RESEARCH ARTICLE
Open Access

Journal of Veterinary and Animal Sciences
ISSN (Print): 0971-0701, (Online): 2582-0605
https://doi.org/10.51966/jvas.2023.54.2.499-509

Chemical properties of aerobic compost from abattoir and poultry slaughter waste#

M. Manasa[1], V. N. Vasudevan[2*], A. Latha[3], B. Sunil[4], A. Irshad[5], P.T. Suraj[6],

V.V. Akhila[1], C. Hridhya[1] and K. Anjitha[1]
Department of Livestock Products Technology,
College of Veterinary and Animal Sciences, Mannuthy, Thrissur-680 651,
Kerala Veterinary and Animal Sciences University,
Kerala, India

Citation: Manasa, M., Vasudevan, V. N., Latha, A., Sunil, B., Irshad, A., Suraj, P. T., Akhila, V. V., Hridhya, C. and Anjitha, K. Chemical properties of aerobic compost from abattoir and poultry slaughter waste. *J. Vet. Anim. Sci.* **54**(2):499-509
DOI: https://doi.org/10.51966/jvas.2023.54.2.499-509

Received: 14.11.2022 *Accepted: 24.01.2023* *Published: 30.06.2023*

Abstract

The present study was undertaken to analyse the chemical properties of aerobic compost from abattoir and poultry slaughter waste. Various abattoir waste materials like rumen contents, abattoir sewage sludge, poultry feathers and commercially available coir pith were pre-processed and separately analysed for their physico-chemical properties. Based on the analysis of physico-chemical properties of raw materials, five different combinations were selected for aerobic composting viz. sludge and coir pith (1:1); rumen contents alone (100); rumen contents and poultry feathers (1:1); rumen contents and sludge (1:1); rumen contents, sludge and coir pith (1:1:0.5). The selected combinations were subjected for aerobic composting for a period of 60 days in biobins. Chemical properties like organic carbon, total nitrogen, carbon to nitrogen ratio (C: N ratio), total phosphorus and total potassium before and after composting were analysed. There was a significant (p<0.05) increase in total nitrogen, total phosphorus and total potassium content and significant (p<0.05) decrease in C: N ratio and organic carbon content after composting.

Keywords: *Abattoir waste, aerobic composting, chemical properties*

India has about 4,000 slaughter houses registered with the local bodies and 111 export-oriented abattoirs. In Kerala, about 38,100 tonnes of slaughter waste is being generated from 15,680 meat handling units among which only 666 units have proper waste disposal system. A substantial proportion of slaughter house by-products and waste materials are incinerated or land

#Part of MVSc thesis submitted to Kerala Veterinary and Animal Sciences University, Pookode, Wayanad, Kerala

1. *MVSc Scholar, Department of Livestock Products Technology*
2. *Associate Professor and Head, Department of Livestock Products Technology*
3. *Professor and Head, Department of Agricultural Research Station*
4. *Professor and Head, Department of Veterinary Public Health*
5. *Assistant Professor, Department of Livestock Products Technology*
6. *Associate Professor, Department of Livestock Production and Management*

**Corresponding author: vasudevan@kvasu.ac.in, Ph. 9447382558*

filled, leading to additional production costs and adverse environmental impact (Adhikari *et al*., 2018).

Organic wastes generated in slaughterhouses are mainly bovine blood and rumen digesta characterized by the presence of organic carbon and nitrogen and contain several infectious pathogens as well (Salminen and Rintala, 2002). Rumen contents and blood constitute 16 per cent and four per cent of the live weight of the animal, respectively. Their safe disposal is an economical as well as an environmental challenge not only in India but also in other developing countries. Generally, slaughterhouse wastes are treated through anaerobic digestion, acid hydrolysis, rendering, incineration and composting methods. These sophisticated waste management technologies are not adopted by the small rural Indian slaughterhouses due to lack of infrastructure and low volume of wastes generated.

