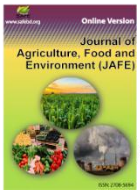
Vol 2 No 2 June 2021 Pages 62-67 e-ISSN 2708-5694

Journal of Agriculture, Food and Environment (JAFE)

Journal Homepage: http://journal.safebd.org/index.php/jafe

http://doi.org/10.47440/JAFE.2021.2211



Original Article

Production and evaluation of vermicompost from different types of livestock manures

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Article History

Received: 02 June 2021

Revised: 23 June 2021

Accepted: 25 June 2021

Published online: 30 June 2021

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Keywords

Manure, earthworm, vermicompost, vermicast, organic fertilizer.

A B S T R A C T

This study aimed to identify the quality of vermicompost produced from different types of livestock manures at the same environmental condition. For this purpose nine concrete pits, locally called as 'chari' was used to prepare vermicompost. Three treatments (T_1: cow dung, T_2: horse manure and T_3: goat manure) were replicated three times each and the total of nine vermicomposting pits were used in this experiment. The parameters studied were DM, OM, ash, TN, CF and pH at different day intervals. The results showed that the manure type has a significant influence on the quality of the final vermicompost. This study found that DM content increased gradually up to 45th day and differed significantly ($p<0.01$) among treatments and among day intervals. Organic matter (OM) also decreased gradually in all treatments of vermicomposting over 45 day's period of composting. CF content in T_1, T_2 and T_3 decreased gradually and the degradation of CF varied significantly ($P<0.01$) between treatments and day intervals up to 45 days period. In all three treatments of vermicomposting, TN content gradually increases with the increase of time. Over the time, a little change occurred in pH in all treatments but those were not followed a trend. pH also differ significantly ($P<0.05$) among treatments and among day intervals but not significant ($P>0.05$) between treatments and day intervals. Finally, it may be concluded that organic matter degradation rate is faster in vermicomposting of goat manure than cattle and horse manure.

Introduction

Livestock is an integrated part of agriculture that plays important role in the economy of Bangladesh (Rahman *et al.*, 1997, 1998 and 1999; Begum *et al.*, 2007). Based on the population, Bangladesh ranked the 3rd largest position of cattle in Asia and a large number of chicken and duck which are the key source of milk, meat and eggs in Bangladesh (Baset *et al.*, 2003). Besides these products, huge amounts of manures produced daily from these large numbers of livestock. It is estimated that a total of 375 million livestock animals in Bangladesh, including 24 million cattle, 25 million goat, 3 million sheep and 1.9 million buffalo where chicken population is about 255.31 million (Hamid *et al.*, 2017). Approximately 156 million tons of cattle manure and 4.5 million tons poultry manure produced in Bangladesh every year (Modak *et al.*, 2019). These manures create serious environmental problems by releasing nitrate and phosphate to the surface and ground water; as well as release ammonia, carbon di oxide, hydrogen sulphide gas in the air (Ahsan *et al.*, 2013 and 2014; Lee *et al.*, 2009; Rahman *et al.*, 2008; Sarker *et al.*, 2009; Won *et al.*, 2016). Not only are these, livestock manures are the potential source of pathogens that caused serious public health issue (Alam *et al.*, 2013; Rahman *et al.*, 2013; Runge *et al.*, 2007). Moreover, manure biomass is also a potential source of green house gases that are responsible for global warming. Indiscriminate dumping of manures creates several problems including nuisance odor, flies and beetles and heavy traffic causing damage of roads. These livestock manures could be a valuable resource if proper recycling method is adopted; otherwise these are the burden for environment (Al Amin *et al.*, 2020; Krishan *et al.*, 2014; Punde and Ganorkar, 2012; Rahman *et al.*, 2020a and 2020b; Rana *et al.*, 2020). Manures are the most significant resource for soil fertility that supplies macro and micro-nutrients for crop growth (Ghos *et al.*, 2004; Islam *et al.*, 2010; Sarker *et al.*, 2018). Recently, emphasis is given to produce compost and vermicompost rather than biogas from manures due to problems arisen from bioslurry management. It needs a considerable awareness for managing biogas plant and bioslurry management, because bioslurry may contain coliform and other pathogens that are a burning environmental issue (Poudel *et al*., 2009). Composting and vermicomposting are the processes that decompose the organic matter into humus like substances. Both compost and vermicompost are excellent soil amendments that enhance soil fertility and plant growth. Rahman *et al*. (2020b) stated that vermicompost is superior to compost in several cases such as higher NPK concentration, presence of auxin and gibberellins that enhances plant growth and reduced the growth of pathogens. Earthworm along with aerobic microorganisms helps to stabilize nutrients during vermicomposting process from waste biomasses and reduce the risk of environmental pollution. Vermicomposting is a process that involves Physico-chemical and biological transformations of solid biomasses in the gut of earthworms (Atiyeh *et al*, 2001). The earthworm aids the fragmentation of organic substances, thereby increasing the surface area available for microbial colonization. Earthworms act as mechanical blenders that break the organic matter into smaller particle and extended the surface area for better microbial activity. Thus the earthworm makes it much more favorable for microbial activity and further decomposition (Dominguez *et al*., 1997). It has been estimated that about 1800 species of earthworm distributed worldwide. But the most commonly used is *Eiseniafetida,* commonly known as the compost worm, manure worm, red worm, and red wiggler. Worms can digest several times than their own weight each day and large quantities of excreta are passed out through an average population of earthworm. Amount of substrate consumed depends upon substrate properties and environmental conditions. Vermicompost is the product of the composting process using various species of worms to create a mixture of decomposing vegetable or food waste, livestock manure and bedding materials as vermicast. Vermicast, also called worm castings, worm humus, worm manure, worm poop or worm feces which is the end-product of the breakdown of organic matter by earthworms. These castings have been shown to contain reduced levels of contaminants and a higher saturation of nutrients than the organic materials before vermicomposting. In some cases, organic residues require pretreatment before being vermicomposted as they may contain substances that are toxic for earthworms, such as acidic compounds (Nair *et al*., 2006). Vermicompost contains most nutrients in plant available form such as nitrates, phosphates and exchangeable calcium and soluble potassium (Edwards *et al*., 1998). It promotes better root growth and nutrient absorption. It improves nutrient status of soil both macro and micro-nutrients. It is the potential way of recycling waste to valuable fertilizer. Some small scale industry can be developed in our country in rural areas that may help to create some employment opportunities. Compost can also provide a steady supply of nutrients to growing plants and increase the soil ability to retain essential minerals (Roy *et al.,* 2013; Stevenson, 1994). It improves the fertility and water holding capacity of the soil. It also enriches the soil with useful microorganisms which add different enzymes like phosphatases and cellulases to the soil. Vermicompost enhances germination, plant growth and thus overall crop yield (Gajalakshmi and Abbasi, 2004). Therefore, the present study was undertaken with the following objectives:

