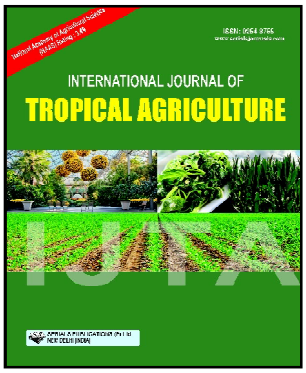

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Standardisation of Protocol for Vermicomposting of Tender Coconut Waste

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Abstract: Tender coconut is the finest natural refreshing drink, valued both for sweet water and its gelatinous kernel because of its high medicinal values. The consumption of tender coconuts as a refreshing drink generates an average 400 – 500 MT. of waste in major cities causing sanitary problems.Hence, a study was carried out to standardized the protocol for vermicomposting of tender nut waste as organic manure. The results of the experiment revealed that the tender coconut waste bits was pretreated with cow dung slurry @ 200kg/ton of tender nut waste, uniformly spread over the tender nuts in layers and incubated for one month for partial decomposition of the material & then earthworms *Eudrilus euginiea* @2000no's were released for vermicomposting. The composting of tender nut waste with earthworms *Eudrilus eugeniae* was achieved with in 68 –70 days with compost recovery of 63% of the substrate. Data on CN ratio, lignin and cellulose percentage revealed that there was a considerable decrease in CN ratio from 64.26 to15.35, cellulose from 21.56 to 10.70% and lignin from 17.5 – 4.28%.Nutrient composition of vermicompost was nitrogen varied from 1.36 – 1.72%, Phosphorus 0.20 – 0.27% and potash 2.04-2.94 % respectively. The vermicompost was also rich in micronutrients *viz.,* manganese (164ppm), Iron (8381 ppm), Zinc (134.60 ppm), copper (38.33 ppm). A total microbial load of 486.61(cfu/g) was observed high in vermicompost. The compost also This study endorses vermicomposting of tender coconut as a feasible economic possible small scale industry which can not only be used by farmers & agro based industries but also for commercial us.

Key words: Vermicompost, Tender coconut waste, Nutrient, Lignin, Cellulose.

INTRODUCTION

Andhra Pradesh is one of the major coconut growing states in the country and the state commands an area of nearly 1.02 lakh hectares with annual production of 1092.7 million nuts. Nearly 70% of the coconuts produced in the state are utilized as raw nuts, while 25-30% are utilized as tender coconuts. Tender coconut is the finest natural refreshing drink, valued both for sweet water and its gelatinous kernel. It is not merely a thirst quenching drink, but a mineral drink that cures man's most of the diseases. Its numerous medicinal properties prompt doctors to recommend tender coconut water for the patients suffering from skin/mouth cancer, measles, mumps, chickenpox etc. By and large the consumption of tender coconuts in the state is increasing day by day. With increased consumption of tender coconut as a refreshing drink, the disposing of the empty nuts is a problem in many cities. Few shells are shredded and dried in sun to use as a fuel.Majority is dumped on roadsides was accumulated in towns and cities near public places *viz*., parks, bus or railway stations, hospitals etc. Tender nut husk contains chemicals, nutrients, lignin, cellulose and high percentage of tannins. Due to high tannin content the exposed portion turns brown easily. Reports have shown that a good amount of potash can be squeezed out of empty shells and can be used as manure, but it's a laborious process. Under natural conditions, the degradation of empty shells took more than two years. No research work has been carried out so far to utilize empty tender nuts. Hence, the present study is attempted to estimate the actual consumption of tender nut in the state, and standardization of protocol for compositing of tender coconut shells.

MATERIALS & METHODOLGY

Estimation of the consumption of tender coconut in Andhra Pradesh

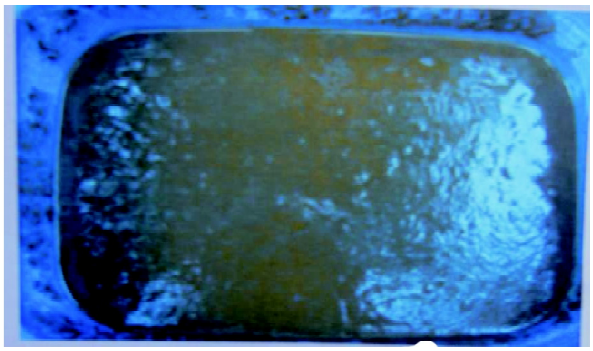
Twelve cities are selected at randomly in Andhra Pradesh for survey to collect the actual consumption of tender coconuts.In each city, around 2-3 points/ shops were selected for collection of data.

