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Impact of poultry manure enriched with sugar press cake on the growth and reproductive performance of earthworm species *Eudrilus eugeniae* (Kinberg,1867) and *Eisenia fetida* (Savigny, 1826)

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Abstract
An experiment was conducted between two species of *Eudrilus eugeniae* and *Eisenia fetida* to assess the quality of vermicomposting from chick-fowl excreta, mixed with molasses by product press cake vermicompost manufacture. Consequently, a relative analysis performed between *E. eugeniae* and *E. fetida* to evaluate their effectiveness in the vermicomposting of poultry excreta. The process of vermicomposting Poultry Excreta (PE) enriched with Press Cake (PC) requires a duration of 90 days, leading to a significant difference in growth and reproductive performance between the two species. Vermiculture treatments with varying ratios of PE and PC were implemented to observe the growth and reproductive capacity of earthworms over a period of 90 days. The results indicated that the highest increase in worm biomass was recorded in the control group, which consisted of 100% PC, while the lowest increase was noted in the feed mixture containing 20% PC and 80% PE. Accordingly, the production of cocoons and hatchlings was markedly higher in all bio-treatments, with the exception of those containing more than 50% PE for both worm species. Therefore, this study concluded that a higher percentage of PE in various bio-treatments had a significant impact on the growth and reproduction of both species of worms.

Keywords: Press cake, poultry excreta, fecundity, vermicompost, bio-treatment

Introduction

India is a fast-developing nation and a major agricultural producer globally, the substantial quantity of poultry excreta produced by the poultry industry poses challenges abundantly for eliminating its wastes, primarily owed to numerous soil contaminants, including wholesome compounds, non-biodegradable metals, and disease-causing agents. The aggregation and movement of fowl farm waste from the impacted regions shows mitigate-adverse ambience impacts associated with its usage on land [4]. Conversely, excessive and direct application of these wastes onto land may result in the runoff of plant nutrients into surface waters, potentially leading to the eutrophication of aquatic reservoirs [3, 15].

The sugarcane industry produces a significant amount of residue following the clarification of sugarcane juice, commonly referred to as press cake. Despite being relatively rich in plant nutrients, press cake presents a major disposal challenge for the sugar industry, as it is utilized minimally as an agricultural fertilizer. The main cause of this issue is the indissoluble and demented composition of the concentrations of the essential dietary substances present in it. Nevertheless, waste produces temperature (60ºC), emits a bad smell, requires an extended period for typical decomposition. The unregulated removal of fowl wastes on irrigated lands leads to sand, water and crop morbidness, adversely affecting the natural conditions of the earth [14]. Therefore, there exists a significant necessity for technologies that are both ecologically and economically sustainable, which facilitate the potential recovery of recyclable components from these two types of waste, in their actual condition abundant in nourishing essentials and dominate a much content of degradable matter.

Industrial waste affluent in degradable matter and devoid of cyanogenic physical entity or particulate may serve as appropriate substrates for vermicomposting [11]. Over the years, extensive research has been undertaken regarding the potential application of various earthworm species in the recovery of nutrients from agro-industrial waste. It is widely recognized surface-dwelling earthworms can significantly accelerate the wither debasement process, resulting in a higher quality of vermicompost when compared to that produced through traditional composting methods [2]. It is widely recognized that surface-dwelling earthworms can accelerate the wither removal activity. Numerous biodegradable inhospitable things were reformed into vermicompost by various diversity of wriggler worms, including slurry residues [22]; cattle dung [9, 10]; horse waste [18]; wood waste [12]; solid waste from the sago industry [19]; filter mud [11]; water hyacinth [7]; paper waste [6], among others. This process results in a significantly higher quality of vermicompost compared to that produced through traditional composting methods. The bibliographic review indicates a significant lack of comprehensive data regarding the use of vermicomposting for poultry excreta, particularly when utilizing earthworm species that are readily available in local environments. This gap in research is concerning, as it highlights the need for more studies to better understand the potential benefits and challenges of this practice. Additionally, farmers exhibit hesitance in adopting vermicomposting methods for their fields. Their reluctance stems from various concerns, including the unpleasant odors that may arise during the composting process, the costs associated with transporting the materials, fluctuations in pH levels that could affect soil health, the formation of crusts on the compost surface, and the potential for environmental pollution. These factors collectively contribute to the cautious approach that farmers take towards implementing vermicomposting of poultry waste. Vermicomposting poultry waste converts it into a valuable product and reduces pollution from poultry industrialization. This study explores the feasibility of using native earthworm species to vermicompost poultry waste mixed with press cake.