Slaughterhouse wastewater is rich in organic carbon, nitrogen and phosphorus that provides plant nutrients and organic matter to the soil required for crop production. The sludge obtained from slaughterhouse wastewater treatment is a potential rich source of plant nutrients. In addition, it includes a large amount of organic matter, which could facilitate the bioavailability of macro and micronutrients and improve the soil structure. However, direct application of untreated organic wastes to agriculture is improper because of their undetermined composition (Roy *et al*., 2015). Rintu *et al*. (2021) reported that disposal of abattoir sludge was the most difficult part of its management. The current method of sludge utilisation includes land filling. But this may cause some serious consequences like odour, pathogenic contamination and excessive nutrients in the soil. Poultry feathers are rich with keratin protein and therefore they could be a source for good nitrogen fertilizer. Coir pith is a by-product of the coir industry which not only helps in upgrading the structure of soil but also enhances the physical properties of soil (Arun *et al*., 2022).

Composting has both an immediate and long-term beneficial effect on the soil structure when used in appropriate amounts. Previous works by Ragalyi and Kadar (2012) had demonstrated that agricultural application of composted slaughterhouse wastes enhanced the quality and productivity of maize, mustard and triticale in Hungary as well as residual soil fertility which was noticed even after three to four years of cultivation. Incorporation of sludge and poultry feathers can improve the soil quality and nutrient content which also makes them useful as mulch for crops. With this background, the current study was undertaken to determine the chemical properties of aerobic compost from abattoir and poultry slaughter waste.

Materials and methods

Collection of raw materials

Rumen contents and blood were collected from cattle and buffaloes slaughtered as per scientific slaughter procedures in Meat Technology Unit of Kerala Veterinary and Animal Sciences University, Mannuthy. Coir pith for this study was purchased locally. The sludge was collected from the secondary settling tank of sewage treatment plant maintained at Corporation Slaughterhouse, Thrissur. Poultry feathers were collected from broiler chicken and duck routinely slaughtered in Meat Technology Unit, Mannuthy.

Preprocessing of rumen contents, poultry feathers, coir pith and sludge for composting

Rumen contents collected from slaughtered animals were initially sun dried for three days (approximately 18 h) to attain a moisture content of less than five per cent. The collected poultry feathers were sun dried for about nine hours and later on pulverised using a pulveriser having a fine mesh (East India Company, Cochin). In order to reduce electrical conductivity, the coir pith was washed twice using tap water. The washed coir pith was spread on a polythene sheet and sun dried for about nine hours. The sludge was initially filtered using a muslin cloth to separate the suspended sludge from the fluid. The filtered sludge was spread on a polythene sheet and sun dried for two days to have a moisture content of less than five per cent.

Analysis of physio-chemical properties of pre-processed rumen contents, poultry feathers, coir pith and sewage sludge

The pre-processed raw materials were evaluated for pH, electrical conductivity, moisture, organic carbon, total nitrogen using modified Kjedahl method described by Prasannakumar (2016), carbon: nitrogen ratio, total potassium by diacid method using flame photometer as per Jackson (1967) and total phosphorous by diacid digestion method as described by Jackson (1967).

Formulation of different combinations of pre-processed rumen contents, poultry feathers, coir pith and sewage sludge for composting

Five different combinations of pre-processed rumen contents, poultry feathers, coir pith and sewage sludge which were used for composting are presented in Table 1. Based on physico-chemical properties of individual raw materials, the five different combinations were formulated with the criteria that each combination had the highest values for at least two of the three primary nutrients for plant growth (nitrogen, phosphorous and potassium). Very high or very low C: N ratio is not recommended for composting (Asadu *et al*., 2018). Hence the selection was based on the criteria that the selected combination attains optimum C: N ratio.

Table 1. Compost treatments

Combinations	Proportions
Sludge + Coir pith	1:1
Rumen contents alone	100
Rumen contents + Poultry feathers	1:1
Rumen contents + Sludge	1:1
Rumen contents + Sludge + Coir pith	1:1: 0.5

Aerobic composting of different combinations of rumen contents, poultry feathers, sludge and coir pith

Before composting, about 100g each of the five treatments as mentioned in Table 1 were analysed for their chemical properties viz. organic carbon, total nitrogen, C: N ratio, total, potassium and total phosphorus.

