Bangladesh Journal of Animal Science 51 (2): 40-46, 2022 https://doi.org/10.3329/bjas.v51i2.60493

Bangladesh Journal of Animal Science
Journal homepage: http://www.banglajol.info/index.php/BJAS

Effects of moisture content on the quality of vermicompost produced from cattle manure

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ARTICLE INFO

Article history:
Received: 12 March 2022
Revised: 29 May 2022
Accepted: 08 June 2022
Published: 30 June 2022

Keywords:
Cattle manure, moisture content, earthworm, vermicompost, CF degradation

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ISSN: 0003-3588

OPEN ACCESS

ABSTRACT

This research aimed to evaluate the quality of vermicompost produced from cattle manure at different levels of moisture content. For this purpose, cattle manure containing different moisture content such as 60% moisture (T_1), 70% moisture (T_2) and 80% moisture (T_3) treatments were adopted with 3 replications. A total of 9 vermicomposting pits were filled with 25 kg of cattle manure, each having the same amount of red worms. Parameters studied were dry matter (DM), crude fibre (CF), crude protein (CP), ether extract (EE), ash and pH. Results showed that 63% DM was increased in T_2 and this value was significantly higher than T_1 and T_3 ($p > 0.05$). The rate of CF degradation was 46, 78 and 72% in T_1, T_2 and T_3, respectively. The CF degradation was also significantly higher in T_2 compared to the other two treatments ($p > 0.05$). In the case of CP, a slightly higher CP was found in T_2 followed by T_1 and a little bit lower in T_3 after 60 days of vermicomposting period. The EE content was slightly higher in all 3 treatments after 60 days of vermicomposting, but this difference was not significantly different among the treatments. The ash content was slightly higher in all 3 treatments after 60 days of vermicomposting, but this difference was also not significantly varied. The pH was significantly differed with the 3 treatments after 60 days of vermicomposting. From the above results, it was revealed that T_2 would be the suitable level of moisture for CF degradation and increased CP content in the final vermicompost. Therefore, it might be concluded that cattle manure containing 70% initial moisture would be a good option for vermicomposting.

Introduction

Livestock plays an important role in producing meat, milk, eggs and draught power supplementation (Baset *et al*., 2003; Rahman *et al*., 1997, 1998 & 1999; Begum *et al*., 2007). Statistics show that about 2.9% of the national GDP is covered by the livestock sector, and its annual growth rate is 5.5%. About 20% of the total population of Bangladesh improves their livelihood through cattle and poultry rearing activities. Draught power is used for tillage operation, crop harvesting, and transportation, the cow dung is used as compost, vermicompost and biogas make up significant GDP. Besides livestock products, approximately 156 million tons of cattle manure is produced in Bangladesh every year (Haque *et al*., 2021; Modak *et al*., 2019; Sarkar *et al*., 2021). These manures are the causes of environmental pollutions by releasing N & P to the water stream; as well as releasing ammonia, carbon dioxide, and hydrogen sulphide gas to the air (Won *et al*., 2016; Lee *et al*., 2009; Sarker *et al*., 2009; Ahsan *et al*., 2014 & 2013; Rahman *et al*., 2008). Furthermore, the livestock manures are also the potential source of pollution that causes serious public health issues (Alam *et al*., 2013; Runge *et al*., 2007; Rahman *et al*., 2013).

These livestock manures might be converted into a valuable resource through proper recycling; otherwise, these are a burden on the environment

How to Cite

MS Hossen, MRI Khan, MAK Azad, MA Hashem, MKJ Bhuiyan, MM Rahman (2022). Effects of moisture content on the quality of vermicompost produced from cattle manure. *Bangladesh Journal of Animal Science* 51 (2): 40-46. https://doi.org/10.3329/bjas.v51i2.60493.

(Rahman *et al*., 2020a & 2020b; Al Amin *et al*., 2020; Rana *et al*., 2020; Punde and Ganorkar, 2012). Cattle manure is a valuable resource that provides high amounts of macro- and micro-nutrients for plant (Sarker *et al*., 2018; Islam *et al*., 2010; Ghos *et al*., 2004). Recently, emphasis has been focused on to produce compost and vermicompost than biogas production due to the problems arising from bioslurry management. It needs a considerable awareness for managing biogas plant and bioslurry management (Poudel *et al*., 2009; Roy *et al*., 2013). Vermicompost contains higher NPK than in the compost and also contain auxin and gibberellins that enhance plant growth simultaneously reducing the growth of pathogens. Earthworm helps to stabilize nutrients during the vermicomposting process from waste biomasses and to reduce the risk of environmental hazard (Rahman *et al*., 2020b). Worm castings or worm feces are called vermicast that are produced after digestion in the earthworms.

