

Influence of Wastes of Taro Leaf, Sugar Beet and Saw Dust on Physiochemical Parameters of Produced Vermicompost

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Climatic change and its negative impacts may consider as one of the big global challenges, and eliminate soil and water availability time by time. Adding organic fertilizers (i.e. vermicompost) as soil amelioration may consider as one of effective approaches in order to recover soil degradation and enhance water retention in soil. Through vermicomposting, agro-wastes are converted into vermicompost that rich in humus, growth promoters (i.e. amino acids, growth hormones) and nutrients. Obtained results of this study indicated that these agro-wastes resulted in varying of physiochemical parameters and vermicompost content of amino acids and growth promoters.

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Whereas, adding Saw Dust (SD) to Cow dung (CD) during vermicomposting resulted in raising Organic matter and N content. Meanwhile, adding SD to Fish Sludge (FS) resulted in increment in C:N ratio and P content in vermicompost. Besides, adding Taro leaf (TL) to cow dung during vermicomposting led to increment in amino acids. In addition, adding Sugar Beet (SB) to cow dung during vermicomposting resulted in raising Abscisic acid (ABA) and gibberellins (GA3) content. Moreover, these different agro-wastes resulted in varying microbial activity and the highest activities produced when TL adding to FS during vermicomposting. Finally, these different agro-wastes led to differing in antimicrobial activity in produced vermicompost. From the results of the study, research team concluded that there is a great potential to produce vermicompost with specific quality that may play a crucial role in combat climatic change particularly reinforce tolerant plant to drought stress.

Keywords: Amino acids content; antimicrobial; microbial activity; nutrient contents; vermicompost.

1. INTRODUCTION

Converting agro-wastes into vermicompost is known globally as recycling organic wastes [1,2]. Through this process, earthworm have a crucial role in degrading these agro-wastes through fragmentation and ingestion of organic matter (agro-wastes) and produce an efficient organic fertilizer (vermicompost) that rich in humus and nutrients; "Moreover, various micro-organisms including bacteria, fungi, and actinomycetes help earthworm in its crucial role and vermicompost processing agro-wastes, and Vermicomposting has been arising as an innovative eco-technology for the conversion of various types of wastes into vermicompost" [2].

This vermicompost may be an effective substitute for chemical fertilizers. Whereas, [3] reported that "the vermicompost products are good sources for plant nutrient elements, various hormones, enzymes, humic substances and especially organic matter when added into the soil".

Again, [4] emphasized that through their study, "vermicompost contains a combination of macro- and micro-nutrients and the uptake of the nutrients has a positive impact on plant nutrition, growth, photosynthesis and chlorophyll content of the leaves".

Application of vermicompost may play an effective role in encourage plant growth through direct or indirect way. "Vermicompost as any organic fertilizer is rich material in terms of nutrition, antioxidants, vitamins, humic and phenolic substances and various hormones" [5]. All these substances play a significant role in promoting plant growth.

"Besides , vermicompost may improve plant growth performance though its positive effect on leaf chlorophyll content, and photochemical efficiency, yield, and electron transport rate (ETR) of mature leaves, as well as increased leaf succulence, and carotenoid, protein, and amino acid content" [6].

"In respect for indirect way, vermicompost application may improve soil conditions or works as soil amendment. Whereas several studies indicated that applying vermicompost resulted in enhancing soil properties particularly porosity, water holding capacity (WHC), cation exchange capacity (CEC) and occurrence of macronutrients" [7,8]. Additionally, vermicompost as any organic matter resulted in promoting microorganisms activity in soil and that will reflect on facilitate nutrients in root zone and improving soil condition in root zone [9].

In addition, [10] mentioned that "vermicompost appeared to more significantly increase bacterial number in soil and it has a potential to be used as an alternative to farmyard manure to improve and maintain soil biological activity". Besides, [11] showed that "applying vermicompost resulted in increasing amount of humus in soil which resulted in favorable changes in physical, chemical and biological properties of soil, and in enhancing the water-holding capacity".