For composting, 1.5 kg each of the five treatments were placed in aerobic composting units referred to as "biobins" used for composting household wastes which was developed in the Department of Agricultural Microbiology, College of Horticulture, Vellanikkara (Fig. 1.). Biobins had a cylindrical structure having 3.5 feet height and 1.5 feet diameter and made of steel mesh with an inner cylinder of 3 feet height and 1 feet diameter. The spaces between the two mesh cylinders were filled with dry leaves. The components in the biobins were placed in two layers, each of six-inch thickness. On the day of placing raw material in the biobins,

Fig. 1. Biobins set up for composting slaughter house waste

first layer in the biobins was sprinkled with 200 ml of diluted (1:4 in water) Composting Tonic. After layering the second layer over the first, the Composting Tonic (200 ml) was once again sprinkled followed by wetting of layers using 500 ml of water after 30 minutes (approximately). Every day, materials in the biobins were mixed manually using a metal rod. On every seventh day, 500 ml of water was sprinkled over the composting materials in the biobins to retain moisture for proper microbial action (Shilpa and Girija, 2021). One month after the start of composting, a second application of diluted Composting Tonic (400 ml) was carried out. Three composting trials were conducted for each of the five treatments. Composted samples of each of the five treatments were also analysed for their chemical properties viz. organic carbon, total nitrogen, C: N ratio, total, potassium and total phosphorus contents.

Results and discussion

pH

The pH of different pre-processed raw materials are presented in Table 2 which differed significantly (p<0.05). The lowest pH (5.76±0.05) was observed for poultry feathers which differed significantly from other raw materials. The rumen contents recorded the highest pH (8.1± 0.05) which was significantly (p<0.05) higher than all other raw materials. The pH of the treatments was in compliance with the range of values prescribed by FCO (1985) except for rumen contents. The results obtained were in accordance with Roy *et al*. (2013). Micronutrients were more mobile at low pH levels (4.0), resulting in toxicity. At high pH (>9.0) the micronutrients were less mobile, which lowered plant uptake and led to symptoms of shortage (Pennisi and Thomas, 2009).

Electrical conductivity

The electrical conductivity values of different pre-processed raw materials are shown in Table 2. Electrical conductivity was the lowest (0.028 ±0.001dS/m) for coir pith. The highest electrical conductivity was observed for rumen contents (4.5±0.05dS/m) which was significantly higher (p<0.05) than all other raw materials. Electrical conductivity in the present study was similar to the values reported by Han *et al*. (2016) for cattle manure. The electrical conductivity value of coir pith in the present study was in accordance with Jana and Boxi (2022). Sankar *et al*. (2022) reported that repeated washing of coir pith significantly reduced its electrical conductivity which could be attributed to the loss of salts during the washing of coir pith.

Organic carbon

The organic carbon contents of raw materials are shown in Table 2. The organic carbon content was the highest (96±0.05 per cent) for rumen content which was significantly (p<0.05) different from all other raw materials. The lowest organic carbon content (27.11±0.11per cent) was recorded in sludge.

Li *et al*. (2017) reported that the application of NPK + cattle manure increased total organic carbon (TOC) by 143.4 per cent than NPK alone. The carbon content obtained for sludge in the current study was in accordance with Rintu (2022). Tesfaye *et al*. (2017) noted that the organic carbon content of poultry feathers ranged from 47.4 to 59 per

Table 2. Physico - chemical properties of raw materials

Parameters	Rumen contents	Sludge	Coir pith	Poultry feathers
pH	9.7± 0.05^{d}	6.1±0.05^{b}	6.5±0.05^{c}	5.76±0.05^{a}
Electrical Conductivity(dS/m)	4.5±0.05^{d}	2.38±0.01^{c}	0.028±0.01^{a}	0.820±0.01^{b}
Organic carbon (%)	96±0.05^{d}	27.11±0.11^{a}	72±0.05^{c}	58.2±0.05^{b}
Nitrogen (%)	1.48±0.01^{b}	2.96±0.01^{c}	0.84±0.01^{a}	14.85±0.01^{d}
Carbon /Nitrogen ratio	64.86±0.21^{c}	9.15±0.01^{b}	85.71±0.52^{d}	3.91±0.002^{a}
Potassium (%)	1.85±0.01^{c}	1.72±0.01^{a}	1.76±0.01^{b}	1.72±0.01^{a}
Phosphorous (%)	1.52±0.01^{c}	1.83±0.01^{d}	0.22±0.01^{a}	0.72±0.01^{b}