Collection, multiplication of earthworms culture for composting

Isolation and Mass multiplication of earth worm *Eudriluseugenia:* The tender nut waste was chopped, mashed and mixed with cowdung slurry in 1:2 ratio in cement tub (Plate 1). The substrate was allowed for partial decomposition for one month and adult earthworms were released into tub @15-20 worms per one kg of substrate. Then the substrate was mulched with wet gunny bag inorder to maintain moisture in the tub. During the vermiprocessing, the earthworms get acquitted with the tender nut waste and multiplied rapidly (Plate 1).

Pretreatment of tender coconut waste

For vermicomposting the tender coconut waste, the raw was chopped into 5cm bits, a fresh cow dug slurry @200kgs/ tonne of tender nut waste is spread uniformly over the tender nuts in layers and incubated for one month for partial decomposition of the material. The substrate was maintained at 28 -32 ^{0}c and 60-70% relative humidity.Sufficient moisture with 60-70% is maintained by regular sprinkling of water. One or two turnings were made at intervals. After one month, the African night crawler, *Eudrilus Eugenia* were released into the tub@2000 no's/tonne of raw material and incubated by regular watering to maintained the moisture. Mixing of material was done at 15 days interval for uniform composting and enhanced aeration. Compost samples were collected after 56-63% conversion of raw material and data were recorded on time taken for vermicompost production and compost recovery, earthworm count, vermiwash collection etc.Raw samples & compost samples were also collected and send to CTRI, Rajahmundry for analysis of physio chemical properties and nutrient content and economics of vermicompost production was calculated.



Tender coconut bits (mashed) + cow dung slurry (1:2)

Release of earthworm *Eudrilus euginiea*

Mulched with wet gunny

Plate 1: Pretreatment of Tender Coconut Waste

Raw Tender Coconut Waste

Cowdung slurry @200kg/ton of TCW

Release of earthworms

Earthworms @2000/ton

Feeding of the earthworm on TCW

Vermicompost of TCW

Plate 2: Protocol for vermicomposting of Tender Coconut Waste

Results: The data on arrival of nuts and the consumption were collected from 6-8 sale counters in each city during the peak summer by personal interview. The city wise consumption of tender coconut was recorded and the data revealed that maximum consumption of tender nuts was recorded in the major cities *viz*., Hyderabad, Vijayawada, Visakhapatnam with maximum price Rs.30 – 50 per nut during summer months and minimum of Rs.20-25 per nut during off season. In Hyderabad and Vijayawada, public are collecting tender nut water in plastic water bottles @ Rs.50 per one liter. Among all the cities, the pace of increase in the tender nut consumption was pronounced in Hyderabad and Vijayawada was mainly due to the heavy floating population and also more number of hospitals in these cities.

The cities received 4-5 truck loads of tender coconuts from Srikakulam, East Godavari and West Godavari districts during summer months and from Bangalore city during off season. In villages such as Vadali (near Palakollu), Siddhantham, Gannavaram (East Godavari district), villages near Eluru(West Godavari dist), the farmers bought their nuts to the collecting points and the traders paid money to the farmers based on the size of nuts. The price ranged from Rs.5.00 to Rs.7.00 per nut. Daily on an average 4-5 truck loads of each weighing a capacity of 5000 nuts – 10,000 nuts were transported to the cities such as Vijayawada, Guntur, Hyderabad, Warangal etc. The city Visakapatnam received maximum nuts from Srikakulam, nearby villages of Visakapatnam. On an average 400 – 500 MT. of waste was generated in these major cities throughout Andhra Pradesh and for disposal of tender nut waste, the sale counters are paying Rs. 20 – 30/- per day for scavengers. Again, this tender nut waste was dumped on road sides and city outskirts causing lot of sanitary problems.