"Generally, several studies reported that use of vermicompost is effective for improving soil aggregation, structure, aeration and fertility; contains most of the nutrients in plant-available form such as nitrates, phosphates, exchangeable calcium and soluble potassium; increases beneficial microbial population diversity and activity; improves soil moisture-holding capacity; contains vitamins, enzymes and hormones; and

accelerates the population and activity of earthworms” [12-19].

Moreover, [20] mentioned that “the application of vermicompost showed better result in comparison to chemical fertilizers in terms of soil physical and chemical properties as well as productivity of soil”.

Similar studies indicated the effects of type agro-wastes (whether crops wastes or animal wastes) on quality of vermicompost. Khwanchai, K. and S. Kanokkorn [21] indicated that quality of vermicompost is greatly affected by the input of organic matter. A study conducted by Moustafa et al. [22] reported that potential of utilizing different agro-wastes (i.e. banana leaves, Rice straw and sugarcane) in feeding earthworm and effect of these different agro-wastes on quality of produced vermicompost. Their results indicated that type of agro-wastes have different impact on quality of vermicompost. Researchers suggested that there is a great potential to produce vermicompost with specific quality as growers needs or requirements of plant stage via using different agro wastes.

In this context, [23] showed that “the best original material to be used for vermicompost production was cattle manure. The maximum positive effect occurred when vermicompost represented 30 to 50% of the soil volume”.

This study investigates the impacts of different agro-wastes (i.e. taro leaf, sawdust and sugar beet) on vermicompost quality. Specially, these wastes differ among them self in its nutrient, amino acids contents and other composites.

2. MATERIALS AND METHODS

This study was carried out from March 2019 to September 2020 through cooperation both of National Research Center, the Central Laboratory for Aquaculture Research (CLAR) and Faculty of Science, Tanta University, Egypt. Whereas vermicompost types were produced at the Central Laboratory for Aquaculture Research (CLAR) during (2019-2020) and all needed analysis were done at the National Research Centre (NRC), except microbiological analysis was done at the Faculty of Science, Tanta University, Egypt.

2.1 Specimen Collection and Processing

Mixing three species of earthworm (*Eiseniafetida*, *lumbricusrubellus* and *Perionyxexcavatus*) were

raised on cow dung and fish sludge until utilized in the experiment.

2.2 Preparation of Different Feeding Materials

1. **Cow Dung (CD) processing:** Fresh cow dung was obtained from a cow farmer adjacent to the central lab for aquaculture research (CLAR) and applied directly to the treatments, assuming the moisture is about 50% of the wet weight.
2. **Fish sludge collection and preparation:** Fish Sludge (FS) was collected from the concrete ponds of Nile tilapia *Oreochromisniloticus* brood stock and fry, at the Nile tilapia hatchery belonging to CLAR; during fry harvesting from the brood stock ponds as well as from fry rearing ponds. The produced FS, with a moisture content of 96.5% and dry solid content of 3.5%, was collected in barrels and then spread out in a thin layer on a cement floor for drying over fourteen days, so it can be stored safely until being used.
3. **Taro Leaves (TL) processing:** Taro leaves were collected from CLAR nearby farm, then sun-dried for 3 days and were crushed into small pieces.
4. **Saw Dust (SD):** saw dust was bought from CLAR nearby carpentry shop. Saw dust soaked in water for three days before utilized in vermicompost producing.
5. **Sugar Beet (SB):** Sugar Beet wastes were collected from sugar beet factory and sun-dried for 3 days then minced into small pieces by machine.

