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Physical changes during poultry waste composting with coirpith waste and sugarcane top

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Abstract
This study focused on composting dead birds using cage layer manure (CLM) combined with low-cost carbonaceous materials such as coir pith waste and sugarcane tops, and assessing key physical parameters. Mini compost bins (4×4×4 ft) were constructed using wooden planks and loaded with sequential layers of CLM, dead birds and carbon materials. Monitored parameters included temperature profile, peak temperature, odour, fly nuisance, weight and volume reduction. Peak temperatures were reached on the 8th day (56.4 °C) for the coir pith group and the 6th day (59.3 °C) for the sugarcane top group. Thermophilic conditions (> 55 °C) persisted for 12 days in the coir pith group and 23 days in the sugarcane top group. The composting process was completed within 43-53.5 days and remained free from obnoxious odour and fly menace, indicating good hygiene. Coir pith retained more moisture, while sugarcane tops showed higher weight reduction. Overall, the method was effective, eco-friendly and ensured bio-safety through sustained thermophilic conditions.

Keywords: Dead birds, composting, physical changes, thermophilic conditions

Introduction
Larger production units with higher bird density generate large quantities of waste, which includes a mixture of excreta (manure), bedding material or litter, waste feed, dead birds, broken eggs and feathers. Safe disposal and utilization of such waste is essential to ensure bio-safety. Among the farm waste, handling of dead bird is a major problem to the poultry growers.
An alternative and economically feasible method of disposal of poultry waste is composting. Composting is a natural biological decomposition process that takes place under aerobic and thermophilic conditions (Mukhtar *et al.*, 2004) [12]. To augment the composting process, addition of carbon source is essential (Rynk *et al.*, 1992) [15]. Poultry litter (McCaskey, 1994) [10], sawdust (Keener and Elwell, 2003) [7], sorghum hay waste and paddy straw (Sivakumar *et al.*, 2007) [17] are reported as useful carbon sources in dead bird composting process. But cost and availability may be hindrances in wide spread acceptability of composting method.
In this line, an attempt is made composting of dead birds with cage layer manure (CLM) and low cost carbonaceous materials like coir pith waste and sugarcane top was carried out to study the feasibility of composting.

Materials and Methods
The dead birds composting experiment was carried out at the Livestock Farm, Department of Livestock Production and Management, Veterinary college and Research Institute, Namakkal, Tamil Nadu, India.

Study area and climate
Namakkal is situated in northwestern zone of Tamil Nadu, located at 11˚09'42.1"N latitude and 78˚09'39.7"E longitude at an altitude of 192 meters above mean sea level (MSL). The maximum temperature ranges from 31 to 39˚C and minimum temperature ranges from 13 to 24 °C with a mean annual rainfall of 908.5±6.19 mm.

Mini composter

A mini compost bin of 4 feet x 4 feet x 4 feet size was established with country wooden planks. All the four sides of the bin were closed with 4 inch size wooden plank fixed apart with an air space of 2 inch (Donald *et al*., 1996 and Sivakumar *et al*., 2007) [2, 17]. A total of 10 such bins were arranged in two rows inside a tile roofed shed to protect the bins from rain and sun light.

Selection of ingredients and compost treatment

Dead birds and cage layer manure were obtained from commercial poultry farms. The low cost carbon sources like 'coir pith waste' and 'dried sugarcane top' were collected from coir pith industry and local farmer's field, respectively. In this experiment C:N ratio and moisture content were fixed as 20:1 and 50 to 60 per cent, respectively. According to the recipe the compost bins were loaded by sequential layering of cage layer manure, dead birds and carbonaceous materials.

The treatment groups were

- T_1-Dead birds + Cage layer manure + Coir pith waste + water
- T_2-Dead birds + Cage layer manure + Dried sugarcane top + water
- T_3-Cage layer manure + Coir pith waste + water
- T_4-Cage layer manure + Dried sugarcane top + water
- T_5-Cage layer manure (control)

Composting procedure

The base layer was filled up to 6 to 8 inches with cage layer manure for the purpose of absorbing leachate. Coir pith waste or dried sugarcane top was added according to the composting formula then, layer of carcass, manure, carbon source and water were added as per formula, the successive layering of ingredients was then continued up to filling up of compost bin. After filling a final cover was laid with caged layer manure over the top for a thickness of 6 inches. The temperature of the compost was recorded daily at different locations. The temperature dropped below 40 °C, indicative of reduced composting activity. This indicated the end of the primary stage. The compost bins were opened, mixed thoroughly and samples were collected and refilled after addition of sufficient water, which was the start of secondary stage. Samples were again collected at the end of secondary stage indicated by fall in compost temperature below 40 °C.

