

BIOCONVERSION OF FISH WASTE INTO VERMICOMPOST: A SUSTAINABLE APPROACH FOR WASTE MANAGEMENT AND VALUE ADDITION

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Abstract: Fish-processing waste is generated in large quantities and requires sustainable management and value-addition strategies. The present study evaluated fish-waste-based vermicomposting under field conditions in Chengalpattu district, Tamil Nadu, India. Demonstrations were conducted at 20 locations/villages through Self-Help Groups of fishermen and farmers. Vermicompost yield, C:N ratio, and economic parameters were recorded. The treatment produced a higher annual yield ($2480 \pm 36 \text{ kg year}^{-1}$) than the control ($2200 \pm 30 \text{ kg year}^{-1}$), with yield percentage increasing from $55 \pm 1.63\%$ to $62 \pm 2.33\%$. The C:N ratio improved from 1:35 to 1:25. The treatment also recorded lower gross cost (Rs. 11,400), higher gross return (Rs. 24,800), net return (Rs. 13,400), and BCR (2.18) compared with the control values of Rs. 12,000, Rs. 22,000, Rs. 10,000, and 1.83, respectively. The observations were analyzed using the Wilcoxon signed-rank test at a 5% significance level ($p < 0.05$). The findings demonstrate that fish-waste-based vermicomposting is a feasible, sustainable, and economically beneficial approach for fish-waste management and value addition.

Keywords: BCR; C:N ratio; Fish waste; Value addition; Vermicompost; Waste management.

INTRODUCTION

Fish and seafood are important sources of high-quality protein, essential amino acids, and micronutrients. Global fish consumption is approximately 20.6 kg per capita per year, contributing about 15% of animal protein and 6% of total protein intake. For nearly 3.2 billion people, fish provides at least 20% of their animal protein intake (FAO, 2024). However, increasing seafood production and processing generate substantial quantities of by-products and waste. Fish processing may generate 60–75% of the harvested biomass as waste, depending on species and processing methods. Finfish processing produces approximately 10–50% non-edible components, including heads, viscera, skin, bones, and residual flesh, while crustacean processing may generate up to 85% waste. The increasing demand for skinless and boneless products and the contribution of by-catch further increase the volume of seafood residues (Kumar et al., 2022).

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Improper disposal of fish waste can cause odour, microbial contamination, eutrophication, and environmental pollution. However, these residues contain valuable proteins, lipids, enzymes, carotenoids, collagen, and chitin, making them suitable for applications such as animal feed, fish meal, silage, nutraceuticals, biofuel, and organic fertilizers (Xia et al., 2024). Despite this potential, much of the seafood waste remains underutilized (Briones-Labarca et al., 2025). Among biological waste-management approaches, vermicomposting offers a simple and sustainable method for converting organic residues into nutrient-rich vermicast. Earthworms and associated microorganisms facilitate decomposition and stabilization of organic matter while enhancing nutrient availability and soil fertility (Gao et al., 2025). However, field-level adoption of fish-waste vermicomposting remains limited due to inadequate awareness, technical knowledge, and exposure to value-addition technologies among fishing and farming communities. Therefore, the present study was undertaken to evaluate fish-waste-based vermicomposting as a sustainable waste-management and value-addition technology under field conditions. The resulting vermicompost was assessed for yield, quality characteristics, and economic returns, and treatment effects were statistically evaluated to determine its feasibility and effectiveness.

MATERIALS AND METHODS

The present study was conducted at 20 selected locations/villages in the fields of fishermen and farmers in Chengalpattu district, Tamil Nadu, India. Field-level demonstrations were implemented through Self-Help Groups (SHGs), with each group comprising a minimum of five members. The participating SHGs were provided with HDPE vermicompost beds with roofing, procured from Arjun Tarpaulin Industries, Salem, Tamil Nadu, India. Each unit received 2 kg of adult Clitellate native earthworms, collected locally, along with other essential materials required for vermicomposting. The demonstrations focused on the utilization of fish waste as a substrate for vermicompost production and its potential for waste management and value addition. Activities included fish-waste substrate preparation, vermibed preparation and filling, introduction and maintenance of earthworms, vermicompost harvesting, and assessment of selected physicochemical parameters following the methodology of Ilangovan et al. (2022). The harvested vermicompost was evaluated for yield and quality, particularly the C:N ratio. Economic performance was assessed based on gross cost, gross return, net return, and benefit–cost ratio (BCR). The collected data were compiled and statistically analyzed. Since the control and treatment observations were paired, the Wilcoxon signed-rank test was used as a non-parametric alternative to the paired-samples

t-test to assess differences in vermicompost yield between the control and treatment. The findings were used to evaluate the effectiveness, quality improvement, and economic feasibility of fish-waste-based vermicomposting under field conditions.