2.3 Earthworm Inoculation and Vermicompost Production

Both of fresh cow dung and dried fish sludge were mixed individually with agro-wastes (SD, SB or TL) at a ratio of 2:3 respectively and moistened to 60-70% in Styrofoam boxes with dimensions of 60x 40x 30 cm. After 24 h, three species of earthworm (*Eiseniafetida*; *Perionyxexcavatus* and *Lumbricusrubellus*) were added to the media at a rate of 50 g worm per 1000g media. For eight weeks the boxes were checked weekly and re-moistened and mixed until the vermicompost matured. All boxes were kept indoors and the temperature maintained between 18-25°C during the vermicompost maturation. At harvest time, vermicompost was checked manually on white plastic surface and the adult as well as pre-adult earthworms were

collected then the vermicompost was returned to the boxes again for one more month. Later, the vermicompost was re-checked again and all hatched earthworms were collected. The harvested vermicompost was packed in plastic bags and delivered to laboratories to be analyzed.

2.4 Experimental Treatments

Eight setup (treatments) containing different feeding materials (Cow dung (CD) alone, Fish sludge alone (FS) and CD or FS supplemented with TL, SD and SB respectively) with three replicates of each were prepared as following

CD	FS	CD+	CD+	CD+	FS+	FS+	FS+
		TL	SD	SB	TL	SD	SB

Samples of all these treatments delivered to different laboratories in order to be analyzed.

2.5 Analysis of Chemical and Microbial Parameters

“The following chemical and microbial parameters were measured during the study-Dry weight (g); Organic matter (%); Humidity (%); Ash; C/N ratio; Nitrogen in % (through Kjeldahl method); Available Phosphorus through Modified Olsen’s method” [24] ; Available Potassium (Ammonium acetate method); Amino acids content (mg/100g dry weight); Growth promoters content (g/100g sample); Bacterial and Fungal population (through Serial dilution and plate count method) etc.

2.6 Physiochemical Analysis of Vermicompost

Vermicompost samples were dried in a ventilated oven at 70°C to constant weight for determining the dry weight and chemical analysis.

“Macronutrients were extracted using the dry ashing digestion method” according to Chapman and Pratt [25]. “Nitrogen was determined by using the Kjeldahl method, the ash was dissolved in HCl (2N) and phosphorus was photometrical determined in the digested solution using vanado-molybdate color reaction” according to the method described by Jackson²⁴. Potassium was measured in the digested suspension using the Flamephotometer, (Eppendorof, DR Lang). Organic matter content was determined according to Walkely and Black, [26].

2.7 Analysis of Free Amino Acids and Growth Promoter’s

To determine the total free amino acids, the modified ninhydrine colorimetric method that described by Rosein, 1957 & Selim et al., [27,28] was used for this purpose.

Besides, growth promoters in samples of vermicompost were estimated according to the method described by Dobrev et al., [29].

2.8 Microbiological Analysis of Vermicompost Samples

2.8.1 Sampling and sample preparation

Five grams from vermicompost samples were placed in sterile Stomacher bags and treated by a Stomacher 400 Circulator for 60 s at middle speed after adding 45 ml sterile 0.85% NaCl. The Stomacher blending step was repeated three times and the microbial suspension was obtained.

2.9 Estimation the Counts of Total Viable Bacteria Count

Tenfold serial dilution of the microbial suspensions obtained with the protocol described above made with sterile 0.85% NaCl were plated onto plate count agar medium for the estimation of total viable counts, counts of colony forming units (CFU) were estimated after 3 days of incubation at 28°C and were calculated per gram vermicompost. The total resistant bacteria were estimated by planting the same dilution onto plate count agar medium sublimated with (20mg/l) for (penicillin, ampicillin, erythromycin and tetracycline respectively).

2.10 Antimicrobial Activity Assay

This method was done by agar well diffusion test according to Schillinger and Luck, [30]. To determine the antimicrobial activity of the vermicompost samples against the selected identified pathogenic bacteria e.g. *Citrobacter freundii*, *Enterobacter cloacae*, *Pseudomonas aeruginosa*, and *Klebsiella pneumonia*. The prepared nutrient agar plates were overlaid with 100 µl of overnight culture of tested pathogens (in nutrient broth), then spread well with L- shaped glass rod. After 15 min, wells of 5 mm diameter were made with a sterile cork borer. Samples of vermicomposts extract were

placed into wells. Plates were then incubated at 30°C for 12 hrs. The inhibition zones were measured to assay the antimicrobial activity of vermicompost samples.