Mean ± S.E. of different raw materials with different alphabets as superscripts differ significantly at p<0.05

cent which was in accordance with the results obtained in the current study. Coir pith recorded higher values of organic carbon which was in concurrence with Abad *et al*. (2002) and Solaimalai *et al*. (2003) who stated that coir pith recorded higher carbon content and majority of that carbon being in the form of lignin and cellulose, rendered it extremely resistant to microbial deterioration.

Total nitrogen

Total nitrogen contents of different raw materials are shown in Table 2. Poultry feathers recorded the highest nitrogen value (14.85±0.01per cent). The amount of nitrogen was the lowest (0.84±0.01 per cent) in coir pith which was significantly ($p<0.05$) different from rumen contents (1.48±0.01 per cent) and sludge (2.96±0.01 per cent).

The nitrogen content of the sludge in the present study was in accordance with Gomez *et al*. (2005). They observed that the total nitrogen content ranged from 2.1-6.2 per cent for aerobic-digested sludge. Ozdemir *et al*. (2018) reported that application of poultry abattoir sludge (PAS) had a substantial impact on plant tissue's nitrogen content and applying PAS at higher rates resulted in increased nitrogen content. Tesfaye *et al*. (2017) observed that chicken feathers contain a significant amount of nitrogen (about 15 per cent) which was in accordance with the total nitrogen content observed for poultry feathers in the current study. Coir pith recorded lowest nitrogen content which was in concurrence with Thomas *et al*. (2013) who stated that coir pith had lesser nitrogen content and wide C: N ratio, the raw application of which would result in nitrogen deficiency due to microbial immobilisation and hence not recommended.

Carbon: Nitrogen ratio

The carbon: nitrogen (C: N) ratios of different raw materials are presented in Table 2. The highest C: N ratio (85.71±0.52) was observed in coir pith followed by rumen contents (64.86±0.29). The lowest C: N ratio was recorded in poultry feathers (3.91±0.002) which was significantly ($p<0.05$) lower than all other raw materials.

In the current study coir pith recorded highest C: N ratio which was almost similar to value obtained by Ghosh *et al*. (2007) who recorded carbon: nitrogen ratio of 82:1 in coir pith. Durmaz and Sanin (2003) reported that C: N ratio was found to be 9 for an activated sludge which was in accordance with value obtained for sludge in the current study.

Total potassium

Total potassium contents of different raw materials are shown in Table 2. The highest potassium content (1.85±0.01 per cent) was observed in rumen contents followed by coir pith (1.76±0.01per cent). Total potassium content was the lowest in sludge (1.72±0.01) which was significantly ($p<0.05$) lower than all other raw materials.

In the current study the highest potassium value was observed in rumen contents which was in agreement with Belyea *et al*. (1978) who stated that rumen potassium concentration was highly correlated with potassium intake and potassium concentration in the diet. There was a significant increase in rumen potassium level when forages rich in potassium were fed. Abad *et al*. (2002) reported that coir pith had a high potassium content which was in agreement with the current study

Total phosphorus

Total phosphorus contents of different raw materials are shown in Table 2. Maximum phosphorus content (1.83±0.01 per cent) was recorded in sludge followed by rumen contents (1.52±0.01 per cent) which were significantly ($p<0.05$) different. The lowest phosphorus content of (0.22±0.01per cent) was recorded in coir pith.

In the current study highest phosphorous content was recorded in sludge which was in agreement with Ahmad *et al*. (2016) who reported higher phosphorus content (2 per cent) in raw sewage sludge. Coir pith recorded the lowest phosphorus content which was in compliance with Jeyaseeli and Raj (2010) who stated that coir pith medium had rich quantities of potassium, sodium and chloride and had very low levels of phosphorus, calcium and nitrate.