Mostly the tender coconuts of 5th, 6th, 7th month old nuts are saled in the market. So the tender nuts of different age groups viz., 5^{th}, 6^{th}, 7^{th} month @ three nuts per age group were collected and chopped into small bits, dried in oven at temperature of 50 – 60°C for about 48 hours. Then the dried bits were made into fine powder with blender. The powdered material was sieved and packed according to the age of nuts and sent to Central Tobacco Research Institute, Rajahmundry for analysis of physico – chemical properties of tender coconut waste.The analysied data on physico- chemical properties of raw tender coconut waste was presented in the Table 1, revealed that the pH was slightly acidic ranged from 6.0 to 6.5 with an average of 6.27. The electrical conductivity ranged from 2.25-2.75 dsm^{-1} and organic carbon percentage ranged from 35.60 to 42.20 respectively in different age group of tender coconuts. The tender coconut waste was rich in major and micro nutrients and the nitrogen percentage ranged from 0.45 – 0.62, phosphorous ranged from 0.09 – 0.12 percent while potassium ranged from 2.00 to 2.41 percent. Besides major nutrients, the tender nut waste is rich in iron, manganese, zinc and copper (ppm) etc. Iron ranged from 889- 1261 ppm, manganese from 10.16 -18.33 ppm, zinc from 19.23 to 12.90 ppm and copper from 5.77 – 6.76 ppm. The tender nut waste also contain high amount of cellulose and lignin percentage and the cellulose ranged from 20.23 – 24.30, while lignin percentage ranged from 11.86 to 13.91 percent.

The tender coconut contains lignocellulosic biomass that are highly recalcitrant and strongly resists biodegradation. Hence, under natural condition, the degradation of tender coconut waste took more than two years for complete decomposition. So lignocellulosic biomass of tender coconut waste has to be treated so that the cellulose fibers are exposed to microbial actions. The chopped tender coconut waste was first treated with cowdung slurry @200kg/tonne of raw material for a period of one month & then earthworms @2000no's were released in the tub. The results of the experiment revealed that the biodegradation and decomposition of tender nut waste with earthworms *i.e*., *Eudrilus*

Table 1
Initial physico - chemical properties in Raw Tender Coconut Waste

S. No.	*Physio-chemical properties*	*Tender Nut waste*				
		5 th monthold nut	*6 th monthold nut*	*7 th monthold nut*	*Range*	*Mean*
1.	pH	6.50	6.00	6.30	6.0 – 6.5	6.27
2.	Electrical Conductivity(dsm-1)	2.75	2.25	2.50	2.25 – 2.75	2.50
3.	Organic Carbon	42.20	37.89	35.60	35.60 – 42.20	38.56
4.	Cellulose(%)	20.23	21.43	24.30	20.23 – 24.30	21.99
5.	Lignin(%)	12.11	11.86	13.91	11.86 – 13.91	12.63
6.	Nitrogen(%)	0.62	0.45	0.53	0.45 – 0.62	0.53
7.	Phosphorus(%)	0.12	0.09	0.10	0.09 – 0.12	0.10
8.	Potassium(%)	2.00	2.28	2.41	2.00 – 2.41	2.23
9.	Mn(ppm)	12.15	10.16	18.33	10.16 -18.33	13.55
10.	Fe(ppm)	908.33	889.00	1261.66	889.00- 1261.66	1019.66
11.	Zn(ppm)	10.23	11.48	12.91	10.23 – 12.90	11.54
12.	Cu(ppm)	5.77	6.16	12.91	5.77 – 12.91	8.28

eugeniae significantly reduces the time of composting (Table 2). Vermicompost from tender coconut waste was obtained within 65 –70 days with compost recovery of 63% of the substrate. The pH of the vermicompost is neutral (6.9 – 7.3) with an average of 7.1. The EC (dsm-^{1}) of the vermicompost of tender coconut waste ranged from 0.87 – 0.96 with an average of 0.91. Data recorded on CN ratio, cellulose %, lignin % revealed that there was considerable decrease in CN ratio ranging from 11.92 – 19.06, cellulose % from 9.68 – 11.87 and lignin % 3.97 – 4.86 with an average of 15.35, 10.70% and 4.28% respectively.

The nutrient status of final vermicompost depends upon the raw material used for composting. Vermicasts are rich in nitrogen, phosphates and potash, micronutrients and beneficial soil microbes. It is observed from the table-3, that the average nutrient composition of the vermicompost of tender coconut waste was nitrogen varied from 1.36 – 1.72%, phosphorus 0.20 – 0.27% and potash 2.04 - 2.94%, organic carbon % 20.51 – 25.93 % with an average of 1.55%, 0.23%, 2.48% and 23.42% respectively. The vermicompost recovered from tender nut waste was also rich in micronutrients. All the micronutrients *viz.,* manganese, copper, zinc, iron (ppm) were higher in quantity as compared to the raw tender coconut waste. The vermicompost contained manganese 164 ppm, Iron 8381 ppm, zinc 134.6 ppm, copper 38.33 ppm respectively. Among all the micronutrients, Iron recorded maximum (8381 ppm) in the vermicompost.