2.11 Data Analysis

Vermicompost samples were analyzed using the standard procedures in the laboratory at National research Centre and Faculty of Science, Zoology department, Tanta University, Egypt. All data are the means of triplicates. Statistical analysis of data, analysis of variance (ANOVA) and mean separation were carried out using Duncan's multiple range test and significance were determined at the ($P \leq 0.01$) level [31]. Data analysis was performed using ASSISTAT version 7.7 beta (2015).

3. RESULTS AND DISCUSSION

Table 1 showed that utilizing Saw Dust (SD) in producing vermicompost was resulting in higher dry weight and organic matter comparing with other types of vermicompost types. In respect for ash percentage, findings were indicated that the highest ash percentage achieved with (FS) alone or (FS+TL). However low ash (%) was achieved when (CD) used alone to produce vermicompost. In respect to nutrients content utilizing SD in vermicompost production resulted in increasing N % content with CD and P% content with FS. However, higher K % content was obtained when (FS+SB) utilized in vermicompost producing.

In addition, Table 2 represented concern amino acids and growth promoters influenced with different carbon sources. Higher amino acids content was obtained when using TL wastes with CD in producing vermicompost. Meanwhile utilizing SB wastes with CD in vermicompost lead to increasing ABA (1.62g/100g) and GA₃ (2.23) comparing with two other carbon sources either (SD) or (TL) wastes. Besides, using wastes of SB with FS was resulted in producing the highest content of IAA (0.19g/100g).

Physio-chemical results showed variation. The vermicompost that produced from Cow Dung organic matter represented high results in comparison with Fish Sludge organic matter in all treatments (Table 1). The organic matter results was 46.6, 50.15, 33.00 and 37.33 with Cow Dung vermicompost (Cow dung, Saw Dust, Sugar beet and Taro Leaves respectively), while, the results with Fish Sludge was 21.06, 32.14, 26.48 and

19.73 (Fish sludge, Saw Dust, Sugar beet and Taro Leaves respectively).

Similar to the aforementioned results in organic matter, Cow Dung vermicompost types represented the highest results comparing with Fish Sludge types in the case of total nitrogen.

The opposite result occurred on C/N, i.e., the most of Fish Sludge results increase comparison to Cow Dung vermicompost except with Cow Dung alone. Hui et al., [32] reported that "compost made from the mixture spent mushroom waste with livestock manure, and soybean cake had a C/N ratio of 30". The compost was produced through composting alone [32]. Based on the results of statistical analysis, composition of vermicompost materials affected the total organic C, total N and C/N ratio of the vermicompost. It showed that vermicomposting can lead to mineralization process which reduced C by N ratio of vermicompost. Our results were in line with previous report according to the research of Hui et al. [32].

Hoitink and Boehm, [33] reported that "C/N ratio is one of the parameters used for measuring compost maturity. Researchers have suggested various ideal C/N ratios ranging from >12 to <25" [34]. According to Gomez-Brandon et al. [35] "the stabilized compost has a C/N ratio from 10 to 15". Majlessi et al. [36] showed that "to produce a stable vermicompost of food waste needed 7 weeks of the process duration. The vermicomposting duration in our research was four weeks and then continued by composting for two weeks". Domiguez, [37] reported that "the decaying organic in vermicomposting system is a spatially and temporally heterogeneous matrix of organic resources with contrasting qualities that result from the different rates of degradation, occur during decomposition. This means that the vermicompost still needs the composting process. To improve the quality of generated vermicompost, the systematic study of composting process and the addition of additives material such as fish meal and egg shell flour was conducted. After the composting process, the quality of vermicompost increased which marked by a lower C/N ratio of vermicompost (average 15.3). The decrease in C/N ratio was caused by the decomposition process of microorganisms during the composting process. During decomposition process, soil microorganisms burn carbon as a source of energy, but not all of the carbon remains in its

body; a certain amount is lost as carbon dioxide during respiration” [38]. Frankenberger and Abdelmagid, [38] states that “the organic matter with a value of C/N ratio lower than 20 include high quality of organic matter and will undergo mineralization in the soil”. Majlessi et al. [39] stated that “the vermicompost with low C/N ratio (14-30) indicate a mature and stable vermicompost”.