Experimental Design

Bio-waste and earthworm species

press cake (PC), a byproduct of sugar production, was sourced from the sewage treatment plant of Amaravathi Co-op Sugar Mills India palced in Palani, Dindigul District. Additionally, one-week-old poultry excreta (PE) harvested from Selvamani Poultry Farms in Melakkotai, Palani, Dindigul district. Various age categories of local earthworm species *E. eugeniae* (Kinberg) and *E. fetida* (Savigny) were cultivated under shed, utilizing partly decomposed cow dung as them cater substantial. *E. eugeniae* (25 days old) and *E. fetida* (30 days old) chosen from their stock-culture and preserved at research lab for further analysis.

Experimental setup

This research was conducted in a shed area for utilizing concrete setup with a volume of 10 liters as bio-treatments. We formulated various bio-treatments (BTEE1 to BTEE5 for *E. eugeniae*; BTEF1 to BTEF5 for *E. fetida*) that included specific waste mixtures of PC and an increasing percentage of PE, totaling 5 kilograms. All quantities of PE and PC were measured on a based on dried mass, and each bio-treatment was replicated three times. The food composition was manually rotated each day for a duration of 10 days to ensure the feed became palatable for the worms. Following this 10-day period, 100 worms (20 per kilogram) were introduced into each bio-treatment individually. Moisture level was consistently maintained at 65-75% throughout the experiment. To prevent moisture loss, the bio-treatments were covered with damp jute. The term zero day indicates when earthworms were inoculated into bio-treatments subsequently the normalization period of 10 days.

Maturation and fecundity study

The weight gain, along with the production of cocoons, hatchlings by *E. eugeniae* and *E. fetida,* was periodically recorded during the various bio-treatments throughout the experimentation. Subsequently, the food sources in the bio-treatments was refined, and the earthworms and cocoons were manually separated from the substrate. Following this, they were enumerated and measured after being washed by use of H_2O. Afterwards, study animals along with the source were back to their designated bio-treatments. The results presented in this text represent the average of three replicates. A one-way ANOVA was employed to assess the significant differences across various bio-treatments. To analyse the mean average using Turke's 't' test established for statistical significance were $P < 0.05$ for the conducted tests.

Results and Discussion

The alteration in earthworm maturation, fecundity and mortality of each bio-treatments for *E. eugeniae* and *E. fetida* over the vermi-composting period are given in Tables 2-5. *E. eugeniae* and *E. fetida* showed remarkable changes in biomass production and reproduction potential, i.e., maximum biomass recorded at end (mg worm^{-1}), biomass gain (mg worm^{-1}), growth rate (mg worm^{-1} day^{-1}), the overall count of cocoons and the total number of hatchlings across various bio-teatments were recorded. Two species of worms exhibited the higher and lower mean respective biomass attained at the conclusion of the bio-treatments, respectively. However, *E. fetida* showed significantly higher individual mass in PC (1240±72.37mg) followed by VLT2, VLT3, VLT4 and VLT5 and *E. eugeniae* showed significantly higher individual mass in VPT1 (959±35.21mg), followed by VPT2, VPT3, VPT4 and VPT 5, during the experimentation (Table 2). On the other hand, biomass gain (mg worm-1) and upper limit growth rate (mg worm^{-1} day^{-1}) of *E. fetida* and *E. eugeniae* in CD bio-treatments was higher than other bio-treatments studied. The order of biomass gain among bio-treatments was: VPT1 >VPT2>VPT3>VPT4 and VPT5 in *E. eugeniae* and VLT2>VLT3>VLT4> and VLT5 in *E. fetida* during the observation (Table 2&3). However, deviation among PC alone and PC mixed with PE up to 50% in bio-treatments for *E. eugeniae* and *E. fetida* in respect to upper limit biomass achieved (mg worm^{-1}), biomass gain (mg worm^{-1}) and growth rate (mg worm^{-1} day^{-1}) were not statistically significant ($p < 0.05$).