Sludge and coir pith (1:1)

The comparison of different chemical properties for the combination of sludge and coir pith before and after composting is shown in Table 3. There was a significant ($p<0.05$) increase in total nitrogen, total phosphorus, and total potassium content of composted sludge and coir pith as compared to non- composted material. However, there was a significant ($p<0.05$) decrease in organic carbon content (35.5±0.05) and C: N ratio (30.87±0.35) after composting.

Garcia *et al*. (1991) reported that aerobic composting of sewage sludge increased its agricultural value, as it raised potassium and phosphorous content and reduced the total organic carbon ratio which was in accordance with the current study. Further, they stated that sewage sludge composts acted as a good organic fertilizer as they provided an enormous quantity of organic matter, macronutrients and improved crop yield.

Rumen contents

The comparison of different chemical properties of rumen contents before and after composting is shown in Table 4. Total nitrogen (1.81±0.01), total phosphorus (0.98±0.01) and total potassium content (1.71±0.01) were significantly higher in composted rumen contents ($p<0.05$). C: N ratio and organic carbon content reduced significantly ($p<0.05$) after composting.

The nutrients in rumen contents are highly unstable in the raw state and their direct application into the soil, results in high nitrate levels because of the stabilisation process taking place in the soil during which these unstable nutrients react and bond with each other which ultimately leads to altering that soil's existing nutrient balance and soil structure. This condition can create high nitrates and an overall unhealthy soil condition (Wilson 1992). Mieldazys *et al*. (2019) reported the organic carbon content of granulated beef cow manure compost fertilizer to be 46.92 per cent which was lower than the value obtained in the current study. The significant reduction in carbon content and C: N ratio could be attributed to the fact that carbon is used by microorganisms as a source of energy for growth and multiplication. Some fractions are lost as carbon dioxide (CO_2) during decomposition while the remaining fractions are converted to humus (Asadu *et al.*, 2018). Souza *et al*. (2016) reported that routine soil analysis showed significant increase in N, P

Table 3. Comparison of chemical properties of combination sludge and coir pith before and after composting

Parameters	Before composting	After composting
Organic carbon (%)	50.66±0.38^{B}	35.5±0.05^{A}
Total nitrogen (%)	0.97±0.01^{A}	1.15±0.01^{B}
Carbon /Nitrogen ratio	52.23±0.30^{B}	30.87±0.35^{A}
Total potassium (%)	1.18±0.01^{A}	1.77±0.01^{B}
Total phosphorus (%)	1.53±0.01^{A}	1.61±0.01^{B}

Mean ± S.E. of sludge and coir pith with alphabets A-B as superscripts within rows differ significantly at $p<0.05$

Table 4. Comparison of chemical properties of the combination of rumen contents before and after composting

Parameters	Before composting	After composting
Organic carbon (%)	96±0.05^{B}	52.5±0.01^{A}
Total nitrogen (%)	1.48±0.01^{A}	1.81±0.01^{B}
Carbon /Nitrogen ratio	64.86±0.29^{B}	29.00±0.01^{A}
Total potassium (%)	1.512±0.01^{A}	1.71±0.01^{B}
Total phosphorus (%)	0.88±0.01^{A}	0.98±0.01^{B}

Mean ± S.E. of rumen contents with alphabets A-B as superscripts within rows differ significantly at $p<0.05$

and K concentrations along with an increase in compost rate application containing ruminant's waste.

Rumen contents and poultry feathers (1:1)

The comparison of different chemical properties for the combination of rumen contents and poultry feathers before and after composting is shown in Table 5. There was a significant ($p<0.05$) increase in total nitrogen, total phosphorus and total potassium content of composted rumen contents and poultry feathers as compared to non-composted material. After composting there was a significant ($p<0.05$) decrease in the C: N ratio (18.35±0.01). Organic carbon content was significantly lower after composting in comparison with organic carbon content before composting.