In addition, [40] reported that “the mixing sawdust with the other organic waste in composting process could increase N content of the organic fertilizer” [41] and “increase in N content lower the C/N ratio”.

3.1 Effect of Carbon Sources Microbial activity

Table 3 and Fig. 1 represent data concern impact of different carbon sources (SD, SB and TL) on microbial activity in produced vermicompost. From first view it was observed that FS vermicompost with whether TL or SB wastes surpassed in microbial activity comparing with CD vermicompost types with the same type of carbon source (TL or SB). Again, incorporation TL wastes with FS during vermicompost processing resulted in considerable increment in microbial activity (56 CFU) comparing with other studied treatments meanwhile adding TL to CD during vermicomposting produced lower value of microbial activity (28.67 ±11.79). The lowest value of microbial activity (11.33± 2.83) was achieved with (FS+ SD).

Moreover, [42] stated that “the vermicomposting process involved the activity of earthworms which modify wastes physically and feces excreted by worms can increase the activity of the microorganisms so that the rate of mineralization to be faster”.

Findings of this study represented in Table 4 showed that anti-pathogenic activity of vermicompost was varied with varying added agro-wastes (as carbon source i.e. SD, SB and TL) whereas CD+SD resulted in the highest anti-activity for *Bacillus anthracis* (15mm) comparing with other vermicompost types. Meanwhile this vermicompost has no anti-pathogenic effect for both of *Escherichia coli* and *Pseudomonas aeruginosa*. Besides, it can noticed that FS+SD surpassed other types of vermicompost whereas it has higher anti-pathogenic effect for three pathogens *Escherichia coli*, *Klebsiella pneumonia* and *Pseudomonas aeruginosa* in addition to *Bacillus anthracis*.

Moreover, vermicompost from (FS + TL) showed anti-pathogenic effect for only three of studied pathogenic (*Bacillus anthracis*, *Escherichia coli*, and *Pseudomonas aeruginosa*).

Major findings of this research indicated that anti-pathogenic effect differed in vermicompost according for input crops wastes. Some crop wastes might be resulted in multi-anti-pathogenic effect than other.