Sample collection and analysis of samples

Samples (250 g) were collected from six different locations at the end of both the primary and secondary stage and stored in an air-tight polythene bag. The compost temperature was recorded daily at different locations using a dial type analogue compost thermometer (WIKA make; model 'TREND'). A score cord with hedonic scale was designed (8-extremely desirable and 1-extremely undesirable) and carried out odour and fly score analysis. Moisture content of composting samples was determined by drying the sample at 105 °C in the hot air oven for 24 hours (Tiquia and Tam, 2002) [19]. Total weight reduction at the end of the secondary stage was calculated on dry matter basis. Volume and reduction are also recorded at the end of secondary stage.

Statistical analysis

The data thus collected were analyzed statistically as per the methods suggested by Snedecor and Cochran (1996) using SPSS software package.

Results and Discussion

Temperature profile

The increase in the bin temperature facilitates elimination of pathogens (Haug, 1993) [5]. The increase in the compost pile temperature also reflects the degree of microbial degradation of organic waste (Keener *et al*., 2000) [8]. In the present experiment, the treatment bins with dead birds (T_1 and T_2) showed a good heating phase. T_1 attained the peak temperature of 56.4 ºC by the 8th day in the primary stage and by the 6th day after initiation of the second heating phase. Similarly, in T_2 also the peak temperature of 59.3 ºC was attained by the 6th day after commencement of the composting process and during the second heating phase it attained the maximum temperature of 61.8 ºC by the 6th day (Table). The temperature profile was similar to that one reported by Sivakumar *et al*. (2008) [18]. The optimum C:N ratio, moisture and availability of organic matter and N hastened the microbial degradation, which might be the reason for the increase in the bin temperature (Mukhtar *et al*., 2004) [12]. On the other hand, the control bins (T_3, T_4 and T_5) did not exert such a temperature profile, which indicated that the microbial degradation was slow.

Peak temperature

The peak temperature attained in T_1 was 56.4 and 57.9 ºC, respectively, during the primary and secondary stage of composting. Similarly, in T_2 the peak temperature was 59.3 and 61.8 ºC, respectively during primary and secondary stage of composting (Table 1). Such peak temperature was attained by Cummins *et al*. (1994) [1], Vuorinen and Saharinen (1997) [20] and Sivakumar *et al*. (2008) [18]. In control bins (T_3 and T_4) the peak temperature was less than 55 ºC in both the primary and secondary stage of composting. Various reasons are responsible for less heating, like poor microbial degradation, low moisture content (Mukhtar, *et al*., 2004) [12], seasonal effect (Sivakumar, *et al*., 2008) [18], size of bin and improper loading etc., (Senne *et al*., 1994) [16]. In this case, the heating process was impaired in both the control bins (T_3 and T_4) at different stages of composting, which ruled out the reason of improper loading.

Table 1: Mean (±SE) peak temperature (ºC), persistency of thermophilic (above 55 C) temperature (days) and composting period (days)

Treatment	Peak Temperature (ºC)		Persistency of thermophilic (above 55ºC) temperature in days			Composting period in days		
	Primary stage	Secondary stage	Primary stage	Secondary stage	Total composting period	Primary stage	Secondary stage	Total composting period
T_1	56.4	57.9	7.00	5.00	12.00	26.50±3.50	16.50±0.50	43.00±3.00
T_2	59.3	61.8	13.50	9.50	23.00	36.50±3.50	16.00±1.00	53.50±4.50
T_3	51.8	50.1	0.00	0.00	0.00	8.50±1.00	6.00±0.00	14.50±2.50
T_4	50.6	45.3	0.00	0.00	0.00	7.50±0.50	6.50±1.50	14.00±1.00
T_5	55.3	55.5	2.00	2.00	04.00	19.00	14.00	33.00

Persistency of thermophilic (above 55ºC) temperature

The persistency of temperature above 55 ºC for 3 days ensured the maximum pathogen reduction (EPA, 1985). In the present experiment both the treatment bins with dead bird recorded good persistency of thermophilic temperature (12 days for T_1 and 23 days for T_2). McCaskey (1994) [10], Rodriguez et *al*. (2001) [14] and Sivakuamr *et al*. (2008) [18] also reported such a prolonged thermophilic phase in their composting experiment. But the control bins (T_3 and T_4) were not able to maintain the temperature above 55 ºC. The CLM alone (T_5) was able to maintain thermophilic phase for 4 days. The results revealed that there was a poor microbial degradation in T_3 and T_4. The dead bird compost bins (T_1 and T_2) were able to maintain thermophilic temperature for more than 3 days (Table 1) and ensure the bio-safety.

Total composting period

In the present experiment, dead bird composted with coir pith as added carbon source took 43 days to finish, whereas a dead bird composted with dried sugarcane top took 53.5 days to complete its heating phase (Table 1). The reported period of decomposition process ranged between 14 and 127.5 days (Murphy, 1988, Cummins *et al*., 1994, McCaskey, 1994, Lawson and Keeling, 1999, Monnin, 2000 and Sivakumar *et al*., 2008) [13, 1, 10, 9, 11, 18].

