

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
 ISSN Online: 2617-4707
 NAAS Rating (2026): 5.29
 IJABR 2026; 10(5): 579-582
www.biochemjournal.com
 Received: 19-03-2026
 Accepted: 21-04-2026

R Sakthivadivu
 Assistant Professor, Livestock
 Farm Complex, Veterinary
 College and Research Institute,
 Namakkal, Tamil Nadu, India

V Ramesh
 Professor and Head, Livestock
 Farm Complex, Veterinary
 College and Research Institute,
 Namakkal, Tamil Nadu, India

K Sivakumar
 Faculty of food and
 Agriculture, St Augustine
 Campus, The University of the
 West Indies, Jamaica

N Bharathy
 Associate Professor, Livestock
 Production Management,
 Veterinary College and
 Research Institute, Salem,
 Tamil Nadu, India

P Vasanthakumar
 Professor and Head,
 Department of Animal
 Nutrition, Veterinary College
 and Research Institute,
 Namakkal, Tamil Nadu, India

PC Sakthivel
 Associate Professor,
 Department of Animal
 Nutrition, Veterinary College
 and Research Institute,
 Orathanadu, Tamil Nadu,
 India

Corresponding Author:
R Sakthivadivu
 Assistant Professor, Livestock
 Farm Complex, Veterinary
 College and Research Institute,
 Namakkal, Tamil Nadu, India

Economics of caged layer manure composting by passive aeration with biochar and cocount coir pith waste

R Sakthivadivu, V Ramesh, K Sivakumar, N Bharathy, P Vasanthakumar and PC Sakthivel

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i5g.8460>

Abstract

The present experiment was undertaken to evaluate the economic feasibility of composting caged layer manure (CLM) through passive aeration techniques using biochar and coconut coir pith (CCP) waste as co-composting substrates. The study was conducted at the Livestock Farm Complex, Veterinary College and Research Institute, Namakkal, Tamil Nadu, during the monsoon and summer seasons (September-October 2022 and March-April 2023). Nine treatment combinations involving static and passive aeration composting methods were evaluated for production cost, net return and benefit-cost ratio (BCR). The economic analysis revealed that the total cost of compost production was highest in treatments containing 50 percent biochar and 50 percent coconut coir pith waste due to the high market price of biochar. Among all treatments, T₉ (caged layer manure alone under static composting) recorded the highest net return (Rs. 720.00), maximum net return per kilogram of compost (Rs. 4.80) and superior BCR (6.54), primarily due to lower input costs. However, compost amended with biochar exhibited comparatively higher nutritive value and improved compost quality owing to enhanced microbial activity and nutrient retention. The findings indicate that composting of poultry manure through passive aeration is an environmentally sustainable and economically viable waste management strategy capable of producing nutrient-rich organic manure suitable for sustainable agricultural systems.

Keywords: Caged layer manure (CLM), composting, economics analysis, organic manure

Introduction

The poultry industry is one of the most rapidly expanding sector in worldwide and plays a significant role in food security, employment generation and rural economy. In India, the poultry sector has witnessed remarkable growth over the past few decades due to advances in genetics, nutrition, disease management and intensive production systems. According to the 20th Livestock Census, the poultry population in India reached 851.81 million in 2019 compared to 73.50 million in 1951, indicating substantial industrial growth (Report, 2019)^[12]. Tamil Nadu is among the leading poultry producing states in India, with Namakkal district contributing significantly to commercial egg production and earning the title “Egg City” due to its intensive layer farming systems.

Intensive poultry production generates enormous quantities of manure and litter, which pose serious environmental and public health concerns when improperly managed. Poultry manure contains high concentrations of nitrogen, phosphorus, potassium, heavy metals, pathogens and residual antibiotics (Gupta and Charles, 1999)^[3]. Accumulation and indiscriminate disposal of poultry waste may lead to groundwater contamination, eutrophication, greenhouse gas emissions, foul odour and proliferation of pathogenic microorganisms (Bernal *et al.*, 2009)^[1]. Therefore, scientific disposal and utilization of poultry manure have become essential components of sustainable poultry production systems.