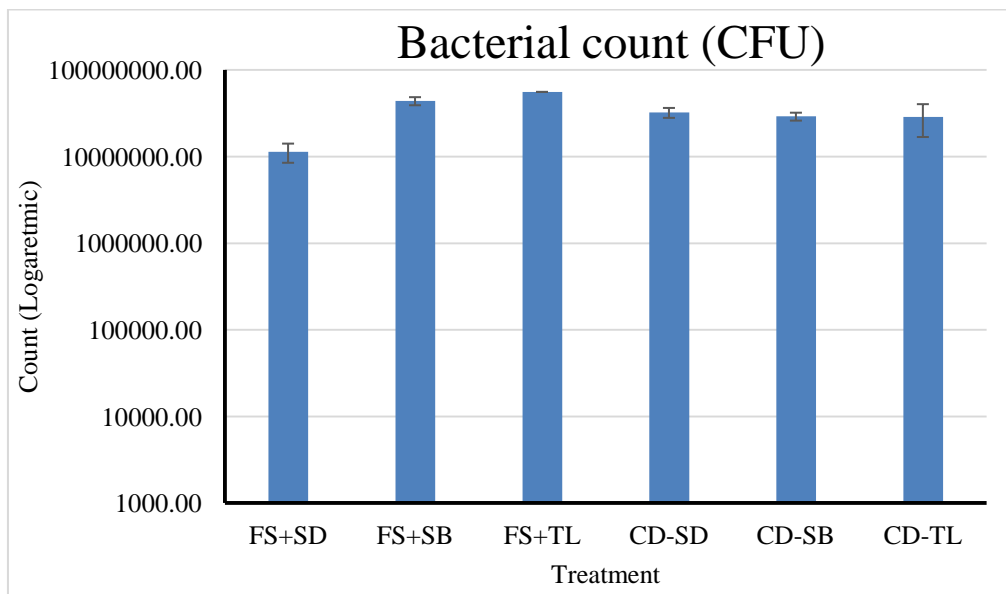


Fig. 1. Microbial activity influenced by utilizing different agro-wastes as carbon source

Table 1. Effect of different agro-wastes (TL, SB and SD) as carbon sources on physiochemical parameters of vermicompost

TRT	FW (g)	Dry Weight (g)	O.M (%)	Humidity (%)	Ash	N (%)	C / N ratio	P (%)	K (%)	
CD (Control)	10	6.70	b 46.60	a 33.00	b 20.40	d 1.33	B 20.40	a 0.35	ba 1.08	c
CD + SD	10	7.68	a 50.15	a 23.20	d 26.65	cd 2.51	A 11.48	b 0.12	b 1.65	b
CD + SB	10	6.80	b 33.00	ab 32.00	b 30.00	bcd 1.87	ab 11.58	b 0.18	ba 1.70	b
CD + TL	10	6.01	c 37.33	ab 39.90	a 22.77	d 1.87	ab 11.23	c 0.45	ba 1.58	b
FS (Control)	10	7.27	a 21.06	b 27.33	c 54.94	a 1.09	B 11.58	b 0.40	ba 1.88	ab
FS + SD	10	7.62	a 32.14	ab 23.83	cd 44.03	abc 1.61	B 11.63	b 0.48	a 1.53	b
FS + SB	10	7.45	a 26.48	b 25.50	cd 46.02	ab 1.54	B 11.50	b 0.42	ba 2.13	a
FS + TL	10	7.52	a 19.73	b 24.83	cd 52.10	a 0.99	B 11.58	b 0.36	ba 1.42	b

Means were represented as average of replicates.

Different letters are express for significant differences while the same letters are non-significant at L.S.D. $p>0.05$.

CD= cow dung, SD= Saw dust, SB= Sugar beet, TL= Tour leaf FS= Fish

Table 2. Effect of different agro-wastes (TL, SB and SD) as carbon sources on amino acids and growth promoters in produced vermicompost

	Amino acids (mg/g DW)		ABA (g/100 g)		GA3 (g/100 g)		IAA (g/100 g)	
CD (Control)	0.27	c	0.33	c	1.08	c	0.04	c
CD + SD	0.41	c	0.70	b	0.37	f	0.05	c
CD + SB	1.43	b	1.62	a	2.23	a	0.15	b
CD + TL	1.82	a	0.19	d	0.94	d	0.05	c
FS (Control)	0.44	c	0.01	e	0.16	g	0.03	c
FS + SD	0.29	c	0.01	e	0.92	d	0.02	c
FS + SB	0.46	c	0.17	d	1.59	b	0.19	a
FS + TL	0.34	c	0.67	b	0.78	e	0.13	B

Means were represented as average of replicates.

Different letters are express for significant differences while the same letters are non-significant at L.S.D. $p>0.05$.
 CD= cow dung, SD= Saw dust, SB= Sugar beet, TL= Tour leaf FS= Fish

A study carried out by Garczyńska et al. [43], highlighted “the effectiveness of vermicomposting manure of different origins to reduce pathogenic microorganisms. A reduction in pathogens occurs by passage through the intestines of an earthworm, which obviates the need to raise the temperature”. Moreover, other studies indicated that “earthworm influences microbial community, physical and chemical properties of soil. They breakdown large soil particles and leaf litter and thereby increase the availability of organic matter for microbial degradation and transforms organic wastes into valuable vermicompost by grinding and digesting them with the help of aerobic and anaerobic microbes” [44]. “Earthworms’ activity is found to enhance the beneficial micro flora and suppress harmful pathogenic microbes. Soil worm casts are rich source of micro and macronutrients, and microbial enzymes” [45].