A total microbial load (CFU's) was observed high in vermicompost (486.65 CFU/g.). Among all the microbes bacteria recorded highest in vermicompost of tender coconut waste (409.66 x 10^{6} CFU/g.) compared to fungi (41.33 x 10^{4} CFU/g.) and actinomycetes (35.66 x 10^{5}CFU/g.) (Table 4). The compost yield, worm count and vermi wash revealed from the Table 5 that, the compost recovery ranged from 580kg to 680kg with an average of 630 kgs out of one tonne of raw tender coconut waste, while the earth worm count in the final compost ranged from 3782 to 3926 with an average of 3845

Table 2
Compost recovery and physico chemical properties of vermicompost of tender coconut waste

S.no	*Particulars*	*Range*	*Mean*
1.	Days taken for conversion	65.00 -70.00	67.67
2.	Compost recovery (wt. in kgs/one tonne of material)	580.00 – 680.00 (58% -68%)	630.00 (63%)
3.	pH	6.9 -7.3	7.1
4.	EC (dsm^{-1})	0.87 -0.96	0.91
5.	CN ratio	11.62-19.06	15.35
6.	Cellulose (%)	9.68 -11.87	10.70
7.	Lignin (%)	3.97 -4.86	4.28

Table 3
Nutrient content of vermicompost from tender coconut waste

S. no	*Particulars*	*Range*	*Mean*
1.	Nitrogen (%)	1.36 -1.72	1.55
2.	Phosphorus (%)	0.20 -0.27	0.23
3.	Potassium (%)	2.04 -2.94	2.48
4.	Organic Carbon (%)	20.51 -25.93	23.42
5.	Mn (ppm)	158.00 -170.00	164
6.	Fe (ppm)	7986.00 -8964.00	8381
7.	Zn (ppm)	124.00 -148.00	134.60
8.	Cu (ppm)	45.00 -53.00	48.33

Table 4
Microbial load of final vermicompost of tender coconut waste

S.no	*Microbes*	*Range*	*Mean*
1.	Bacteria x 10^6	400.00 -420.00	409.66
2.	Fungi x 10^4	31.00 -45.00	41.33
3.	Actinomycetes x 10^5	34.00 -38.00	35.66
4.	Total CFU	474.00 -503.00	486.65

Table 5
Compost yield, Earthworm count and vermiwash in the Vermicompost of tender nut waste

S.no	*Particularss*	*Range*	*Mean*
1.	Compost yield (kg/one tonne raw material)	580.00 -680.00	630.00
2.	Earthworm count (Nos)	3782.00 -3926.00	3845.67
3.	Vermi wash (litres)	64.00 -83.00	73.00

no's and the vermi wash collected during the process of composting ranged from 64 litres to 83litres with an average of 73litres.

The physico chemical properties of vermicompost of tender coconut waste were compared with raw tender nut. From the table-6, it was evident that Electrical conductivity, Organic carbon (%), cellulose (%), lignin (%), Carbon Nitrogen ratio decreased significantly in vermicompost as against the raw tender coconut waste. There was a considerable increase in pH, major nutrients *viz*., nitrogen, phosphorous and potash content and drastic increase in the micronutrient such as Manganese, Iron, Copper, Zinc when compared with the values of raw tender nut waste. The initial pH of tender coconut waste was ranged from 6.9 – 7.3 with an average of 7.1 and there was 18.33 percent increase of pH in vermicompost as against initial pH (6.0) of tender nut waste. Electrical conductivity (dsm^{-1}) and Carbon Nitrogen ratio are important parameters that determine the compost maturity and Electrical Conductivity (dsm^{-1}) & Carbon Nitrogen ratio gradually reduced with the ageing of composting. An ideal compost should have EC < 1 dsm^{-1}. The matured vermicompost had electrical Conductivity (dsm^{-1}) reduced by 60.40 percent and Carbon Nitrogen ratio by 76.12 compared to 2.50 dsm^{-1} electrical conductivity and 64.26 Carbon Nitrogen ratio in raw tender nut waste. High organic carbon percentage (38.56) was recorded in raw tender nut waste, that was reduced to 23.42% in vermicompost. A significant increase in major nutrients was observed in vermicompost compared to raw tender nut waste. The reason was that vermicomposting process accelerates the mineralization of N content in tender nut waste and this activity of the earthworm attributed to the increase of nutrients in the vermicasts. Nitrogen was increased by 158 percent, phosphorus by 130 percent where as there was slight decrease in potassium content by 11.21% compared to the values of NPK in raw tender nut waste. The micronutrients (ppm) *viz*., Cu, Fe, Zn, Mn, were increased drastically in the vermicompost compared to raw tender nut waste. Manganese was increased from 13.54 ppm in tender nut waste to 164 ppm in vermicompost, Iron 1019.66 ppm to 8381 ppm in vermicompost, Zinc 11.54 – 134.60 ppm in vermicompost whereas Copper 6.23 – 48.33 ppm in vermicompost.