Composting is widely recognized as an effective biological process for stabilizing organic wastes through microbial decomposition under controlled aerobic conditions. Composting converts unstable organic matter into a humified, pathogen-free and nutrient-rich product suitable for agricultural application (Waqas *et al.*, 2023)^[15]. Aerobic composting also reduces waste volume, minimizes odour emission, destroys weed seeds and pathogens and

improves manure handling characteristics (Tiquia and Tam, 2002) [14].

Among various composting methods, passive aeration composting is considered economical and energy efficient because oxygen is supplied naturally through perforated pipes without mechanical turning or forced aeration systems. Adequate oxygen availability is essential for thermophilic microbial activity, which accelerates decomposition and enhances compost stabilization (Haug, 1993) [4]. However, poultry manure possesses a narrow carbon nitrogen (C:N) ratio due to its high nitrogen content; hence, addition of carbonaceous bulking agents is necessary to optimize composting conditions.

Coconut coir pith (CCP), an abundant agro-industrial by-product in South India, serves as an excellent bulking material because of its high carbon content, porosity and moisture holding capacity (Mahimairaja *et al.*, 1994) [9]. Similarly, biochar has recently gained considerable attention as a compost amendment due to its porous structure, large surface area and ability to adsorb nutrients and reduce nitrogen losses during composting (Steiner *et al.*, 2008) [13]. Incorporation of biochar into composting systems has been reported to improve microbial activity, reduce ammonia volatilization, enhance nutrient retention and increase compost maturity (Jindo *et al.*, 2012) [6].

Despite these advantages, the use of biochar and co-composting materials substantially increases production costs, which may influence the economic viability of composting operations. Therefore, comprehensive economic assessment is necessary before recommending such technologies for commercial adoption.

Considering the environmental significance and economic implications of poultry waste management, the present study

was undertaken to evaluate the economic feasibility of composting caged layer manure using passive aeration techniques with biochar and coconut coir pith waste.

Materials and Methods

This study was carried out at Livestock Farm Complex, Veterinary College and Research Institute, Namakkal, Tamil Nadu. Namakkal is situated in the 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 region experiences semi-arid tropical climatic conditions favourable for poultry production.

The experiment was conducted in a tile-roofed concrete floored shed, long axis oriented east west with both the sides open for better ventilation. The height of the ridge was 13 feet and the eave was 6.5 feet. The width of the shed was 22 feet and the length was 60 feet.

Collection of composting materials

The ingredients were collected nearby area. Coconut coirpith (CCP) was procured from nearby coir processing industries. Caged layer manure (CLM) was procured from commercial layer farms and transported to Veterinary College and Research Institute, Namakkal under moisture proof condition and caged layer manure biochar was prepared by conventional pyrolysis method.

Experimental treatments

A static and passive aeration composting experiment with the following treatments and control was carried out. Each trial of composting was replicated simultaneously in the same season

CLM biochar and coir pith waste was utilized as co-compost material.

Treatments	Recipe	Method of composting
T ₁	CLM + 25% biochar + 50% CCP	Passive aeration (vertical 'T' shape pipe)
T ₂	CLM + 25% biochar + 50% CCP	Passive aeration ('V' shape pipe)
T ₃	CLM + 25% biochar + 50% CCP	Static compost
T ₄	CLM + 50% biochar + 50% CCP	Passive aeration (vertical 'T' shape pipe)
T ₅	CLM + 50% biochar + 50% CCP	Passive aeration ('V' shape pipe)
T ₆	CLM + 50% biochar + 50% CCP	Static compost
T ₇	CLM	Passive aeration (vertical 'T' shape pipe)
T ₈	CLM	Passive aeration ('V' shape pipe)
T ₉	CLM	As such

Economic analysis

The cost of production of caged layer manure compost was worked out with following assumptions.