Poultry feather wastes have become an environmental problem so the cheap and easy way of feather-utilisation is composting with manure (Tronina and Fabiola, 2008). In the present study there was significant decrease in C: N ratio after composting which was in accordance with Asadu *et al.* (2018) who reported that there was significant decrease in organic carbon and decrease in C: N ratio of composts of sawdust and chicken litter from 27.9-31.3 to 19.4-22.8 after composting. Further, they also noticed that there was significant increase in total nitrogen, total phosphorus and total potassium after composting.

Rumen contents and sludge (1:1)

The comparison of different chemical properties for rumen contents and sludge before and after composting is shown in Table 6. Total nitrogen (1.93±0.01), total phosphorus (1.77±0.01) and total potassium content (1.72±0.01) were significantly higher ($p<0.05$) after composting. The C: N ratio and organic carbon content reduced significantly after composting.

Nunes *et al*. (2015) noted that compost made by combining tannery effluent sludge and slaughterhouse waste (rumen contents) contained 1.83 percent nitrogen which was almost similar to the values obtained in the current study. They also recorded significant increase in total phosphorus, total potassium and decrease in C: N ratio in composted material. The increase in nitrogen content during composting could be attributed to *Streptomyces* spp. which was widely known for its ability in fixing nitrogen (Azimi *et al.*, 2016).

Table 5. Comparison of chemical properties of combination of rumen contents and poultry feathers before and after composting

Parameters	Before composting	After composting
Organic carbon (%)	$54±0.05^{B}$	$34.5±0.05^{A}$
Total nitrogen (%)	$1.58±0.01^{A}$	$1.88±0.01^{B}$
Carbon /Nitrogen ratio	$34.18±0.16^{B}$	$18.35±0.01^{A}$
Total potassium (%)	$1.55±0.01^{A}$	$1.75±0.01^{B}$
Total phosphorus (%)	$1.69±0.01^{A}$	$1.89±0.01^{B}$

Mean ± S.E. of rumen contents and poultry feathers with alphabets A-B as superscripts within rows differ significantly at $p<0.05$

Table 6. Comparison of chemical properties of combination of rumen contents and sludge before and after composting

Parameters	Before composting	After composting
Organic carbon (%)	$57±0.05^{B}$	$39±0.05^{A}$
Total nitrogen (%)	$1.49±0.01^{A}$	$1.93±0.01^{B}$
Carbon /Nitrogen ratio	$38.12±1.50^{B}$	$20.20±0.01^{A}$
Total potassium (%)	$1.52±0.01^{A}$	$1.72±0.01^{B}$
Total phosphorus (%)	$1.52±0.01^{A}$	$1.77±0.01^{B}$

Mean ± S.E. of rumen contents and sludge with alphabets A-B as superscripts within rows differ significantly at $p<0.05$

Rumen contents, sludge and coir pith (1:1:0.5)

The comparison of different chemical properties for the combination of rumen contents, sludge and coir pith before and after composting is shown in Table 7. There was a significant ($p<0.05$) increase in total nitrogen, total phosphorus and total potassium contents of composted rumen contents, sludge and coir pith as compared to non-composted material. After composting there was significant decrease in the C: N ratio. Organic carbon content was significantly ($p<0.05$) lower after composting

Conclusion

According to the findings of the current study, aerobic composting was the best way to dispose of slaughterhouse solid waste in cost effective and ecofriendly manner. It was an effective method of conversion of solid waste into valuable end product which can be utilised as soil amended for agricultural purposes. There was a significant reduction in organic carbon and C: N ratio which results in quick mineralization of nutrients resulting in early availability of nutrients to the plant. There was a significant increase in the plant primary nutrients like total nitrogen content, total phosphorus and total potassium content after composting in all the combinations resulting in increased plant growth and yield parameters. Rumen contents, sludge and coir pith (1:1:0.5) had lowest C:N ratio and higher nitrogen, potassium and phosphorous content and hence can be considered as the best combination that can yield better plant growth and yield parameters.

