Original Research Article

Feasibility and product maturity of compost developed from poultry waste in temperate agroclimate of Kashmir region.

ABSTRACT

Present work was carried out in the Department of LPM, FVSc and AH (SKUAST- Kashmir) to assess the feasibility and compost maturity in terms of temperature and bio-mineral (Nitrogen, Phosphorus and Potassium) changes due to composting of poultry waste under the temperate agro-climatic conditions of Kashmir Valley. Poultry waste in the form of poultry carcass (including feathers) and litter manure was used for this study. Four treatment groups with four replicates each were formulated as: $G_{1:}$ Poultry carcass; litter manure, G_2: Poultry carcass; litter manure; Paddy straw, G_3: Poultry carcass; litter manure; effective microbes (*Lactobacillus plantarum, Lactobacillus casei, Saccharomyces cerevisiae and Rhodopseudomonas palustris*) and $G_{4:}$ Poultry carcass; litter manure; Paddy straw; effective microbes. During the primary stage of composting the group G_4 had attained a significantly (P<0.05) highest peak temperature (^{0}C) of 59.0±5.04 and 59.50±5.04 respectively during winter and summer seasons. Significantly ($P \leq 0.05$) highest nitrogen content of 24.7 g/Kg was observed in group G_4 at the end of secondary stage during summer season. The phosphorus content in end product of composting was significantly ($P \leq 0.05$) highest (1.0 g/Kg) in group G_4 during summer season. Similarly significantly ($P \leq 0.05$) highest K content of 10.23 g/Kg was observed in group G_4 during summer season. It was concluded that the addition of paddy straw and effective microbes assistant the composting process and yield better bio-mineral values and higher temperature gain.

Key words: Composting, dead birds, poultry litter, bio-minerals, seasons.

INTRODUCTION

Over the last decade poultry industry in India has been growing at an enormous pace is being considered now as the fastest growing sectors of livestock with the latest annual growth rate of 16.81 % (Anon. 2021). This sector is involved in high levels of concentrated inputs because of intensive production system and hence generates volumes of waste in the form of dead birds; litter manure (including saw dust and droppings). when such waste is kept as such for a long time it will be associated with air, water and soil pollution (Benali and Kudra, 2002). Poultry manure when excreted starts producing ammonia gas which causes ill effects on the performance of live birds and the working staff associated with it (Pierson *et al*., 2001; Zhang and Lau, 2007; Amon *et al*., 2006). At present in Kashmir Valley poultry sector has also many issues like social, environmental and economic associated with it and are currently faced by the farmers. Thus the waste generated needs quick and prompt removal and scientific disposal from the farm premises to avoid different menaces like smell, flies etc (Bolan, 2010). By selecting a suitable waste disposal method will minimize the different problems associated with the traditional methods (Baba *et al.,* 2018 and Sheikh et al, 2018).

Composting is an eco-friendly technology, low cost driven, effective and easily practicable method of disposing and converting poultry waste like carcass and litter into a valuable final product in the form of organic bio-manure (Hutchinson and Seekins, 2008). Composting needs a moisture content of 50-60 % and temperature in the rage of 30-40^{o}C in the waste pile. When composting is done properly it shrinks the volume of the waste and destroys pathogens (Keener *et al*., 2000) effectively. The final product of composting resembles humus and is rich source of different bio-minerals like nitrogen, phosphorus and potassium (Sorathiya et al., 2014).

MATERIALS AND METHODS

The study was carried out in the Division of Livestock Production and Management, Faculty of Veterinary Sciences and Animal Husbandry Shuhama Ganderbal.

Composting process

Poultry farm waste (dead birds and poultry litter) was utilized to study the composting in two separate trails during summer and winter seasons. Composting was done in wooden bins (Mini composter) with a specification of 3 feet length x 3 feet width x 3 feet height (Image 1.) designed as per the method of Donald *et al.*, (1996). The floor of the compost bin was made impervious to prevent seepage of leachate and subsequent moisture and nutrient loss. The sidewalls of the compost bins were made up of country wooden planks of 4 to 5 inches wide and one inch thick. An air space of 1-2 inch was provided between wooden planks to aid sufficient aeration to the compost piles (Plate: 1). Dead birds for the present study were collected from local poultry farms and stored at – 5^{o}C till sufficient carcasses were made available to fill all the compost bins in a single day. Similarly, poultry litter was collected from poultry farm of LPM Division.

Paddy Straw

Paddy straw (*Oryza sativa*) was used as a carbonaceous as well as bulking agent wherever it was required. Paddy straw was purchased from farmer's field and stored in advance.

Compost Recipe

The compost recipe was prepared based on the C: N ratio of different ingredient used. The C:N ratio and moisture content of the compost mixture are the most important criteria for effective composting, heat generation and subsequent pathogen reduction. In this experiment, the criteria for C:N and moisture content was fixed as 20-25: 1 and 50-60 per cent respectively. Based on this the compost recipe, was calculated as per the formula recommended by the USDA-NRCS (2000).

