 24.2%. Under the mixed CP conditions, the bulk density and the organic matter decomposition rate increased as the moisture content increased. The organic matter decomposition rate of CP_{78}, whose bulk density was within the recommended range, was 24.7%.

Discussion

The addition of CP enhanced the organic matter decomposition in compost under conditions of higher MC compared to RH, which is a conventional bulking agent. Bulk density is regarded as a factor in managing the composting process (Huerta-Pujol et al. 2010). It has been recommended that the initial bulk density of composting material should be adjusted to 500 kg/m^3-700 kg/m^3 (Abe et al. 2009). The bulk density of the mixed CP conditions was lower than that of the mixed RH for the same moisture content; even the condition of 82% MC had only slightly higher bulk density than 700 kg/m^3. Abe et al. (2003b) and Kojima & Abe (2011b) reported that the composting process could not proceed well using the same composting device used in this study under a condition of approximately 75% MC or more than 780 kg/m^3 of bulk density which were adjusted with mixing recycling compost, spent mushroom compost or airdrying. In this case, defective aeration occurred, and the composting material temperature did not increase until more than one week after starting or did not increase after four weeks of composting. Similarly, the temperature increased from the first week

Table 3. Changes in composting material properties before and after composting

			CP_{70}	CP_{74}	CP_{78}	CP_{82}	RH_{70}
Weight	before	(kg)	157.4	180.6	227.3	277.5	172.4
	after		131.3	150.8	171.0	205.1	104.9
	†DR	(%)	16.6	16.5	24.8	26.1	39.2
Volume	before	(L)	431	431	431	382	431
	after		419	389	392	306	392
	†DR	(%)	2.8	9.7	9.0	19.9	9.1
Bulk density	before	(kg/m^3)	365	419	527	726	400
	after		313	388	436	671	268
TS	before	($\%_{w.b.}$)	30.2	26.9	22.4	19.1	30.6
	after		32.4	27.3	23.2	16.9	39.8
	†DR	(%)	10.5	15.1	22.3	34.6	20.9
VS	before	(%DM)	90.9	90.5	89.9	89.5	83.7
	after		90.1	88.9	87.1	84.0	80.3
	†DR	(%)	11.3	16.7	24.7	38.7	24.2
pH	before	(–)	5.8	6.1	6.3	7.3	6.2
	after	(–)	6.4	6.5	6.7	7.2	8.3
EC	before	(mS/cm)	8.2	5.7	6.5	6.5	4.2
	after	(mS/cm)	5.4	4.6	7.2	7.2	2.8
C/N ratio	before	(–)	42.7	34.1	30.4	23.9	34.1
	after	(–)	33.5	26.9	24.2	16.4	29.5
Water absorption at finish		($g/g_{w.b.}$‡)	2.3	1.8	1.7	1.2	1.1
Average temperature		(°C)	32.4	41.7	48.3	51.9	35.1
Days over 55°C of material temperature		(days)	0.3	5.8	11.9	13.8	2.3

This table shows properties before and after composting under all conditions. The average temperature and days over 55°C of material temperature were calculated by the average temperature at all heights.
CP: Coco peat, RH: Rice husks
† DR: Decreasing ratio by the change in total amount, volume, TS or VS
‡ Water absorption shows g of water/g of material.