i. To study the changes in chemical properties over time periods during vermicomposting of different livestock manures.
ii. To know the efficiencies of earthworm activity during decomposition of different livestock manures.

Materials and Methods

The experiment was conducted in two phases where the first phase was the production of vermicompost from different livestock manures and the second phase was the chemical analysis of those vermicomposts. Production of vermicompost was carried out at waste recycling shed of animal farm under the Department of Animal Science and the laboratory analysis of the compost was carried out at laboratory in the Department of Animal Science, Bangladesh Agricultural University, Mymensingh.

Design of experiment

To fulfill the objectives of this experiment, vermicomposting with cow dung (T_I), horse manure (T_2), and goat manure (T_3) were conducted with three replications to minimize the experimental errors. A total of nine vermicomposting pit were used in this experiment. The parameters studied were DM, OM, ash, TN, CF and pH at different day intervals. The vermicompost samples from each pit were collected at 0, 15, 30 and 45 days for proximate analysis.

Collection of raw materials and preparation of vermicomposting pit

The manure was collected from the animal farm, BAU. Red worm for vermicomposting was collected and stored in appropriate breeding condition previously before setting the compost. Nine earthen pots, locally called chari were used to prepare vermicompost. Three treatments (T_1: cow dung, T_2: horse manure and T_3: goat manure) were replicated three times each and a total of nine vermicomposting pit were used. Approximately 25 KG manure was collected for each pit to conduct the experiment. Clean, dry pits were used in this experiment and no bulking materials were used.

Vermicomposting process

First of all, vermicomposting pits were prepared and then different types of manures were added at different pits (chari) and placed about 0.5 meter distance from each. Then, approximately 100g earthworms were added on each chari (pit). Vermicomposting worms or red worms were bought from one commercial farm, as this was not available in the local market. Approximately 70-75% moisture was maintained initially in the manure, since it helps the worms for easy movement. Moisture level was checked in the vermicomposting pit on a regular basis and kept the pits on a dry place. The experiment was conducted under a shed to avoid direct sunlight and rain.