In the current research, the highest biomass observed for both types of study organism in the bio-treatments could be attributed to the enhanced taste and amiability of the nutrient by earthworms. Conversely, the least biomass in the bio-treatments containing a higher proportion of PE (exceeding 50%) may be a result of the presence of certain growth-inhibiting substances within it. The findings of the current study, regarding the variation in individual worm weight relative to stocking density, align with the conclusions drawn by other researchers [16, 17]. It is proposed that the decrease in individual worm weight at elevated stocking densities may result from the depletion of food resources below the maintenance level in the bio-treatments as the scientific research concludes. The maturation rate (measured in mg of biomass gained per worm per day) regarded as an effective comparative metric for assessing the growth of earthworms across various feed types [5]. Consequently, the variations in growth rate observed among the various bio-treatments in this research appear to be significantly associated with the quality and combinations of the feed.

Table.4 clearly explicit that, production of cocoons by *E. eugeniae* and *E. fetida* across various bio-treatments. Sum of cocoons differed among the bio-treatments, with the highest and lowest counts recorded at the conclusion in BTEE1 and BTEE5 for E. eugeniae, and BTEF1 and BTEF5 for *E. fetida*, respectively. The production of cocoons (per worm) and the fecundity rate (cocoon per worm per day) showed significant variation across the different bio-treatments ($p<0.05$). At the view of data point, there was no significant difference in cocoon production between BTEE1 to BTEE5 in *E. eugeniae* and BTEF1 to BTEF5 in E. fetida (Table 4). The highest number of hatchlings was observed in BTEE1 to BTEE5 for *E. eugeniae* bio-treatments and in BTEFT1 and BTEF5 for *E. fetida*, respectively. Nevertheless, the bio-treatments from BTEE1 to BTEE5 in *E. eugeniae* and BTEF1 to BTEF5 in *E. fetida* did not exhibit a statistically significant difference in reproduction rate (Table 4). The findings indicated that elevated levels of PE combined with PC were unsuitable for cocoon production. It can be inferred that the production of cocoons within the feed mixtures may be associated with the biochemical quality of the feed, which is a significant factor. Furthermore, alongside the biochemical characteristics of waste, the microbiota and the process of disintegration during vermicomposting also play a crucial role in influencing cocoon formation [1, 8]. Certain earlier studies [13, 20] have determined that the chemical composition of the feedstock may play a crucial role in the cultivation of earthworms or organic waste resources. Consequently, the disparity in cocoon production might be attributed to differences in substrate quality. *E. eugeniae* and *E. fetida* exhibited a significant variation in worm death rate across various bio-treatments (Table 5). Nevertheless, the variation between BTEE1 and BTEE5 in *E. eugeniae,* as well as BTEF1 to BTEF5 in *E. fetida* bio-treatments concerning overall worm mortality, was not statistically significant ($p<0.01$) for both worm species.

The development, persistence and longevity of earthworms within nutrient composition are significantly affected by the chemical conditions and surrounding climatic fluctuations. Additionally, the rate at which earthworms consume food during the initial critical phase also plays a crucial role in determining their survival rate. The C:N ratio of the initial feedstuff can also serve as a limiting factor for rate of assimilation of food by earthworms [13], thereby impacting their survival during the process of vermicomposting. Instances of worm mortality were noted throughout the vermicomposting experiment. A higher rate of mortality was recorded in the bio-treatments with elevated PE concentrations, leading to the conclusion that precomposting is crucial to prevent earthworm mortality [10]. As a result, the vermicomposting treatments that contained more than 50% press cake combined with PE did not effectively enhance the maturation and fecundity rates. It was concluded that the maximum percentage of PE in the nutrient composition remarkably impressed the production of cocoons and hatchlings.