The data on economics analysis of vermicompost of tender coconut waste depicted in table 7 showed that a net returns of Rs 10,890/- per annuam can be obtained through vermicompost and sale of earthworm with benefit cost ratio of 2.15.

DISCUSSION

Tender coconut waste was collected from different places of the villages and nearby towns contains 11.86 to 13.91 % lignin and 20.23 – 24.30% cellulose materials. These lignocellulosic biomass are highly recalcitrant and strongly resists biodegradation due to high lignin content, high crystallinity, high degree of polymerization and presence of acetyl groups on hemicellulose. The presence of lignin in the biomass leads to the protective barrier that prevents plant cell

Table 7
Cost benefit ratio in production of vermicompost through tender nut waste

Particulars	*Gross returns /Tonne*	*Gross returns/annum*	*Cost of Production/annum*	*Net returns/annum*
Compost yield .	Rs. 3,150/-	Rs. 12,600/-	8400/-	4200/-
Earthworms yield	Rs. 1,922/-	Rs. 7,690/-	1000/-	6690/-
Total	**Rs. 5,072/-**	**Rs. 20,290/-**	**9400/-**	**10,890/-**

Vermicompost price @ Rs.5/kg, Earthworm price @ 0.50 paise

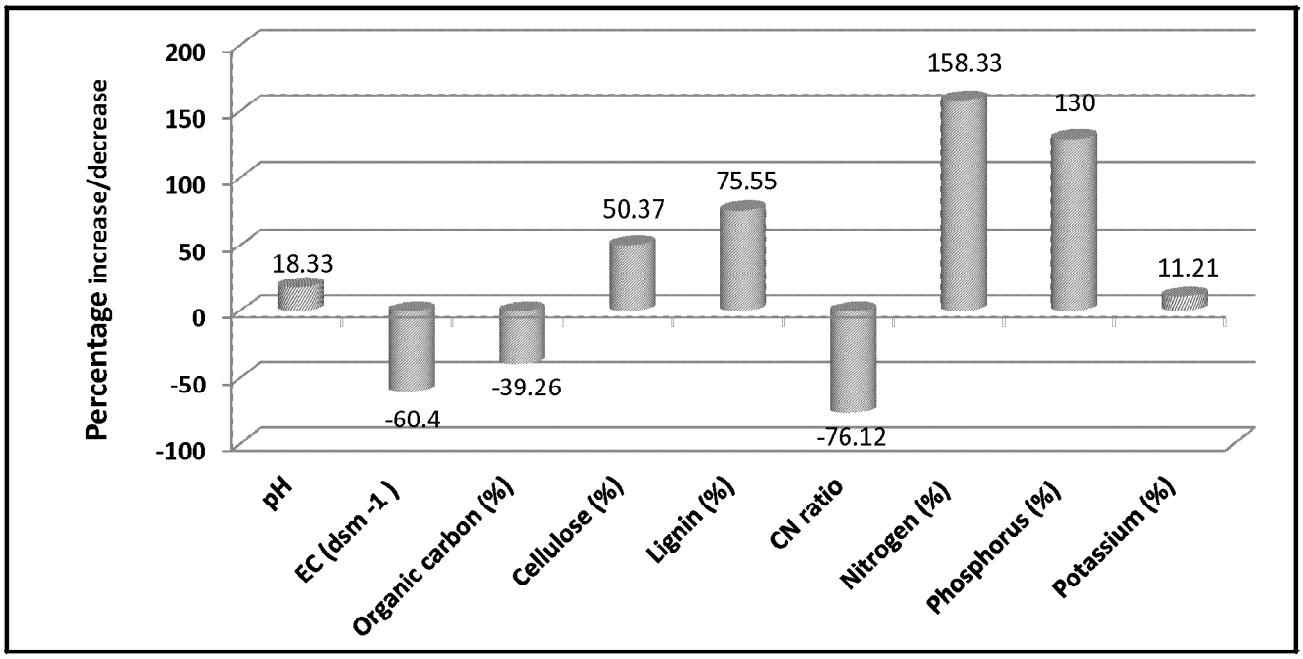


Figure 1: Percentage increase/decrease of physico-chemical parameters in the vermicompost of tender coconut waste