A versatile advantage is found in vermicompost at any stage of the field crop as well as horticultural, ornamental and vegetables plants. In Bangladesh, it generally costs about Tk 4-5 to produce 1 kg of vermicompost, which can be sold at 29-30 TK/kg in the open market (Hossen, 2020). Vermicompost improves the soil structure, water-holding capacity, soil aeration and prevents the soil from erosion. It also prevents macro and micro nutrient losses and enhances the utilization of chemical fertilizers. Stabilization involves in decomposing waste materials and decreases in microbial activity and concentrations of labile compounds (Garg *et al*., 2008). Nutrient stabilization reduces the environmental pollution along with the management of manure by transforming it into a more valuable substance for soil (Ghos *et al*., 2004). Furthermore, based on the quality of the waste materials, high-quality organic fertilizers can produced through vermicomposting. The optimal moisture content in manure is very important for organic matter degradation during vermicomposting (Palsania *et al*., 2008). So, the study was taken to evaluate the degradation pattern of crude fiber and other organic materials by the earthworm and the quality of vermicompost in cattle manure at different levels of moisture contents.

Materials and Methods

Design of experiment

The experiment was conducted in a two factorial Complete Randomized Design. There were three treatments: vermicomposting at 60% (T_1), 70% (T_2) and 80% (T_3) moisture contents in cattle manure. Each treatment was tested in two time periods, initial and 60 days and was replicated three times. The samples were collected initially from raw cattle manure just before starting and finally after 60 days of incubation.

Collection of raw materials

The manure was collected from Goat, Sheep and Horse farm, Department of Animal Science, BAU, Mymensingh, Bangladesh. Approximately 25 kg of manure was collected to conduct the experiment for each treatment. For vermicomposting, about 1 kg of red worm (*Eisenia foetida*) was collected and stored in an appropriate breeding condition before setting in the vermicompost pit.

Preparation of vermicomposting pit

An earthen pot, locally called Chari was utilized to produce vermicompost. For vermicompost preparation, no filler materials were used. The pot was semicircular, having a diameter of 0.5 m and a height of 0.3 m. The pot was kept still and secure under a tin-shed building with a secured perimeter.

Composting method

Nine vermicomposting pits were arranged for three treatments with three replications. Each pit was filled with 25 kg of mixed cattle manure and 100 g of red worm to fulfill the objectives of the research. At the beginning of composting the ambient temperature was 28ºC. It was winter and hence affected the process a little.

Collection of samples for laboratory analysis

Samples were collected from raw materials on the first day of the experiment. The collected samples were stored in the refrigerator in the Animal Science laboratory for further analysis. The final sample collection was done on the 60th day of the vermicomposting process. After each collection, each sample was analyzed to determine DM, CP, CF, EE, ash and pH of each replication of the respective sample.

DM determination

The collected samples were weighed and dried in an oven at a temperature of 105 ^{o}C for 2 days until the constant weight was attained.

Crude protein determination

Nitrogen content of all samples was determined by Kjeldahl digestion a 5 g sample with concentrated H_2SO_4 (120 ml) and 1.5g catalyst mixture distilled into 2 percent boric acid solution and titrated with 0.1N HCl according to the method described by AOAC (2005). Crude protein was estimated by multiplying nitrogen content by 6.25.

Crude fiber determination

About two (2) g of sample was added in 120 ml of 1.25% H_2SO_4 into a beaker and then placed on the heater for boiling for half an hour and the volume of the content of the beaker was shaken to the edge of the beaker. After 30 min of boiling, the beaker was removed from the heater. The content of the beaker was filtrated through a muslin cloth by washing with water for several times until it was free from acid. The acid free sample was then transferred into another beaker and 120 ml of 1.25% NaOH solution was added to it. Again the beaker with the content was fitted to the condenser and was boiled for 30 min maintaining the constant volume of the solution. Then the sample was filtered and washed with distilled water until it was free from alkali. Then the filtrate was transferred in a previously weighed empty dried crucible. Dried and weighed sample was then ignited in a muffle furnace at 550-600 ^oC for 5-6 hours. After ignition, the weight of sample plus crucible was taken. The CF content of the supplied sample was calculated by deducting the weight of ignited sample from the weight of acid and alkali treated oven dried sample.

pH determination

For pH determination, 2g of sample from each treatment were taken followed by adding 50 ml of distilled water and mixed thoroughly by vigorous stirring. The extracts were filtered through filter paper and the pH of the sample was identified using a laboratory pH-mV meter.