Table 1: Mixture of poultry waste and press cake with different bio-treatments

Bio-treatments	Composition of feed substrate	
	PE (%)	PC (%)
BTEE1 &BTEF1 (control)	-	100
BTEE2 & BTEF2	10	90
BTEE3 & BTEF3	30	70
BTEE4 & BTEF4	50	50
BTEE5 & BTEF5	70	30

#BTEE- Bio-treatment of E. *eugeniae;* BTEF - Bio-treatment of *E. fetida*

Table 2: Mean average initial and peak biomass of *E. eugeniae and E. fetida*

Bio-treatments	Mean initial biomass worm^{-1}(mg)		Maximum biomass achieved Worm^{-1} after 90 days	
	E. eugeniae	*E. fetida*	*E. eugeniae*	*E. fetida*
BTEE1 &BTEF1	155±22.5	195±13.1	959±35.21^{ef}	1240 ± 72.37^{e}
BTEE2 & BTEF2	156±21.8	194±12.9	923±46.23^{e}	1138±52.15^{cd}
BTEE3 & BTEF3	154±12.5	193±18.5	862±29.31^{d}	1004±95.15^{c}
BTEE4 & BTEF4	155±17.6	193±30.4	789±46.29^{c}	915±49.23^{b}
BTEE5 & BTEF5	154±11.8	194±19.2	307±19.24^{a}	606±68.17^{a}

#BTEE- Bio-treatment of E. *eugeniae;* BTEF - Bio-treatment of *E. fetida*

Table 3: Biomass production by *E. eugeniae and E. fetida*

Bio-treatments	Biomass gained worm^{-1} (mg) after 90 days		Growth rate worm^{-1} day^{-1} (mg) after 90 days	
	E. eugeniae	*E. fetida*	*E. eugeniae*	*E. fetida*
BTEE1 &BTEF1	804±10.71	1054±25.18	8.9±0.11	11.7±0.27
BTEE2 & BTEF2	767±24.43	944±39.25	8.5±0.26	10.4±0.41
BTEE3 & BTEF3	698±16.81	801±76.5	7.7±0.19	8.9±0.82
BTEE4 & BTEF4	634±28.69	722±18.83	7.0±0.30	8.0±0.20
BTEE5 & BTEF5	153±7.44	412±48.97	1.7±0.08	4.5±0.53

#BTEE- Bio-treatment of E. *eugeniae;* BTEF - Bio-treatment of *E. fetida*

Table 4: Reproduction rate of *E. eugeniae and E. fetida*

Bio-treatments	Total no. of cocoons obtained at the end of experiment		Total no. of hatchlings obtained at the end of experiment	
	E. eugeniae	*E. fetida*	*E. eugeniae*	*E. fetida*
BTEE1 &BTEF1	324±15.2	218±18.7	122±15.3	75±6.9
BTEE2 & BTEF2	254±10.8	171±15.7	98±8.9	67±5.8
BTEE3 & BTEF3	240±16.7	160±8.9	87±6.5	59±2.3
BTEE4 & BTEF4	124±8.6	58±4.2	21±1.5	08±0.5
BTEE5 & BTEF5	29±2.1	32±5.8	05±0.5	03±0.1

#BTEE- Bio-treatment of E. *eugeniae;* BTEF - Bio-treatment of *E. fetida*

Table 5: The mortality (%) of E. eugeniae and *E. fetida during vermicomposting*

Bio-treatment s	*E. eugeniae*	*E. fetida*
BTEE1 &BTEF1	1.4 ± 0	1.2±0
BTEE2 & BTEF2	7.9±0.8	5.4±0.5
BTEE3 & BTEF3	31.3±3.5	22.9±2.6
BTEE4 & BTEF4	53.0±5.1	58.4±8.7
BTEE5 & BTEF5	95.7 ± 10.5	89.2±805

 # mean ± SD between 3 replicates

Conclusion

The data provided in this paper establishes a foundation for the vermicasting of poultry excreta enhanced with press cake. This research investigates the vermicasting of poultry excreta supplemented with press cake using *E. eugeniae* & *E. fetida,* assessing its effectiveness for the growth and reproduction of earthworms. The incorporation of specific organic amendments as bulking agents in poultry excreta creates favorable microenvironments worms. The rate of maturation and cocoon production of both species of worms exhibited a reciprocal correlation with the proportion of poultry excreta in the source. The deducted biomass of the earthworms was outstandingly reduced in feed mixtures with a higher content of poultry excreta. Therefore, our findings indicate that mixing poultry excreta with press cake at a ratio of 50% can serve as an alternative method for managing earthworm biomass and poultry excreta.

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