destruction by microbial enzymes. Hence, under natural condition, the degradation of tender coconut waste took more than two years for complete decomposition. So lignocellulosic biomass of tender coconut waste was treated so that the cellulose fibers are exposed to microbial actions. The tender coconut waste was chopped into bits and treated with 200kg / one tonne of TCW and incubated for one month before release of earthworms.

Vermicomposting involves the bio-oxidation and stabilization of organic material by the joint action of earthworms and microorganisms whereas composting involves the accelerated degradation of organic matter by microorganisms under controlled conditions, in which the organic material undergoes a characteristic thermophilic stage [7]. In vermiprocessing, the tender coconut bits were pretreated with cow dung slurry and incubated for one month, then the earthworms *Eudrilus euginiae* was released @ 2000 no.s/ tonne, that took 68 days for conversion of raw material into vermicompost with compost recovery of 63% of the substrate. Thus, the degradation of tender coconut waste with earthworms significantly reduced the time of composting. In other words, the vermi processing took 3 months for conversion of tender coconut waste.The pH values at the final stage increased and electricial conductivity decreased drastically. These increased pH values at the final stage of vermicomposting can be attributed to the decomposition of nitrogenous substrates, resulting in the production of ammonia which formed a large proportion of the nitrogenous matter excreted by the earthworms [8]. An EC of less than 1 dsm^{-1} is found normal for right compost and EC gradually decreases with ageing of composting. The EC (dsm^{-1}) of the vermicompost of tender coconut waste ranged from 0.87 – 0.96.There was considerable decrease in CN ratio ranging from 11.92 – 19.06, cellulose % from 9.68 – 11.87 and lignin % 3.97 – 4.86. This could be attributed that the earthworms harbor millions of nitrogen – fixing and decomposer microbes in their gut. The worm secrete enzymes; proteases, lipases, amylases, cellulases and chitinases in their gizzard and intestine that brings

rapid biochemical conversion of the cellulosic and lignocellulosic materials in the organic waste. [5] opined that because of the combined action of microorganisms and the earthworms, a large fraction of the organic matter in the initial substrates was lost as CO2 by the end of the vermicomposting period. The lowering of C/N ratio during vermicomposting is achieved by the combustion of carbon substrates during respiration.

A significant increase in the major nutrients and micronutrients was observed in vermicompost of tender coconut waste. The increased levels of macro and micro nutrients in the vermicompostare in agree with the results of the earlier studies [1], [10], [12], [4], [9], [2], opined that the increased organic carbon and nitrogen content of the worm gut might also stimulate the microbial activity. The activity of earthworm *Eudrilus euginiea* increased the microbial load in the vermicompost. Similar trend was observed by various authors [3], [5], [4] and [11], [6] described that the alimentary canal of the earthworm carries great numbers of bacteria, fungi and actinomycetes. The major source of nutrients for earthworms is microorganisms and the earthworms promote microbial activity during the decomposition of organic matter. The process by which the microbes benefit from the mucus secretions of the earthworm and the process by which the earthworms benefit from the enhanced microbial decomposition of ingested organic matter make their relationship mutually symbiotic. During the process of vermicomposting, the earthworm population was doubled and an average of 74 litres of vermi wash was collected which is beneficial to the plants.This study endorses vercompostingof tender coconut as a feasible economic possible small scale industry which can not only be used by farmers & agro based industries but alsofor commercial us.

CONCLUSION

In the light of present investigation carried out, vermicomposting of tender coconut waste with *Eudrilus eugeniae* significantly reduces the time of composting with highest compost recovery, reduced CN ratio, lignin cellulose content. As observed from the results of the present study,by feeding the earthworms with tender nut waste, nutritionally and microbiologically rich vermicasts with good enzymatic activities can be produced which can supplement the nutrients to the soil and help maintaining fertility status.

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