Collection of sample for laboratory analysis

Samples were prepared from raw materials on the 1st day of experiment. Second collections were after 15^{th} days and the third sample collections were on the 30th day of vermicomposting process. The final samples were collected on the 45th day of composting process. The collected samples were stored in a refrigerator in Animal science laboratory for further analysis. The DM, OM, Ash, TN, CF and pH were analyzed after each collection of all replicated samples. Chemical compositions of raw manures were also analyzed just before starting the experiment (Table 1).

Table 1. Chemical composition of raw manures.

Parameters	Treatments (Mean ±SD)		
	T_1	T_2	T_3
DM	24.10±0.85	25.30±0.49	24.61±1.12
OM	21.50±0.43	20.50±0.34	21.54±0.57
Ash	2.91±0.05	2.42±0.08	2.71±0.08
TN	1.09±0.01	1.07±0.01	1.08±0.06
CF	12.48±0.08	14.06±0.09	12.34±0.26
PH	8.16±0.13	7.59±0.26	9.54±0.22

T_1= Composition of cattle manure, T_2 = Composition of horse manure, T_3= Composition of goat manure, DM = Dry matter, OM = Organic matter, TN = Total nitrogen, CF = Crude fiber, C/N = Carbon nitrogen ratio.

Results and Discussion

Proximate components of cattle manure, horse manure and goat manure vermicompost were estimated in this experiment to know the changing pattern of DM, OM, Ash, TN, CF and pH at different day intervals. Organic matter degradation and other changes occurred by red worms at different treatments as well as different day intervals are discussed in this chapter.

DM changing pattern during vermicomposting period

Initial DM was higher in horse manure (T_2) compared to others (T_1 and T_3). In all three treatments of vermicomposting, DM content gradually increases with the increasing of time (Table 2). At the end of the experiment, the highest DM content was also in T_2 (horse manure vermicompost) and the lowest DM content was observed in T_1 (cattle manure vermicompost). There was significant ($p<0.01$) difference in DM content among treatments and significant ($p<0.01$) difference in DM changes among day intervals over 45 days period. Furthermore, the alteration of DM also vary significantly ($p>0.05$) between treatments and day intervals. These same trends of results were observed by Adely and kits (1983) and Rahman *et al.* (2020a) who reported that dry matter content increased with the increasing of time period. DM increasing is a normal phenomena and it was occurred due to reducing the moisture from the vermicomposting pit at the advancement of the time period.

Table 2. Periodic changes in DM of vermicomposting at different types of manures.

DI	Treatments (Mean ±SD)			Mean ±SD	Level of significance		
	T_1	T_2	T_3		Treat	DI	T*DI
0	24.10± 0.85	25.30± 0.49	24.61± 1.12	24.67± 0.60	**	**	*
15	26.86± 0.28	27.80± 0.51	26.88± 0.24	27.18± 0.54			
30	29.74± 0.55	30.62± 0.42	30.59± 0.60	30.32± 0,50			
45	33.83± 0.79	35.10± 0.43	35.70± 0.32	34.88± 0.95			

** means significant at 1% level of probability, * means significant at 5% level of probability, T_1= Vermicomposting from cattle manure, T_2 = Vermicomposting from horse manure, T_3= Vermicomposting from goat manure, Treat= Treatment, DI= Days interval, T*DI= Interaction between treatment and days interval.

Table 3. Periodic change in OM during vermicomposting of different types of manures.

DI	Treatments (Mean ± SD)			Mean ± SD	Level of significance		
	T_1	T_2	T_3		Treat	DI	T*DI
0	21.50[a] ± 0.43	20.50[b] ± 0.34	21.54[a] ± 0.57	21.18 ± 0.44	**	**	*
15	18.24[a] ± 0.33	17.52[b] ± 0.33	18.64[a] ± 0.38	18.13 ± 0.57			
30	14.71[b] ± 0.36	14.44[b] ± 0.48	15.02[a] ± 0.80	14.72 ± 0.29			
45	11.8[b] ± 0.80	11.91[b] ± 0.62	10.64[a] ± 0.68	11.45 ± 0.70			

Figures followed by same letter (s) within a row do not differ statistically, ** means significant at 1% level of probability, * means significant at 5% level of probability, T_1= Vermicomposting from cattle manure, T_2 = Vermicomposting from horse manure, T_3= Vermicomposting from goat manure, Treat= Treatment, DI= Days interval, T*DI= Interaction between treatment and days interval.

