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Maturity of poultry waste fermentation product in terms of different physical and chemical changes

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Abstract
Poultry farm waste in the form of poultry carcass and poultry litter were utilized for this study. Different treatments were formulated with T_1: Poultry carcass + Poultry litter, T_2: Poultry carcass + Poultry litter + *Lactobacillus* @ 1.0 percent T_3: Poultry carcass + Poultry litter + *Lactobacillus* @ 0.5 percent T_4: Poultry carcass + Poultry litter + Yeast @ 1.0 percent T_5: Poultry carcass + Poultry litter + Yeast @ 0.5 percent T_6: Poultry carcass + Poultry litter + *Lactobacillus* @ 1 percent + Yeast @ 0.5 percent T_7: Poultry carcass + Poultry litter + *Lactobacillus* @ 1 percent + Yeast @ 1 percent T_8: Poultry carcass + Poultry litter + *Lactobacillus* @ 0.5 percent + Yeast @ 0.5 percent T_9: Poultry carcass + Poultry litter + *Lactobacillus* @ 0.5 percent + Yeast @ 1 percent. During experimentation significantly (p<0.05) highest moisture content of 58.24 percent was observed in treatment group T_2 during winter season. Significant (p<0.05) highest weight reduction of 7.9 percent was observed in treatment groups T_4 and T_5 during summer season. Similarly significantly (p<0.05) highest volume reduction of 4.70 percent was attained in treatment groups T_7 during summer season. The C:N ratio of 20.25 observed was significantly (p<0.05) lowest in treatment group T_2 during summer season. Significantly (p<0.05) highest total ash content of 46.50 percent was observed in treatment group T_7 during winter season. Significantly highest (p<0.05) nitrogen content of 18.2 g/Kg, were observed respectively in treatment groups T_5 summer season. Highest EC of 4.87±0.33 was observed in T_2 group. Total ash content recorded was highest in T_7 (45.63±0.71). It was concluded that product maturity was attained in the fermentation of poultry waste process in terms of different chemical physical and chemical changes.

Keywords: Poultry waste, fermentation, *Lactobacillus*, yeast, nutrient dynamics, compost maturity

Introduction
Fermentation is a bio-secure method of disposal and utilization of mortalities and farm waste. Lactic acid bacteria and yeast transform sugar into lactic acid, which is a naturally low pH effective preservative agent in an anaerobic process (Baba *et al.,* 2022) [1]. Fermentation is very effective in inactivating pathogenic viruses and bacteria**.** The lactic acid fermentation helps in decontamination of waste with further utilization of the end product as fermented feed for other animals. Thus, the use of fermentation processes for recycling and transformation of wastes may be a good way to ensure the safety of the obtained products and offers a way for further utilization of the disposed end product in future (Vermeiren *et al.,* 2003; Kostrzynska and Bachard, 2006; Leroy *et al.,* 2006) [4, 2, 3]. Waste accumulated at a place when left as such attracts stray dogs, wild birds and flies and thus creates environmental and biosecurity problem. Hence, there is an urgent need to devise a technically sound and economically viable method for disposal and utilization of poultry farm waste (Baba *et al.,* 2017) [5]. Lactic acid fermentation is a metabolic process influenced by various physical and chemical parameters that determine its efficiency, yield, and product quality.

Materials and Methods
Fermentation of the poultry farm waste was carried out in airtight plastic containers during winter and summer trials. Dead birds and poultry litter in 1:1 ratio were fermented in different combinations. Poultry waste was humidified with tap water in the proportion of 1:1 and the pH were adjusted to 6.5 with 50 percent H_2SO_4 solution (Baba *et al.,* 2018) [7]. Nine treatments (with three replicates in each treatment) with different individual as well as

combination levels of culture of *Lactobacillus acidophilus* and Yeast (*Saccharomyces cerevisiae*) was used as shown in Table: 1.