RESULTS

The results presented in Table 1 revealed that the treatment performed better than the control with respect to yield, quality, and economic returns. The annual yield increased from 2200 ± 30 kg year⁻¹ in the control to 2480 ± 36 kg year⁻¹ under the treatment, representing an increase of approximately 12.7%. Similarly, the percentage yield was higher in the treatment ($62 \pm 2.33\%$) compared with the control ($55 \pm 1.63\%$), indicating improved production efficiency. A considerable improvement was also observed in the C:N ratio, which changed from 1:35 in the control to 1:25 under the treatment. The comparatively lower C:N ratio under treatment indicates a more favourable quality characteristic and may be associated with improved nutrient transformation and stabilization. The economic analysis further demonstrated the advantage of the treatment. The gross cost was slightly lower under the treatment (Rupees (Rs.) 11,400) than in the control (Rs. 12,000). Despite the lower cost, the treatment generated a higher gross return of Rs. 24,800, compared with Rs. 22,000 in the control. As a result, the net return increased from Rs. 10,000 to Rs. 13,400, showing a 34% improvement over the control. The benefit–cost ratio (BCR) also increased from 1.83 in the control to 2.18 under the treatment, indicating greater economic efficiency. Overall, the treatment showed superior performance by improving yield and quality while reducing production cost and increasing net returns and BCR. These findings demonstrate the better production potential and economic viability of the treatment compared with the control. The statistical analysis was performed at a 5% level of significance ($p < 0.05$). Under the alternative hypothesis, a statistically significant difference was considered to exist between the control and treatment groups when the observed *p*-value was less than 0.05.

Table 1. The average yield of vermicompost, other parameter and economic parameters recorded in various demo plots from Chengalpattu district, Tamil Nadu, India

Parameters	Control	Treatment
Yield (Kg/year)	2200 ± 30	2480 ± 36
Yield in (%)	55 ± 1.63	62 ± 2.33
Quality parameter (C:N ratio)	1:35	1:25
Gross cost Rs.	12000	11400
Gross return Rs.	22000	24800
Net return Rs.	10000	13400
BCR	1.83	2.18

DISCUSSION

The present study demonstrated the effectiveness of vermicomposting for converting fish waste into a useful organic amendment. The treatment recorded a 12.7% higher annual yield than the control, with yield percentage increasing from $55 \pm 1.63\%$ to $62 \pm 2.33\%$, indicating improved conversion efficiency. Similar potential for fish-waste valorization through native earthworms has been reported by Ilango et al. (2022), who demonstrated the feasibility of incorporating fish waste into vermicomposting systems. Earthworms, together with associated microorganisms, facilitate fragmentation and decomposition of organic substrates and contribute to the stabilization of the final vermicompost (Thirunavukkarasu et al., 2023). The reduction in C:N ratio from 1:35 to 1:25 further indicates improved stabilization and decomposition of the organic substrate. Changes in C:N ratio are commonly associated with the degradation of carbonaceous materials and transformation of organic nitrogen during vermicomposting. The biological activity of earthworms and microorganisms plays an important role in these transformations and in improving the quality of the final vermicompost (Ali et al., 2015; Thirunavukkarasu et al., 2023). The treatment also showed better economic performance, with a lower gross cost and higher gross and net returns than the control. The 34% increase in net return and improvement in BCR from 1.83 to 2.18 indicate greater economic efficiency. Such economic benefits are particularly relevant for fishermen, farmers, and Self-Help Groups, where low-cost and locally adaptable waste-management technologies can provide opportunities for additional income generation. The field-level economic feasibility of vermicomposting remains an important consideration for wider adoption, as highlighted by Thirunavukkarasu et al. (2023).

CONCLUSION

Overall, fish-waste-based vermicomposting showed promising technical and economic potential as a sustainable waste-management and value-addition technology. The higher yield, improved C:N ratio, and better economic returns demonstrate its potential for converting fish-processing residues into a useful organic resource. Further multi-location studies involving detailed nutrient profiling, seasonal evaluation, and larger-scale demonstrations would help validate the technology and support its wider adoption.

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