OM changing pattern during vermicomposting period

Initial OM was higher in goat manure (T_3) compared to cattle manure (T_1) and goat manure (T_2). There was a reducing trend of OM in all treatments during the whole vermicomposting period and the lowest OM was also found in T_3 (Table 3). It was found from the experiment that OM degradation was 45.12, 41.90 and 50.60% at T_1, T_2 and T_3 treatments, respectively. OM degradation is an indicator of efficiency of earthworm that how efficiently they could digest the manure OM. It could be said from the experiment that red worm can efficiently digest the goat manure compared to cattle and horse manure. The study also found a gradual decrease in OM content in all of the treatments of vermicomposting over 45 days period of composting. There was significant difference in OM degradation among treatments and also in the day intervals over 45 day's period. Also, the changing pattern of OM was vary significantly between treatments and day intervals ($p>0.05$). The data revealed that total organic matter decreased with days of vermicomposting. Organic matter content decreases at the end of the vermicomposting because of the organic carbon consumption by earthworm, the transformation in CO_2 by respiratory activity and formation of humic fraction which gives place to the mature vermicompost, i.e., oxidation of carbon to carbon dioxide during decomposition (Pattnaik and Reddy, 2009). Punde and Ganorkar (2012), Mistry *et al.* (2015) and Tripathi and Bhardwaj (2004) reported that significant decline in OM content in vermicomposting process. Rahman *et al.* (2020a) stated that organic matter content of cattle manure significantly reduced during vermicomposting.

Ash changing pattern during vermicomposting period

The study found a little increase in ash content in all of the treatments of vermicomposting over 45 days period of composting (Table 4). Gradual increase of ash in different treatments might be due to increase of dry matter on the advancement of time period. The highest ash content was observed in T_3 (goat manure) after 45 days of composting compared to other two treatments. But, the increasing pattern was not significant statistically among the treatments, day's interval or interaction between them. The similar result was found by Jacob *et al.* (1997) who observed that the ash content was increased on the advancement composting period. Changing pattern of ash content was not significant statistically during vermicomposting of cattle manure, described by Rahman *et al*. (2020a).

Table 4. Periodic change in Ash during vermicomposting of different types of manures.

DI	Treatments (Mean ± SD)			Mean	Level of significance		
	T_1	T_2	T_3		Treat	DI	T*DI
0	2.91±0.05	2.42±0.08	2.71±0.08	2.89±0.07	NS	NS	NS
15	2.93±0.03	2.58±0.03	2.82±0.05	2.78±0.18			
30	2.96±0.02	2.64±0.04	2.93±0.04	2.84±0.18			
45	2.97±0.02	2.74±0.05	2.98±0.05	2.89±0.14			

T_1= Vermicomposting from cattle manure, T_2 = Vermicomposting from horse manure, T_3= Vermicomposting from goat manure, NS = Not significant, Treat= Treatment, DI= Days interval, T*DI= Interaction between treatment and days interval.

TN changing pattern during vermicomposting period

It was found a little change in TN content at different treatments during 45 days of vermicomposting (Table 5). TN content gradually increases with the increase of time, but there were no significant differences in TN changes among treatments, day's interval or interaction between treatments and day's interval. The highest TN was found in T_1, but the increasing pattern was similar both in T_1 and T_2. A little increase of total N in vermicompost was probably due to mineralization of the organic matter containing proteins (Bansal and Kapoor, 2000; Kaushik and Garg, 2003). Earthworms can boost the nitrogen levels of the substrate during digestion in their gut adding their nitrogenous excretory products, mucus, body fluid, enzymes, and even through the decaying dead tissues of worms in vermicomposting subsystem (Suthar, 2007). Similar result also found by Krishan *et al*. (2014), Tripathi and Bhardwaj (2004) and Sitaramlaxmi *et al*. (2013). Rahman *et al*. (2020a) stated that TN content slightly increased during vermicomposting of cattle manure. Yadav and Garg (2013) also found slightly higher nitrogen, phosphorous, and potassium contents in the final vermicompost compared to raw manure.

Table 5. Periodic change in TN during vermicomposting of different types of manures.