C =Xca + Ycb + Zcc

N = XNa + YNb + ZNc

Where,

C: Total carbon

N: Total nitrogen

Xc: Carbon content of dead bird

Yc: Carbon content of manure substrate

Zc: Carbon content of carbonaceous source

XN: Nitrogen content of dead bird

YN: Nitrogen content of manure substrate

ZN: Nitrogen content of carbonaceous source

(a, b and c are the quantity of materials required which is unknown and to be calculated).

The total carbon and total nitrogen content of each ingredient viz., dead bird, poultry litter and paddy straw was analyzed individually and quantity of ingredient required for each layer was calculated and finalized. The moisture content of each ingredient was determined (AOAC, 2005) and the total ingredient mixture moisture content was stabilized to 50-60 per cent by addition of water while layering of poultry litter.

Compost Groups

Four compost recipe groups (with four replicates in each group) were formulated with addition of effective microbial culture (*Lactobacillus plantarum, Lactobacillus casei, Saccharomyces cerevisiae and Rhodopseudomonas palustris*) in two groups (Table. 1). Microbial culture was used in the liquid form and sprinkled on the waste material.

Compost Temperature

Temperature changes during the composting process is the indication of microbial activity and hence it was recorded daily at 0900 hours at different locations (for appropriate temperature). Temperature of the compost pile was recorded at two levels viz., 15 cm and 30 cm from the bottom representing middle and bottom of the composting bin. In all the locations the temperature probe was inserted straight to reach a depth of at least one foot.

Major plant nutrients analysis

The nitrogen, phosphorus and potassium content at initial stage (after thoroughly mixing), secondary stage (turning time) and final stage of composting were recorded. The turning of the compost material was done at the end of primary stage. The nitrogen, phosphorus and potassium content were analyzed as per the Jackson (1973).

Statistical analysis

The data recorded was analyzed as per the standard methods of Snedecor and Cochran (1994). In this regard SPSS software was used for performing the two way analysis of variance test (ANOVA) by comparing the different means.

Results and Discussion:

The maturity of final product of composting determines its shelf-life and applicability. Mature compost shows highest degree of organic matter decomposition and steady temperature change. Mineralization of the waste in terms of nitrogen, phosphorus and potassium content (bio-minerals) of the final product is another parameter for assess the stability and maturity of final product.

Peak Temperature

The temperature change in composting process is one of the main parameters and its rise and fall is directly proportional to the microbial activity. Attaining of higher temperatures indicates a fast decomposition and rapid pathogen elimination from the waste material (Sivakumar *et al.*, 2007). The results of present study indicates that the season had no significant ($P<0.05$) effect on peak temperatures during primary (45 days) and secondary stage (90 days) of composting. During primary stage of composting the peak temperature varied between 49.65 ºC (G_3) to 59.0 ºC (G_4)

during winter and 53.85 ºC (G_2) to 65.5 ºC (G_4) during summer season (Table. 2). However during secondary stage the peak temperatures were lowered and ranged between 36.25 ºC (G_4) and 45.95 ºC (G_1) in winter and 40.25 ºC (G_4) and 47.95 ºC (G_1) during summer season. The results corroborate with the reports of a number workers (Stentiford, 1996; Hassen *et al.*, 2001 and Sivakumar *et al.*, 2007) who observed that the temperature of compost started declining which reached the level below 35 to 40 ºC which is recommended level for maximizing microbial diversity. However Murphy (1988) while composting dead birds with broiler litter recorded a higher temperature of 74 ºC. Similar comparative results were observed by Lawson and Keeling (1999) and Blake *et al*. (1996) with peak temperatures of 60-70 ºC in temperate conditions. The results were also in agreement with Cekmecelloglu *et al*. (2004) who studied that the peak temperature during summer season was at least 4 ºC higher than winter season. During primary stage of composting the temperature was higher in G_4 (paddy straw and effective microbes) when compared to other treatments which was due to more porosity of paddy straw and hence more aeration and oxygenation for microorganism to degrade the material at a faster rate, thus higher peak temperatures were obtained. Similar results were recorded by Harper *et al*. (2001) and Mukhtar *et al*. (2004). Moreover due to the presence of effective microbes in this treatment group could have led to increase in the temperatures of compost due to more microbial activity. In the present study there was significant ($P<0.05$) in the temperature of compost during different seasons with highest peak temperature during summer season. Similar results were also observed earlier by Sivakumar *et al.* (2008) under tropical conditions.