Table 1: Treatment Combinations of Fermentation Experiment

Treatments	Description
Treatment 1	Dead birds + Poultry litter
Treatment 2	Dead birds + Poultry litter + lactobacillus @ 1.0%
Treatment 3	Dead birds + Poultry litter + lactobacillus @ 0.5%
Treatment 4	Dead birds + Poultry litter + Yeast @ 1.0%
Treatment 5	Dead birds + Poultry litter + Yeast @ 0.5%
Treatment 6	Dead birds + Poultry litter + Lactobacillus @ 1% + Yeast @ 0.5%
Treatment 7	Dead birds + Poultry litter + Lactobacillus @ 1% + Yeast @ 1%
Treatment 8	Dead birds + Poultry litter + Lactobacillus @ 0.5% + Yeast @ 0.5%
Treatment 9	Dead birds + Poultry litter + Lactobacillus @ 0.5% + Yeast @ 1%

Different physical parameters (weight reduction, volume reduction and moisture content changes) and Chemical parameters (pH, EC, TDS, N, C, C/N etc) were studied to assess the final product stability and maturity.

Statistical analysis

The data collected was statistically analysed as per the methods suggested by Snedecor and Cochran (1994) [6]. SPSS software was used for comparing the different means using one way ANOVA.

Results and Discussion

Weight reduction

Comparatively Treatment group T_7 (containing *Lactobacillus* @ 1% and Yeast @ 1%) showed more weight reduction in overall fermentation process. The overall lower reduction in weight was because the fermentation process was done in airtight containers and air knobs were loosened for evacuation of air only once in a week. Bosch *et al.* (2015) [13] observed comparable weight loss of 2.2-4.8 percent in the fermentation of organic waste material percent. Scheinemann *et al.* (2015) [17] also observed similar results (2.44 percent weight reduction) in the lactic acid fermentation of sewage sludge or cattle manure.

Volume Reduction

Addition of different levels of *Lactobacillus* and Yeast had in general no significant (p<0.05) effect on volume reduction. However as recorded in the present study treatment group T_7 (containing Lactobacillus @ 1% and Yeast @ 1%) had highest weight reduction. The overall lesser reduction in volume was because the fermentation process was done in airtight containers and air knobs were loosened for evacuation of air only once in a week. Merfield (2012) [16] also recorded lower volume reduction in the fermentation of food waste material.

Moisture Content

The percent moisture content of fermented end product was significantly (p<0.05) variable between 44.86±1.92 (T1) and 56.20±2.54 in T2. It was observed that the moisture content was significantly (p<0.05) reduced due to more environmental temperatures. Similarly the different treatment recipes had a significant (p<0.05) effect on moisture content in almost all the treatments. El-Jalil *et al.* (2008) [8] observed earlier comparable moisture content of around 54.5 percent in lactic acid fermentation of poultry waste manure. However contrary to this, Cai and Pancorbo (1994) [9] observed higher moisture content of 61.4-65.5 percent in poultry farm waste.

Chemical Changes

Total Organic Matter

The overall values of TOM suggested that treatment group T_7 (*Lactobacillus* @ 1% + Yeast @ 1%) produced the best results with better utilization of organic matter. The observed significant (p<0.05) reduction in TOM during summer season indicates effective fermentation during this period. The more reduction in TOM content depicts more microbial degradation and hence more quality generation of end product as reported earlier by Abdelhamid *et al.* (2004) [15].

Total Organic Carbon

From the overall values treatment group T_7 was having highest reduction in TOC of 33.27 percent. Bosch *et al.* (2015) [13] also reported comparative results of TOC reduction. The reduction in TOC during fermentation was due to optimum microbial degradation. It was concluded that T_6 (containing *Lactobacillus* @ 1% + Yeast @ 0.5%) has shown the best results of microbial degradation in poultry farm waste.

Total Nitrogen (%)

The results indicated that T_2 (containing *Lactobacillus* @ 1%) has produced the highest N content among all the treatments during both the seasons. It was also observed that season had no significant (p<0.05) effect on the nitrogen content of the fermented end product. However earlier Faid *et al.* (1995) [14] observed lower nitrogen content of 0.4-0.65 percent in the fermented end product of poultry manure waste. It may be concluded that *Lactobacillus* @ 1% has produced the best nitrogen mineralization in poultry farm waste.

Carbon: Nitrogen Ratio

The overall results suggested that T_2 (containing *Lactobacillus* @ 1%) has produced the best C: N ratio among all the treatments. There was no significant (P>0.05) effect of different season on the C: N ratio. It was due to higher nitrogen content and relatively lower total organic carbon content of the end product. Bosch *et al.* (2015) [13] observed comparable C: N ratio of 19.5-22.3 in the fermented end product of organic waste material.