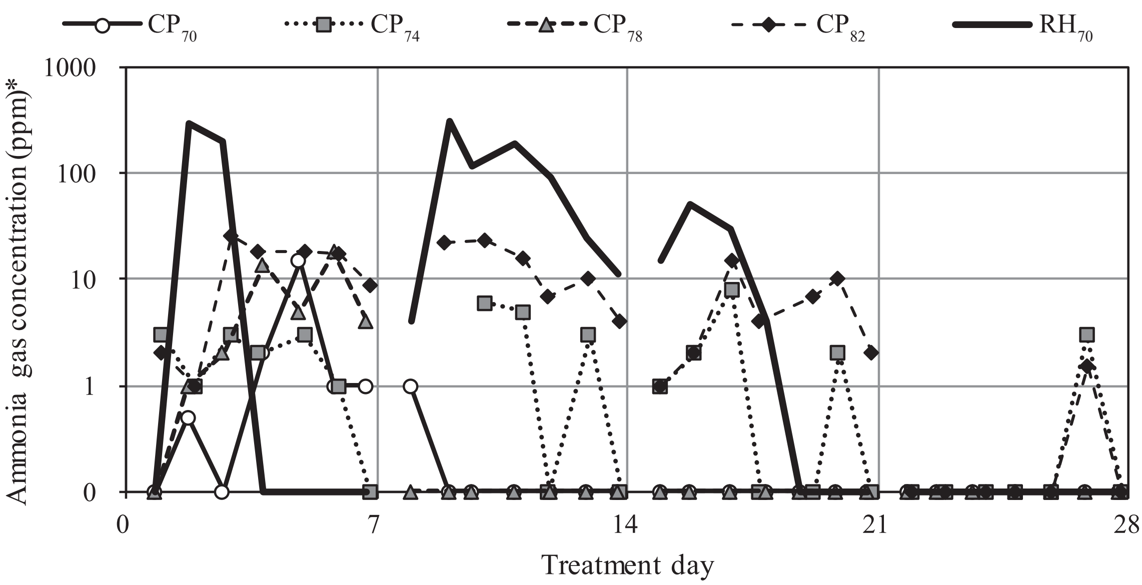

Fig. 6. Changes in ammonia gas concentration in exhaust
* The y-axis in the figure is on a logarithmic scale.

Table 4. Changes in the fertilizer component of composting material

	T-N(%DM)		P_2O_5(%DM)		K_2O(%DM)	
	start	finish	start	finish	start	finish
CP_{70}	1.15	1.39	0.69	0.73	0.91	1.01
CP_{74}	1.39	1.77	0.88	0.94	0.80	0.90
CP_{78}	1.57	1.93	1.12	1.34	0.88	1.18
CP_{82}	1.95	2.69	1.31	1.69	0.89	1.22
RH_{70}	1.24	1.34	1.07	0.67	0.48	0.40

This table shows the change in fertilizer components before and after composting under all conditions. Although the concentration of the fertilizer component increased after the composting process under CP conditions, the P_2O_5 and K_2O concentrations under RH_{70} decreased after composting.
CP: Coco peat, RH: Rice husks

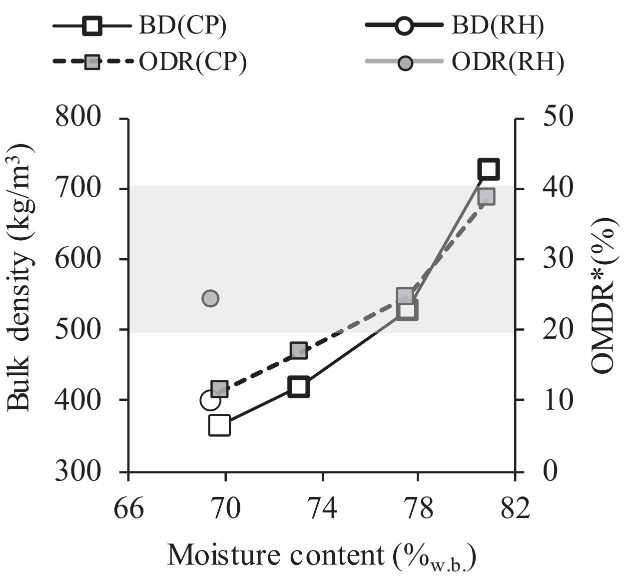

Fig. 7. Relation of moisture content with bulk density at the start and organic matter decomposition
*OMDR: Organic matter decomposition rate
The dark color range showed recommended initial bulk density (500 - 700 kg/m^3).

under the conditions for CP_{82}, which had the highest bulk density of 726 kg/m^3 at the start of composting in this study. Still, the temperature at the bottom of the compost increased slowly, as shown in Figure 3. In suction aeration composting, the temperature increases from the top to the bottom gradually under the composting process, so a slow temperature increase from the bottom of the compost indicates defective aeration. However, CP showed no remarkable stagnation during composting; the material temperature increased more than 55°C in the two days after the start of composting at 82% MC. Moreover, compost temperature increased along with the higher moisture content of the raw materials used. Furthermore, the higher MC conditions contributed to a longer period with temperatures exceeding 55°C, which was an important hygiene index for compost (Brinton 2000; Table 3). A higher MC occurred as more manure was used in the composting material, and the concentration of easily decomposed organic matter in the composting material increased. In addition, since the specific heat of biomass such as compost is strongly affected by the moisture content (Iwabuchi 2009), it could be said that the higher the moisture content, the smaller the temperature decrease by heat release after the temperature increases due to microbial activity. Thus, it was considered that the higher the MC, the more heat was generated during the composting process and the longer the period maintained exceeding 55°C of compost temperature. This phenomenon was also reported by Abe (2003b).

In Figure 4, the ammonia gas concentration of mixed CP conditions was significantly lower than that of the control; the average ammonia gas concentration two weeks after the start of composting for CP_{74} had almost the same initial C/N ratio as RH_{70}, which was only 2.2% of RH_{70}. It was assumed that this low ammonia emission led to an increase in the T-N concentration of the compost, as shown in Table 4. As shown in Figure 5, the pH of the mixed CP conditions was lower than that of RH_{70}, especially under conditions with a moisture content of lower than 78% using CP, and the pH was below 7.0 throughout the composting process. Moreover, Ahn et al. (2016) verified the characteristics of CP as bedding for Hanwoo Cattle and reported that the high ammonia adsorption of CP reduced ammonia emissions significantly. In this study, the low pH and high ammonia adsorption of CP might have reduced the concentration of ammonia emission.