1. The cost of passive aeration vertical 'T' shape pipe was Rs. 300.00 per pile, V shape pipe was Rs. 400 per pile and the life of the pipe was two years.
2. The Labour cost for loading, remixing and unloading of compost pile was worked out as Rs. 100.00 per pile per composting.
3. The cost of CLM was Re. 0.20 per kg and the cost of coirpith waste was Rs. 2.30 per kg. The cost of biochar Rs.30 per kg.
4. The rate of interest for fixed investment was 12 percent.
5. The rate of depreciation for passive aeration pipe was 15 percent.
6. Cost of CLM alone compost Rs. 5/-, CLM with co-compost materials compost Rs. 10/-

7. The cost involved in disposal of caged layer manure was worked out with fixed cost and variable cost.

Statistical analysis

The statistical analyses were performed using standard statistical software packages such as SPSS version.

Results

The economic analysis of compost production under different composting treatments were presented in Table 1. The total expenditure incurred for compost production varied considerably among treatments depending upon the level of biochar incorporation and composting method adopted.

Among the treatments, the highest total expenditure was recorded in T₄ (Rs. 1723.88), followed by T₅ (Rs. 1723.66) and T₆ (Rs. 1721.00), all of which contained 50 percent

biochar and 50 percent coconut coir pith waste. The increased production cost in these treatments was mainly due to the high procurement cost of biochar. In contrast, the lowest total expenditure was observed in T₉ (Rs. 130.00), followed by T₇ (Rs. 135.55) and T₈ (Rs. 137.25), where caged layer manure (CLM) alone was composted without any co-composting materials. The gross return obtained from sale of compost ranged from Rs. 800.00 to Rs. 2000.00. The highest gross return was recorded in T₃ (Rs. 2000.00), followed by T₁ (Rs. 1950.00) and T₂ (Rs. 1900.00). However, despite higher gross returns, the higher production costs in biochar-incorporated treatments reduced

the overall profitability.

The net return differed significantly among treatment groups and ranged from a loss of Rs. 323.88 to a profit of Rs. 953.50. Among all treatments, T₃ recorded the highest net return (Rs. 953.50), followed by T₁ (Rs. 897.29) and T₂ (Rs. 846.69). Negative net returns were observed in T₄, T₅, and T₆ due to excessive expenditure on biochar. The net return per kilogram of compost was highest in T₉ (Rs. 4.80/kg), followed by T₇ (Rs. 4.60/kg), T₈ (Rs. 4.42/kg), and T₃ (Rs. 4.33/kg). Similarly, the benefit-cost ratio (BCR) was highest in T₉ (6.54), followed by T₇ (6.09) and T₈ (5.83), indicating greater economic efficiency of composting CLM alone.

Table 1: Economic analysis of compost production

	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	T ₇	T ₈	T ₉
Fixed investment									
Cost of aeration pipe (Rs.)	300.00	400.00	-	300.00	400.00	-	300.00	400.00	-
Total (Rs.)	300.00	400.00	-	300.00	400.00	-	300.00	400.00	-
Fixed cost									
Interest on fixed investments 12%	2.76	3.02	-	1.28	1.18	-	2.47	3.22	-
Depreciation 15%	3.45	3.78	-	1.60	1.48	-	3.08	4.03	-
Variable cost									
Cost of CLM @ Rs.0.20/kg	24.00	24.00	24.00	6.00	6.00	6.00	30.00	30.00	30.00
Cost of biochar @ Rs. 30/kg	750.00	750.00	750.00	1500.00	1500.00	1500.00	0	0	0
Cost of coconut coir pith @ Rs. 2.30/kg	172.50	172.50	172.50	115.00	115.00	115.00	0	0	0
Cost of labour (Rs.)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total expenditure (Rs.)	1052.71	1053.31	1046.50	1723.88	1723.66	1721.00	135.55	137.25	130.00
Returns									
Sale of compost (Rs.)	1950.00	1900.00	2000.00	1400.00	1400.00	1500.00	825.00	800.00	850.00
Net return (Rs.)	897.29	846.69	953.50	-323.88	-323.66	-221.00	689.45	662.75	720.00
Net return per kg (Rs.)	4.08	3.85	4.33	-2.49	-2.49	-1.70	4.60	4.42	4.80
BCR	1.85	1.80	1.91	0.81	0.81	0.87	6.09	5.83	6.54