Nitrogen

Composting reduces the nitrogen loss by NH_3 volatilization and conserves N by favoring its mineralization. At the end of primary stage group G_4 (with paddy straw and effective microbes) recorded highest N content of 10.9 and 12.9 g/Kg during winter and summer seasons respectively (Table 3). Similarly at the end of secondary stage G_4 also recorded the highest nitrogen content of

23.9 and 24.7 per cent during winter and summer seasons respectively. No significant ($P<0.05$) difference in the nitrogen content was observed between group groups G_2, G_3 and G_4 at the end of primary stage of composting during winter and summer seasons. The reported N value for finished dead bird compost ranged between 25.7 to 40.8 g/Kg (Donald *et al*., 1990; Barton and Benz 1990; Murphy and Carr, 1991 and Cummins *et al*., 1993), which were higher than the observed value. The compost mix with dead bird and poultry litter recorded higher N content in G_4 and was due to the addition of carbon sources (paddy straw) and effective microbial culture (Vuorinen and Saharinen, 1997 and Sakthivadivu *et al.,* 2015). It was observed that the overall results of nitrogen content increased from primary to secondary stage of composting. The results are corroborate with the earlier reports of Tiquia *et al.* (1998) and Huang *et al.* (2004) who observed similar results in spent litter swine manure and saw dust. On the other hand Bharathy *et al.* (2012) recorded significantly ($P<0.05$) lower total nitrogen content in the finished product of compost of broiler slaughter waste.

Phosphorus

At the end of primary stage group G_4 (with paddy straw and effective microbes) recorded highest P content of 0.48 during winter and 0.46 in G_3 (with effective microbes only) during summer season. The P content at the end of secondary stage varied between 0.67(G_3) and 0.92 (G_4) g/kg during winter and 0.76 (G_1) and 1.0 (G_4) g/Kg during summer season (Table. 4). Although the P content during summer season was slightly higher but statistically season was having no significant effect on P content of the end product. However within the different groups the G_4 differed significantly with the other group groups. The observed P contents were higher in the reported values of 8.1 to 14.5 g/kg by Koon *et al*. (1992), 15.38 g/kg Tiquia and Tam (2002) and 7.23 to 10.73 g/kg by Parkinson *et al*. (2004) in cattle manure compost without dead birds. Similarly higher P content was reported in poultry manure compost without dead birds by Rodriguez *et al*. (2003) and Prasanthrajan (2004).

Potassium

At the end of primary stage, group G_1 (control) recorded highest K content of 3.50 g/kg during winter and G_4 (containing paddy straw and effective microbes) 4.02 g/Kg during summer season. At the end of secondary stage, potassium content ranged between 8.4 (G_1) and 9.43 (G_4) g/Kg during winter and 8.56 (G_1) and 10.23 (G_4) g/Kg during summer season (Table. 5). Higher K content was noticed in G_4 group during both the seasons. The group with paddy straw and effective microbes recorded K content ranged between 9.43 and 10.23 g/kg which was comparable with the reported value of 10.8 g/kg in cattle manure compost (Eghball *et al*., 1997) but higher results of 20.7 g/kg by Wong *et al*. (1999) and still higher values (68.8 g/kg) by Wang *et al*. (2004) were reported in livestock manure compost.

Conclusion

Addition of effective microbes and paddy straw (carboneous source and bulking agent) was instrumental in securing a stable end product in terms of attaining a higher peak compost temperature during both the seasons. Consequently the effective microbes and paddy straw also enhanced the composting process in terms of mineralization of nitrogen, phosphorus and potassium bio-manure content.

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Table: 1. Different Groups Combinations for Composting

Groups	Description
Group 1	Dead birds + Poultry litter (Control)
Group 2	Dead birds + Poultry litter + Paddy Straw
Group 3	Dead birds + Poultry litter + Effective Microbes
Group 4	Dead birds + Poultry litter +Paddy straw + Effective Microbes

Table. 2. Peak temperature attained (^{o}C) during different stages and seasons of composting (Mean±SE).

Group	**Primary stage**			**Secondary stage**		
	Winter	**Summer**	**Overall**	**Winter**	**Summer**	**Overall**
G_1	^{B}52.20±6.75	^{A}54.20±6.75	**53.20± 1.41**	^{C}45.95 ±5.71	^{B}47.95 ±5.71	**46.95 ±1.41**
G_2 (Paddy Straw)	^{BC}56.85 ±5.57	^{A}53.85 ±5.57	**55.35 ±2.12**	^{AB}39.25 ±2.67 ^{a}	^{B}45.25 ±2.67^{b}	**42.25 ±4.24**
G_3 (Effective Microbes)	^{A}49.65 ±7.27^{a}	^{AB}55.50±7.27^{b}	**52.575 ±4.13**	^{B}41.05 ±1.54	^{AB}44.5 ±1.54	**42.77 ±2.43**
G_4 (Paddy Straw +Effective Microbes)	^{C}59.0±5.04	^{B}59.50±5.04	**59.25 ±1.35**	^{A}36.25 ±1.29	^{A}40.25 ±1.29	**38.25± 2.82**

Figures with different small superscripts row wise and capital superscripts column wise differ significantly (P<0.05)

Table. 3. Nitrogen content (g/kg) during different stages and seasons of composting.