Electrical Conductivity

T_3 group results suggested that at *Lactobacillus* added @ 0.5 percent in poultry farm waste has produced the highest ionic activity as reported earlier by Salminen *et al.* (2004) [12].

Total Dissolved Salts

The overall values of TDS content were highest in T_3 (3.26 ppt). It was concluded that T_3 (containing *Lactobacillus* @ 0.5%) has shown the highest ionic activity of dissolved salts as reported earlier by Salminen *et al.* (2004) [12].

pH

More acidic pH indicates more lactic acid activity and hence rapid degradation of organic waste. Hence from the overall a lowest pH was observed in T_4 (4.50±0.21) and T_9 (4.50±0.28) suggested a better anaerobic fermentation of the poultry farm waste. Yang *et al.* (2006) [11] and Ozyurt *et al.* (2017) [10] reported comparable results of 4.0-4.6 pH.

Total ash

The overall values suggested that T_7 group (*Lactobacillus* @ 1% and Yeast @ 1%) was more effective in terms of microbial degradation with the result of 45.63±0.71 percent ash in fermented poultry farm waste (El-Jalil *et al.* 2008; Cai and Pancorbo, 1994) [8, 9].

Table 2: Physico-chemical properties of poultry waste ferment

Treatment	Physical Parameters			Chemical Parameters							
	Weight Reduction (%)	Volume Reduction (%)	Moisture Content (%)	Total Organic Matter (%)	Total Organic Carbon (%)	Total Nitrogen (%)	Carbon/ Nitrogen Ration	Electrical Conductivity	Total Dissolved Solids (ppm)	pH	Total Ash%
T_1	4.15±0.94	2.42±0.57	44.86±1.92	75.44±0.20	37.97±0.12	1.49±0.017	25.48±0. 24	4.38±0.06	2.93±0.005	5.00±0.17	32.33±1.01
T_2 (LB = 1%)	4.40±1.14	2.56±0.83	56.20±2.54	62.87±2.85	37.92±1.65	1.80±0.011	21.07±0.66	4.23±0.01	2.83±0.02	4.80±0.47	41.50±0.71
T_3 (LB = 0.5%)	4.70±0.97	2.59±0.93	53.05±1.81	70.04±1.31	40.63±0.76	1.54±0.022	26.38±0.01	4.87±0.33	3.26±0.03	4.60±0.83	40.64±0.80
T_4 (Yeast = 1%)	4.91±0.88	3.42±1.83	55.52±1.70	65.63±2.14	38.07±1.24	1.67±0.022	22.80±1.09	3.94±0.29	2.64±0.15	4.50±0.21	36.63±0.70
T_5 (Yeast = 0.5%)	5.47±1.98	2.39±1.54	53.26±1.63	60.12±1.27	34.87±0.73	1.33±0.022	25.45±0.02	3.91±0.30	2.62±0.14	5.10±0.11	42.90±0.81
T_6 (LB = 1% + Yeast = 0.5%)	5.52±0.72	2.84±0.72	49.86±2.84	67.32±1.91	39.29±1.10	1.39±0.011	27.86±0.92	3.98±0.12	2.66±0.09	4.70±0.31	41.48±0.71
T_7 (LB = 1% + Yeast = 1%)	5.92±1.61	3.49±1.63	51.14±2.30	57.36±2.77	33.27±0.93	1.59±0.011	21.20±0.78	4.63±0.06	3.12±0.09	4.70±0.05	45.63±0.71
T_8 (LB = 0.5 + Yeast = 0.5%)	4.40±1.17	2.65±1.53	48.57±2.15	70.20±0.72	40.72±0.38	1.03±0.040	39.53±1.28	3.79±0.17	2.54±0.08	4.60±0.27	42.54±1.01
T_9 (LB = 0.5 + Yeast = 1%)	4.99±1.31	2.46±1.03	52.17±2.40	65.42±0.72	37.95±0.42	1.60±0.040	23.76±0.28	3.46±0.08	2.32±0.16	4.50±0.28	40.53±0.71

LB: *Lactobacillus acidophilus*

Conclusion

Maturity of lactic acid/yeast fermentation product is a key indicator for assessing its final utility as a valuable product. In this regard, a proper physico-chemical balance is required and consequently it was concluded that fermentation product showed a perfect maturity to be used a proper bio-manure.

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