Discussion

The economic analysis clearly demonstrated that the profitability of compost production was strongly influenced by the type of amendment used and the associated production costs. Treatments containing higher proportions of biochar (T₄, T₅ and T₆) recorded the highest total expenditure, primarily due to the high procurement and processing cost of biochar. Although these treatments produced compost with comparatively higher gross returns, the elevated production costs substantially reduced their economic feasibility, resulting in negative net returns. This finding indicates that incorporation of biochar at higher proportions may not be economically sustainable under prevailing market conditions unless the cost of biochar production and transportation is reduced. Similar observations were reported by Lehmann and Joseph, (2009) [8] who emphasized that the profitability of pyrolysis systems largely depends on reducing feedstock and production costs. They further noted that slow pyrolysis systems often require financial subsidies to become economically viable. Likewise, Nematian *et al.* (2021) [10] reported wide variations in biochar production costs and identified production rate and operational efficiency as major factors affecting overall economic performance. Among all treatments, T₃ recorded the highest net return, followed by T₁ and T₂, indicating that moderate incorporation of co-composting materials improved profitability without substantially increasing production costs. The better economic performance of these treatments may be attributed to an optimal balance between input cost and market value of the final compost product. In contrast, treatments involving composting of caged layer manure

(CLM) alone (T₇, T₈ and T₉) exhibited the highest benefit-cost ratio and net return per kilogram of compost, despite comparatively lower gross returns. This suggests that low-cost composting systems can provide greater economic efficiency and quicker financial returns to farmers. The high BCR values observed in these treatments indicate that composting poultry manure without expensive additives can be a more practical and economically feasible approach for small and marginal farmers.

The findings are in agreement with the observations of Brodie *et al.* (2000) [2] who reported that ingredient costs constituted nearly 60-70 percent of the total compost production cost in poultry litter composting systems. They also stated that operational costs between static and turning windrow methods were relatively similar per unit of compost produced, suggesting that raw material cost remains the dominant economic factor. Furthermore, Hong *et al.* (1998) [5] observed that intermittent aeration reduced operational costs without adversely affecting composting efficiency, highlighting the importance of process optimization in reducing expenditure. Similarly, Keener *et al.* (2014) [7] emphasized that the economic viability of composting systems depends mainly on litter cost, amendment cost, operational expenditure and the market price of finished compost.

The lower profitability observed in biochar-amended treatments may also be associated with the limited commercialization and high transportation costs of biochar. Pokharel and Comer (2021) [11] reported that feedstock acquisition, transportation expenses, capital investment and limited revenue streams remain major constraints affecting the economic feasibility of biochar systems. Therefore,

although biochar incorporation may improve compost quality and nutrient stabilization, its adoption at higher rates may presently be constrained by economic limitations.

Overall, the present investigation indicated that composting of caged layer manure alone or with low-cost amendments was economically superior to treatments containing high proportions of biochar. The results suggest that reducing the cost of biochar production, improving local availability of feedstocks and developing low-cost pyrolysis technologies may enhance the future economic feasibility of biochar-based composting systems.

Conclusion

The present study demonstrated that composting of caged layer manure through passive aeration and static composting systems is both technically feasible and environmentally beneficial. Static composting of CLM alone proved to be the most economically viable treatment due to its low production cost and high benefit-cost ratio. Although incorporation of biochar improved compost quality and nutritive value, the high procurement cost of biochar significantly reduced economic returns.

Therefore, from an economic perspective, composting of CLM alone is more suitable for immediate commercial adoption; whereas biochar amended, composting may be recommended when long-term soil fertility improvement and enhanced compost quality are prioritized. Overall, poultry manure composting represents a sustainable waste management strategy capable of producing high-quality organic manure for eco-friendly agricultural production systems.

Acknowledgment

The authors wish to thank the Dean, Veterinary College and Research Institute, Namakkal, Tamil Nadu for the necessary facilities provided to carry out this research work.

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