Group	Winter			Summer		
	Initial	Primary stage	Secondary stage	Initial	Primary stage	Secondary stage
G_1	3.40 ± 0.12^{a}	$^{A}8.40 \pm 0.70^{b}$	$^{A}18.60 \pm 0.70^{c}$	3.25 ± 0.03^{a}	$^{B}9.50 \pm 0.50^{b}$	$^{A}18.40 \pm 0.90^{c}$
G_2 (Paddy Straw)	3.60 ± 0.02^{a}	$^{A}7.30 \pm 0.50^{b}$	$^{A}16.30 \pm 0.60^{c}$	3.35 ± 0.02^{a}	$^{A}7.60 \pm 0.80^{b}$	$^{A}15.50 \pm 0.80^{c}$
G_3 (Effective Microbes)	3.50 ± 0.10^{a}	$^{A}8.10 \pm 0.30^{b}$	$^{A}15.00 \pm 0.5^{c}$	3.60 ± 0.11^{a}	$^{AB}7.90 \pm 0.20^{b}$	$^{A}16.50 \pm 0.40^{c}$
G_4 (Paddy Straw + Effective Microbes)	3.45 ± 0.22^{a}	$^{B}10.90 \pm 0.3^{b}$	$^{B}23.90 \pm 0.20^{c}$	3.55 ± 0.03^{a}	$^{C}12.90 \pm 0.40^{b}$	$^{B}24.70 \pm 0.31^{c}$

Figures with different small superscripts column wise and capital superscripts row wise differ significantly ($P<0.05$).

Table. 4. Phosphorus content (g/kg) at different stages and seasons of composting.

Group	Winter			Summer		
	Initial	Primary stage	Secondary stage	Initial	Primary stage	Secondary stage
G_1	0.21 ± 0.01^{a}	$^{B}0.47 \pm 0.01^{b}$	$^{B}0.72 \pm 0.01^{c}$	0.25 ± 0.02^{a}	$^{A}0.33 \pm 0.02^{b}$	$^{A}0.76 \pm 0.03^{c}$
G_2 (Paddy Straw)	0.21 ± 0.01^{a}	$^{B}0.45 \pm 0.02^{b}$	$^{B}0.75 \pm 0.02^{c}$	0.24 ± 0.01^{a}	$^{A}0.39 \pm 0.01^{b}$	$^{A}0.86 \pm 0.04^{c}$
G_3 (Effective Microbes)	0.24 ± 0.02^{a}	$^{A}0.37 \pm 0.03^{b}$	$^{A}0.67 \pm 0.01^{c}$	0.24 ± 0.03^{a}	$^{B}0.46 \pm 0.02^{b}$	$^{A}0.80 \pm 0.05^{c}$
G_4 (Paddy Straw + Effective Microbes)	0.23 ± 0.02^{a}	$^{B}0.48 \pm 0.01^{b}$	$^{C}0.92 \pm 0.11^{c}$	0.25 ± 0.02^{a}	$^{AB}0.41 \pm 0.03^{b}$	$^{B}1.00 \pm 0.11^{c}$

Figures with different small superscripts column wise and capital superscripts row wise differ significantly ($P<0.05$).

Table 5. Potassium content (g/kg) at different stages and seasons of composting.

Group	Winter			Summer		
	Initial	**Primary stage**	**Secondary stage**	**Initial**	**Primary stage**	**Secondary stage**
G_1	2.10±0.21^{a}	3.50±0.03^{b}	8.40±0.05^{c}	2.20±0.21^{a}	^{A}2.86±0.03^{a}	^{A}8.56±0.08^{b}
G_2 (Paddy Straw)	2.20±0.12^{a}	2.99±0.01^{a}	8.83±0.35^{b}	2.30±0.11^{a}	^{AB}3.02±0.06^{a}	^{AB}9.50±0.76^{b}
G_3 (Effective Microbes)	2.00±0.13^{a}	3.01±0.11^{a}	8.86±0.20^{b}	2.25±0.06^{a}	^{AB}3.11±0.06^{a}	^{A}8.96±0.14^{b}
G_4 (Paddy Straw + Effective Microbes)	2.25±0.05^{a}	3.33±0.10^{a}	9.43±0.54^{b}	2.25±0.03^{a}	^{B}4.02±0.10^{b}	^{B}10.23±0.96^{c}

Figures with different small superscripts column wise and capital superscripts row wise differ significantly ($P<0.05$).

Image 1. Wooden boxes used for composting