Other studies indicated that earthworm lives in medium rich in wide range of microbes thereby earthworm strive to cover its bodies with mucus rich in antimicrobial to protect their bodies from pathogenic. These excreted mucus lost in the medium via earthworm movement from a while to while and earthworm excretes new mucus continuously. Thereby vermicast is mixed with mucus secretion of the earthworm’s gut wall [22]. Whether the antimicrobial produced from gut wall of earthworms or from excreted mucus to protect earthworms bodies against pathogenic microbes, its affected with type of meals (type of agro-wastes) that offer to earthworms as shown in the results of current study.

Gradually, these results were supported with the findings of Khwanchai, and Kanokkorn, [46] who reported that “provided new evidence that agricultural waste, especially soybean meal

could be used as feeds for the high quality of vermicompost production and earthworm biomass”.

Bajal et al. [47], showed that “ nutrient content of vermicompost was varied significantly among the substrates(Lantana camara, Ageratum conyzoides, banana pseudo stem, garden waste, vegetable waste and cow dung). They reported that *Lantana* was found most effective with 2.53% N, 1.38% P and 2.28% P”.

Ramnarain et al. [48], mentioned that “three agro-wastes were used in this study namely T1 (Rice straw), T2 (Rice straw+grass) and T3 (Grass). Such results indicated that, the combination of rice straw and grass had the highest rate of vermicompost production of 105 kg/m² followed by grass and rice straw with 102.5 kg/m² and 87 kg/m², respectively, at the end of 120 days. Besides, the harvested vermicompost had an excellent nutrient status, confirmed by the chemical analyses, and contained all the essential macro- and micronutrients”.

Table 3. Microbial activity in different vermicompost types based different agro-wastes (TL, SB and SD) as carbon source

TRT	CFU
FS + SD	11.33± 2.83
FS + SB	44.00 ± 4.71
FS + TL	56.00 ± 0.00
CD + SD	32.33 ± 4.24
CD + SB	29.17 ± 3.06
CD + TL	28.67 ± 11.79

Values are represented as average of three replicates.

Different letters within the same column express significant differences at L.S.D. $p>0.05$
 FS= Fish sludge, CD= cow dung, SD = Saw dust SB= sugar beet, and TL= Taro leaves

Table 4. Antimicrobial activity influenced by utilizing different agro-wastes (TL, SB and SD) as carbon source

TRT	<i>Bacillus anthracis</i>	<i>Escherichia coli</i>	<i>Klebsiella Pneumonia</i>	<i>Pseudomonas aeruginosa</i>
CD+S D	15 mm	00	7 mm	00
CD + SB	9 mm	00	16 mm	00
CD + T L	9 mm	00	00	25 mm
FS + SD	11 mm	17 mm	23 mm	26 mm
FS + SB	8 mm	00	22 mm	13 mm
FS + TL	7 mm	7 mm	00	20 mm

Values are represented as average of three replicates.

FS= Fish sludge, CD= cow dung, SD = Saw dust SB= sugar beet, and TL= Taro leaves

4. CONCLUSION

The vermicomposting duration in our research was four weeks and then continued by composting for two weeks, Results showed that vermicomposting lead to mineralization process which reduced C by N ratio of vermicompost caused by the decomposition process of microorganisms during the composting process where decline in C/N ratio of compost improve the compost quality. Incorporation TL wastes with FS during vermicompost processing resulted in considerable increment in microbial activity. Major findings of this research indicated that anti-pathogenic effect differed in vermicompost according for input crops wastes.

CONFERENCE DISCLAIMER

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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