In this study, CP_{70}, with its similar moisture content to RH_{70} and CP_{74}, which had similar bulk density, had lower TS and VS decreasing ratios than RH_{70}. Moreover, CP_{70} had a shorter duration above 55°C than RH_{70}. On the other hand, ammonia volatilization in the mixed CP conditions was lower than that in RH_{70}, and the increase in fertilizer concentration was greater. The bulk densities of RH_{70}, CP_{70}, and CP_{74} were 400, 365, and 419 kg/m^3, respectively, which were smaller than the appropriate bulk density for composting (500 to 700 kg/m^3). At a moisture content of around 70%, CP was not a significantly more effective bulking agent than RH. Here, Abe et al. (2003b) conducted a composting test of dairy cattle manure using the same device as in this study and reported that the bulk density of the condition adjusted to 75% of moisture content mixed with RH was about 450 kg/m^3. Even though the bulk density was smaller than the appropriate range under this condition, the temperature did not increase during the first week of composting, and fermentation stagnation occurred due to poor aeration. In contrast, CP_{78}, with a bulk density of 527 kg/m^3, showed a temperature increase from the first week of composting, the organic matter decomposition rate was like that of RH_{70}, and the ammonia emission was 3.6% as in the likes of RH_{70}. Thus, it was said that CP could be composted under higher moisture content conditions than RH. The water absorption of CP was about five times higher than that of RH, and this high water absorbency was considered to enable composting under high water content conditions. Therefore, the moisture content of composting material using CP as a bulking agent could be adjusted higher than using RH; a 78% moisture content for composting material mixed with CP was the most effective moisture content in this study, regarding as high as organic matter decomposition ratio as RH_{70} and less loss of fertilizer component due to less ammonia emission. In conclusion, in the case of using CP as a bulking agent, the initial MC of composting material should be adjusted higher than the general guidelines. However, the MC changes little during the composting process. In a practical agricultural setting, farmers prefer low-moisture compost, which is advantageous for transportation, storage, and handling. Thus, compost with CP might require a moisture reduction process, such as sun-drying, to transport to distant locations or prevent mold formation.

Tables 1 and 2 show that CP has approximately twice the bulk density of RH, and comparing CP_{78} to RH_{70}, the mixed mass of CP is approximately half (0.53 times) that of RH, and the mixed volume of CP is approximately one-fourth that of RH. In contrast, while the selling price of RH was 20 yen/kg-55 yen/kg (Central Livestock Association 2017), CP was sold as a horticultural material for about 500 yen/kg-2000 yen/kg (BFPRO 2016); using RH is more economically advantageous than CP. However, CP traded at a lower price in the producing countries (BFPRO 2016). If the price decreased as the distribution mass increased and the price per volume of CP decreased to about four times the price of RH, the total cost of the bulking agents would become almost the same. Considering the mitigation effect of CP on ammonia emission, CP could be chosen as an alternative material if the cost of CP decreases. Moreover, because the decrease in nitrogen fertilizer components was small when using CP and CP was conventionally used for horticultural production, the finished composting material was estimated to be valuable for fertilizer without safety concerns. Although some topics, such as handling, need more study, CP could be used as a new material for livestock waste management.

Conclusion

In this study, the use of CP as a bulking agent for composting was examined. Effective composting under high MCs was verified. Using 430-L stainless steel fermenters, 28-day composting was performed with CP adjusted to 70%, 74%, 78%, and 82% MC and RH adjusted to 70% MC, all of them mixed with dairy cow manure. The findings are summarized below.

1) Cow manure could be successfully composted by mixing with CP under high MC conditions, perhaps even higher than 80%. The higher MC using CP led to higher temperature in the composting material and more organic matter decomposition because of better bulk density and more easily degraded organic matter content. However, at the same moisture content of CP and RH, CP was not a significantly more effective bulking agent than RH.

2) Ammonia emissions from the composting material using CP, particularly with less than 78% MC in the first 2 weeks, were much less than those from the control. This was because of the low pH of the CP. The low pH could lead to a delayed temperature rise of the composting material under 70% MC conditions, which had the highest CP mixing ratio.

3) Even at high moisture contents above 75%, which can cause fermentation stagnation in RH, composting proceeded when mixed with CP. The mass of mixed CP was one-fourth that of RH under the condition of 78% MC, which had the same organic matter degradability as RH with 70% MC. Because the decrease in fertilizer components was small when using CP, the finished composting material was estimated to be valuable for fertilizer. Therefore, CP could be used as a new bulking agent for livestock waste management.

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