Table7. Comparison of chemical properties of combination of rumen contents, sludge and coir pith before and after composting

Parameters	Before composting	After composting
Organic carbon (%)	78 ± 0.05^{B}	45 ± 0.05^{A}
Total nitrogen (%)	1.95 ± 0.01^{A}	2.49 ± 0.01^{B}
Carbon /Nitrogen ratio	40 ± 0.08^{B}	18.07 ± 0.01^{A}
Total potassium (%)	1.62 ± 0.01^{A}	1.825 ± 0.01^{B}
Total phosphorus (%)	1.71 ± 0.01^{A}	1.94 ± 0.01^{B}

Mean ± S.E. of rumen contents, sludge and coir pith with alphabets A-B as superscripts within rows differ significantly at $p<0.05$

Ojobor and Egbuchua (2020) reported that abattoir wastewater could be a source of soil nutrients, the wastewater with low C: N ratio (6:2) was used to compost rice dust (C: N ratio 83:1) which enhanced the quality of the rice dust, that could be used for soil amendment. Asadu *et al.* (2018) recorded decrease in C: N ratio of composts of a mixture of sawdust and sewage sludge from a range 25.7- 28.2 to 20.81-23.17 after composting. However, the present study recorded a lower C: N ratio in the composted raw materials than reported by Asadu *et al.* (2018) which could be attributed to the composition of the raw material, time of composting, oxygen availability and composting methodology (Sharma *et al*., 1997). Ratnawati *et al*. (2016) observed a C: N ratio of 13.71 for aerobically composted slaughterhouse solid waste (fresh paunch manure) which was lower than the values obtained in the current study. The increased C: N ratio could be due to the incorporation of coir pith which had a wider C: N ratio.

Acknowledgements

The authors are grateful to the Kerala Veterinary and Animal Sciences University for providing the research facilities to complete this study.

Conflict of interest

The authors declare that they have no conflict of interest.

References

Abad, M., Noguera, P., Puchades, R., Maquieira, A. and Noguera, V. 2002. Physico-chemical and chemical properties of some coconut coir dust for use as a peat substitute for containerised ornamental plants. *Bioresour. Technol.* **82**: 241-245.

Adhikari, B.B., Chae, M. and Bressler, D.C. 2018. Utilization of slaughterhouse waste in value-added applications: Recent advances in the development of wood adhesives. *Polymers,* **10:** 176-180

Ahmad, T., Ahmad, K. and Alam, M. 2016. Sustainable management of water treatment sludge through 3 'R' concept. *J. Cleaner. Prod.* **124**: 1-13.

Arun Sankar, K. J., Vasudevan, V.N., Sunil, B., Latha, A., Irshad, A., Deepak Mathew, D.K. and Safeer Saifuddeen, M. 2022. Evaluation of chemical properties of organic briquettes developed from slaughterhouse waste. *J. Vet. Anim. Sci.* **53**(1): 44-48.

Asadu, C.O., Aneke, N.G., Egbuna, S.O. and Agulanna, A.C. 2018. Comparative studies on the impact of bio-fertilizer produced from agro-wastes using thermo-tolerant actinomycetes on the growth performance of Maize (Zea-mays) and Okro (*Abelmoschus esculentus*). *Environ. Technol. Innovation* **12**:.55-71.

Azimi, S., Basei Salehi, M. and Bahador, N. 2016. isolation and identification of *Streptomyces ramulosus* from soil and determination of antimicrobial property of its pigment. *Mod. Med. Lab*. **1**: 36-41.

Belyea, R.L., Martz, F.A., Young, R.D. and Clark, J.L. 1978. Effects of dietary potassium and rumen contents upon 40K estimation of body composition in dairy cattle. *J. Anim. Sci*. **46**: 320-327.

Durmaz, B. and Sanin, F.D. 2003. Effect of carbon to nitrogen ratio on the physical and chemical properties of activated sludge. *Environ. Technol.* **24**: 1331-1340.

FCO [Fertilizer Control Order]. 1985. *Specifications of biofertilizers.* (1st Ed.). Ministry of Agriculture and Rural Development, Government of India, New Delhi, 91p.

Garcia, C., Hernandez, T. and Costa, F. 1991. The influence of composting on the fertilizing value of an aerobic sewage sludge. *Plant Soil*, **136:** 269-272.