DI	Treatments (Mean ± SD)			Mean ± SD	Level of significance		
	T_1	T_2	T_3		Treat	DI	T*DI
0	1.09±0.01	1.07±0.01	1.08±0.06	1.08±0.03	NS	NS	NS
15	1.09±0.04	1.08±0.03	1.08±0.02	1.08±0.04			
30	1.10±0.02	1.08±0.03	1.11±0.02	1.12±0.02			
45	1.17±0.01	1.15±0.03	1.11±0.03	1.16±0.02			

T_1= Vermicomposting from cattle manure, T_2 = Vermicomposting from horse manure, T_3= Vermicomposting from goat manure, NS = Not significant, Treat= Treatment, DI= Days interval, T*DI= Interaction between treatment and days interval.

CF changing pattern during vermicomposting period

Initial CF contents were 12.48, 14.06 and 12.96% in T_1, T_2 and T_3 respectively, and then a gradual decrease was found in all 3 treatments during vermicomposting (Table 6). A much lower CF was found in all treatments after 45 days of vermicomposting. There was significant difference in CF alteration among treatments, days interval and the interaction of treatment and days interval (p<0.01). It was found that 82, 66 and 81% CF were degraded during 45 days of vermicomposting period from T_1, T_2 and T_3, respectively. The result was due to the worm's subsequent ingestion and digestion of fiber through its digestive system during vermicomposting. Garg *et al.* (2008) stated that the fibrous and other organic substances were digested by the digestive juice available in the earthworm's gut and grinding effect of its gizzard. Formation of the caste or poop is occurred through the muscular movement of earthworm. The result found that CF degradation rate is faster in cattle manure (82%) compared to goat manure (81%) and horse manure (66%). A clear decreasing trend in CF at all treatments indicated that earth worms are very efficient in CF decomposition or digestion during vermicomposting period.

Table 6. Periodic change in CF during vermicomposting of different types of manures.

DI	Treatments (Mean ± SD)			Mean ± SD	Level of significance		
	T_1	T_2	T_3		Treat	DI	T*DI
0	12.48±0.08	14.06±0.09	12.34±0.26	12.96±0.95	**	**	**
15	9.37±0.05	10.47±0.12	9.55±0.28	9.80±0.59			
30	6.07±0.12	7.71±0.12	6.44±0.29	6.74±0.86			
45	2.21±0.05	4.78±0.04	2.40±0.06	3.13±1.43			

** means significant at 1% level of probability, T_1= Vermicomposting from cattle manure, T_2 = Vermicomposting from horse manure, T_3= Vermicomposting from goat manure, NS = Not significant, Treat= Treatment, DI= Days interval, T*DI= Interaction between treatment and days interval.

pH changing pattern during vermicomposting period

An alkaline pH was found in all types of manures throughout the whole experimental period (Table 7). On the advancement of the time period, a little change occurred in pH but those changes were not followed a trend although the changes differed significantly (P<0.05). The pH was gradually increased up to 30 days in T_1 and T_2, and 15 days in T_3 and then stared to reduce. The highest pH was found at 15^{th} day in T_3 (9.63) and finally it was 9.5. The reduction in pH in the final vermicompost might be due to the production of CO_2 and organic acids during the process of bioconversion of different substrates in the beds (Haimi and Huhta, 1986). Nath *et al.* (2009) also reported that Vermicomposting results in significant decreased in pH, total organic carbon, electrical conductivity and C/N ratio.

Table 7. Periodic change in pH of vermicomposting of different types of manures.

DI	Treatments (Mean ± SD)			Mean	Level of significance		
	T_1	T_2	T_3	± SD	Treat	DI	T*DI
0	8.16± 0.13	7.59± 0.26	9.54± 0.22	8.43± 0.20	*	*	NS
15	8.51± 0.38	8.67± 0.15	9.63± 0.21	8.9± 0.24			
30	9.19± 0.23	9.22± 0.16	9.54± 0.11	8.9± 0.16			
45	8.84± 0.25	8.45± 0.12	9.50± 0.17	9.3± 0.18			

*means significant at 5% level of probability, T_1= Vermicomposting from cattle manure, T_2 = Vermicomposting from horse manure, T_3= Vermicomposting from goat manure, NS = Not significant, Treat= Treatment, DI= Days interval, T*DI= Interaction between treatment and days interval.

Conclusion

The present study was carried out to see the effect of manure types on the production and quality of vermicompost. It was found that the DM, TN and ash content were increased in all 3 treatments with the advancement of the vermicomposting period. Subsequently, OM and CF were gradually decreased at different treatments, but the trend of decreasing or degradations were higher in T_1 and T_3. Moreover, a much higher OM degradation was occurred in T_3 compared to T_2. Therefore, it may be concluded that the quality of vermicompost produced from goat manure was better due to faster OM and CF degradation.

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