Statistical analysis

Data were analyzed through two ways ANOVA at 5% level of significance and the differences among the treatment means were determined by Duncan's Multiple Range Test (DMRT).

Results and Discussion

The impact of different moisture levels during vermicomposting on the biomass of earthworms, rate of production, rate of hatchability, rate of recovery of vermicompost, degradation activity on the content of DM, CP, CF, EE, ash and pH on the 0 and 60th days of vermicomposting were analyzed. It was found from the result that the earthworm could grow in a sustained manner and gain a maximum weight at 70% moisture of the feed substrate. Moreover, degradation of organic substances was also slightly higher at 70% moisture than at 80% and 60%.

Composition of raw materials

Proximate components of vermicompost obtained from cattle manure were estimated in this experiment for DM, CP, CF, EE, ash and pH. The initial composition of raw materials (mixed manure) used for vermicomposting process is shown in Table 1.

Table 1. Composition (%) of mixed manure used as raw materials for vermicomposting

Parameters	T_1	T_2	T_3
DM	40.00±0.55	29.98±0.33	20.12±0.19
CF	15.28±0.40	13.02±0.46	10.03±0.93
CP	13.14±0.58	11.84±0.52	9.98±0.81
EE	1.78±0.17	1.11±0.24	0.72±0.17
Ash	2.49±0.19	2.20±0.20	1.75±0.33
pH	8.30±0.38	7.82±0.24	7.46±0.22

T1, 25kg cow dung+100g red worms at 60% moisture; T2, 25kg cow dung+100g red worms at 70% moisture; T3, 25kg cow dung+100g red worms at 80% moisture.

In the beginning, as the same mixed cattle manure was used for vermicomposting, their composition was the same. The mixed manure was subjected to change when set in vermicomposting pit separately.

Changes in composition of vermicomposting on different moisture

Dry matter (DM) alteration over time

It was found that the initial DM was 40, 30 and 20% in T_1, T_2 and T_3 respectively. The DM content was increased after 60 days of vermicomposting period. At the end of the experiment, the DM content was 59.33, 48.84 and 29.79% in T_1, T_2 and T_3 respectively. There was a significant ($p<0.05$) difference in DM content among treatments and a significant ($p<0.05$) difference in DM changes after 60 days of vermicomposting. Rahman *et al*. (2020a) and Adely and kits (1983) observed the same trends of results and reported that dry matter content increased with time. Increasing pattern of DM is a normal phenomenon, and it occurs due to reducing the moisture from the vermicomposting pit at the advancement of time (Table 2).

Crude fiber (CF) alteration over time

Initial CF contents were 15.28, 13.02 and 10.03% in T_1, T_2 and T_3, respectively, and then a gradual decrease was found in all the three treatments during vermicomposting (Table 2). The lowest CF was found in T_2 (3.83%) compared to T_1 (8.30%) and T_3 (6.63%) after 60 days of vermicomposting. There was a significant difference in CF changes among the treatments ($p<0.05$). The result showed that 45.68%, 78.27% and 71.78% of CF were degraded during 60 days of the vermicomposting period from T_1, T_2 and T_3, respectively. The reduction of CF might be occurred due to the worm's subsequent ingestion and digestion of fiber through its digestive system during vermicomposting. Garg *et al*. (2008) revealed that the fibrous & other biomasses were digested and degraded by the digestive enzyme of earthworm and grinding effect of its gizzard. Formation of the caste or feces poop is occurs by the muscular contraction of the earthworm. Sarker *et al*. (2021) conducted a vermicomposting experiment with different types of livestock manures and found that CF degradation rate was faster in cattle manure (82%) compared to goat manure (81%) and horse manure (66%). At all treatments, there found a decreasing trend of CF indicated that earthworms are very effective in CF degradation during the vermicomposting period.