The quick decomposition in this experiment (43 and 53.5 days for T_1 and T_2) might be due to seasonal effect, since the work was carried out during November and December (Maximum temperature 30 ºC, minimum temperatures 19 ºC and number of rainy days 7 days). The impact of seasonal effect on composting period was supported by Sivakumar *et al*. (2008) [18], who reported that the composting process was shorter during winter months (61.5 to 73.5 days) than monsoon (84.5 to 91 days) and summer (107 to 127.5 days). Control bins (T_3 and T_4) without dead birds matured within 14.5 days which coincided with the poor thermophilic phase and indicated that microbial decomposition was retarded. Though the composting period of dead bird with coir pith waste and sugarcane top was shorter, in this work the seasonal effect should be studied in detail for year-round applicability of this process.

Odour and fly score

Odour was the most effective and simple indicator of bin condition, either aerobic or anaerobic activity. In this experiment no putrified or obnoxious odour was noticed in treatment mixtures with or without dead birds. It indicated that coir pith and sugarcane top acted as an effective biofilter (Mukhtar *et al*., 2004 and Sivakumar *et al*., 2008) [12]. Next to odour, fly menace is an important problem. In this study, throughout the composting period none of the bins attracted flies, which might be due to high temperature generated during composting (Sivakumar *et al*., 2008) [18]. This composting process was free from obnoxious odour, fly menace and it was eco-friendly.

Moisture

An ideal moisture level of 40 to 65 per cent is essential for the microorganisms to perform their metabolic activities (Rynk *et al*., 1992) [15]. In the present experiment, the initial moisture was adjusted to 60 per cent. At the end of primary stage, the dead bird compost mixture with coir pith and CLM (T_1) recorded 33.38 (43.7 per cent loss) per cent of moisture and its control (T_3) recorded 31.49 per cent (47.2 per cent loss), whereas T_2 (sugarcane top group) recorded 23.07 (61.6 per cent loss) per cent moisture at the end of primary stage and its respective control recorded 27.28 per cent (54.5 per cent loss). Similar trend was noticed in the secondary stage also (Table 2). The results clearly indicated that the coir pith waste retained moisture better than the sugarcane top. The fine particle size of coir pith might be the reason for better moisture holding than sugarcane top.

Table 2: Mean (±SE) moisture content (%) of compost samples

Treatment	T_1	T_2	T_3	T_4	T_5	'F' Value
End of primary stage	$33.38^a±1.19$	$23.07^c±1.21$	$31.49^a±1.20$	$27.28^b±1.39$	$26.09^{bc}±1.22$	10.94**
End of secondary stage	$36.97^a±1.88$	$19.50^d±1.54$	$32.04^{b±}1.68$	$23.09^{cd}±1.53$	$23.44^c±0.30$	23.24 **

Figures with different small letters row wise differ significantly, **-Significant at one per cent level (p<0.01)

Weight and volume reduction

The loss of weight is reflected directly in the rate of decomposition of organic matter. The percentage of weight reduction was higher in T_2 (38.98 per cent) and its control (43.66 per cent) than T_1 (20.26 per cent) and its control T_3 (30.02 per cent). Though there was a difference in weight reduction, except T_1 and T_5 other treatment mixtures did not differ significantly, which showed that coir pith waste and sugarcane top did not differ much in weight reduction (Table 3). A weight reduction within a range of 8.2 and 48.6 per cent was reported during various composting processes (McCaskey, 1994, Henry and White, 1993, Sivakumar *et al*., 2008) [10, 6, 18]. The result revealed that both coir pith waste and sugarcane top are equally good in weight reduction.

Table 3: Mean (±SE) weight reduction (%) and volume reduction (%) of compost bins

Treatment	T_1	T_2	T_3	T_4	T_5	'F' Value
Weight reduction	$20.26^b±3.57$	$38.98^a±0.86$	$30.02^{ab}±2.61$	$43.66^a±2.75$	23.60^b	18.36**
Volume reduction	$18.84^{ab±}1.80$	$24.53^a±4.53$	$10.17^b±1.12$	$10.39^b±0.89$	22.91^a	12.26**

Figures with different small letters row wise differ significantly, **-Significant at one per cent level (p<0.01)

In the case of volume reduction, a clear trend was noticed. Treatment mixtures with dead birds had better volume reduction (T_1-18.84 per cent and T_2-24.53 per cent) than its control groups without dead birds (T_3-10.17 per cent and T_4-10.39 per cent) indicated that both coir pith waste and sugarcane top did not differ significantly in volume reduction (Table 3). Similar levels of volume reduction were noticed in broiler litter compost (Henry and White, 1993) [6] and in dead bird compost (McCaskey, 1994) [10]. Whereas Sivakumar *et al*. (2008) [18] reported a heavy volume reduction of 42.3 to 53.95 per cent of dead birds composted with CLM and straw or hay. From the results, it could be concluded that the volume reduction was mainly due to decomposition of dead birds and not due to the added carbon source.

Conclusions

To conclude that the composting process was free from obnoxious odour, fly menace and persistency of thermophilic temperature ensure the bio-safty.

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Ethics declarations
Not applicable

Conflict of Interest
Not available

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Not available

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