Table 2. Degradation pattern of cattle manures at different moisture level during vermicomposting

Parameters	Period (days)	Treatment			*p* value
		T_1	T_2	T_3	
Dry matter	At 0 day	40.00[a]	29.98[b]	20.12[c]	0.04
	After 60 days	59.33[a]	48.84[b]	29.79[c]	
Crude fiber	At 0 day	15.28[a]	13.02[b]	10.03[c]	0.03
	After 60 days	8.30[a]	3.83[c]	6.63[b]	
Crude protein	At 0 day	13.14[a]	11.84[b]	9.98[c]	0.02
	After 60 days	13.39[a]	12.41[a]	9.54[b]	
Ether extract	At 0 day	1.78	1.11	0.72	0.07
	After 60 days	2.16	1.86	0.83	
Ash	At 0 days	2.49	2.20	1.75	0.13
	After 60 days	3.48	2.90	1.85	
pH	At 0 day	8.30[a]	7.82[b]	7.46[b]	0.03
	After 60 days	8.49[a]	7.83[b]	7.30[b]	

T1, 25kg cow dung+100g red worms at 60% moisture; T2, 25kg cow dung+100g red worms at 70% moisture; T3, 25kg cow dung+100g red worms at 80% moisture. Mean values in each row having different superscript varies significantly.

Crude protein (CP) alteration over time

On the first day of composting, the mean crude protein contents of vermicomposting were 13.04, 11.84 and 9.98% in T_1, T_2 and T_3, respectively. A little increase in CP content at T_1 and T_2 was found but reduced in T_3 after 60 days of vermicomposting (Table 2). The CP content gradually increased in T_1 and T_2 but decreased in T_3 after 60 days of vermicomposting. There was a significant difference in CP alteration among treatments ($p<0.05$). The highest CP was found in T_1, but the increasing pattern was higher in T_2, but a decreasing pattern of CP was found in T_3. Earthworms can increase the amount of crude protein in the feed materials during digestion in their digestive tract by adding some nitrogenous compounds such as mucus, body fluid, enzymes, and even through the decaying dead tissues of worms in the vermicomposting subsystem (Suthar, 2007). A similar result was stated by Krishan *et al*. (2014), Sitaramlaxmi *et al*. (2013), and Tripathi & Bhardwaj (2004). Rahman *et al*. (2020a) also stated that the TN content slightly increased after vermicomposting of livestock manure. Yadav and Garg (2013) also found slightly higher N, P & K contents in the final vermicompost than the raw manure.

Ether extract (EE) alteration over time

The initial EE content of cattle manure was 1.78, 1.11 and 0.72% in T_1, T_2 and T_3, respectively. After 60 days of vermicomposting mean EE content of vermicomposting increased a little (Table 2). The EE content increased after vermicomposting, but there were no significant differences in EE changes among the treatments. The highest EE was found in T_1, but the increasing pattern was similar in T_2 and T_3. An increased amount of total EE in the final vermicompost might be due to mineralization of the proteinous substance in the organic matter (Kaushik and Garg, 2003; Bansal and Kapoor, 2000).

Ash alteration over time

The initial ash content of cattle manure was 2.49, 2.20 and 1.75% in T_1, T_2 and T_3, respectively. A little increased ash content was found after 60 days' of vermicomposting in all treatments (Table 2). The increased ash content might be due to increase in dry matter over time. The highest ash content was observed in T_1 after 60 days of composting compared to the other two treatments. However, the increasing pattern was not significant statistically among the treatments, day's interval or interaction. Rahman *et al*. (2020b) also stated that the ash content increased with the advancement of the vermicomposting. The increasing pattern of ash was not significant during vermicomposting of manure.

pH alteration over time

A higher pH was found in all treatments after 60 days of the vermicomposting (Table 2). A little change was observed in pH after the vermicomposting and the changes differed significantly among the treatments ($P<0.05$). The pH was increased in T_1 and T_2 after 60 days but little decreased in T_3. The highest pH was observed in T_1 (8.49) after 60 days of vermicomposting. The reduction of pH in T_3 might be due to the formation of CO_2 and organic acids during bioconversion of different substrates in the feed materials (Haimi and Hutha, 1986).

Conclusion

It might be stated from the present study that the degradation of CF or fibrous materials was highest in T_2, along with higher nitrogen mineralization found in T_2 after 60 days of vermicomposting period. Therefore, it might be concluded that cattle manure containing 70% initial moisture would be a good option for vermicomposting.

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