Ghosh, P.K., Sarma, U.S., Ravindranath, A.D., Radhakrishman, S. and Ghosh, P. 2007 A novel method for accelerated composting of coir pith. *Energy Fuels,* **21**: 822–827.

Gómez-Rico, M.F., Font, R., Fullana, A. and Martín-Gullón,I.2005.Thermogravimetric study of different sewage sludges and their relationship with the nitrogen content. *J. Analyt. Appl. Pyrolysis.* **74**: 421-428.

Han, S.H., An, J.Y., Hwang, J., Kim, S.B. and Park, B.B. 2016. The effects of organic manure and chemical fertilizer on the growth and nutrient concentrations of yellow poplar (Liriodendron tulipifera) in a nursery system. *Forest Sci. Technol.* **12**: 137-143.

Jackson, M.L. 1967. *Soil chemical analysis*. (2nd Ed.). Hall of India Private Limited, New Delhi, 498p.

Jana, P. and Boxi, S.S. 2022. Studies on pH, conductivity, and moisture retention capacity of coir pith for its application as the plant growing medium. *J. Nat. Fibers*. **19**: 2861-2867.

Jeyaseeli, D.M. and Raj, S.P. 2010. Chemical characteristics of coir pith as a function of its particle size to be used as soilless medium. *Ecoscan*. **4**: 163-169.

Li, F., Chen, L., Zhang, J., Yin, J. and Huang, S. 2017. Bacterial community structure after long-term organic and inorganic fertilization reveals important associations between soil nutrients and specific taxa involved in nutrient transformations. *Front. Microbiol*. **8**: 187-192

Mieldažys, R., Jotautienė, E., Jasinskas, A., Pekarskas, J. and Zinkevičienė, R. 2019. Investigation of physical-mechanical properties and impact on soil of granulated manure compost fertilizers. *J. Environ. Eng. Landsc. Mgmt.* **27**: 153-162.

Nunes, W.A.G.D.A., Menezes, J.F.S., Benites, V.D.M., Lima Junior, S.A.D. and Oliveira, A.D.S. 2015. Use of organic compost produced from slaughterhouse waste as fertilizer in soybean and corn crops. *Scientia Agricola*. **72**: 343-350.

Ojobor, S.A. and Egbuchua, C.N. 2020. Use of Abattoir wastewater compost as organic fertilizer for rice production on a ultisol in Delta State, Nigeria. *Asian J. Agric. Rural Dev.* **10**: 682-689.

Ozdemir, S., Nuhoglu, N.N., Dede, O.H. and Yetilmezsoy, K. 2018. Mitigation of soil loss from turfgrass cultivation by utilizing poultry abattoir sludge compost and biochar on low-organic matter soil. *Environl. Technol.* **8**: 23-29.

Pennisi, S.V. and Thomas, P.A. 2009. Essential pH management in greenhouse crops-part 1: pH and plant nutrition. *Bioresour. Technol.* **23**: 67-72.

Prasannakumar, B. 2016. Aerobic and anaerobic digestion of agricultural waste followed by vermicomposting and enrichment. *M.Sc. thesis*, Professor Jayashankar Telangana State Agricultural University, Hyderabad, 83p.

Ragályi, P. and Kádár, I. 2012. Effect of organic fertilizers made from slaughterhouse wastes on yield of crops. *Arch. Agron. Soil Sci.* **58**: 122-126.

Ratnawati, R., Trihadiningrum, Y. and Juliastuti, S.R. 2016. Composting of rumen content waste using anaerobic-anoxic-oxic (A2/O) system. *J. Solid Waste Technol. Mgmt*. **42**: 98-106.

Rintu, J., Sathu, T., Sunil, B., Vasudevan, V.N., Deepak Mathew, D.K. Jishnu,P., Ann T.J. andYashodhan, S. P. 2021. Abattoir sludge and food waste combination as a feed source for black soldier fly larvae: optimisation of level of larval incorporation in the substrate. *J. Vet. Anim. Sci.* **53**(4): 617-624.

Rintu, J. 2022. Abattoir sludge as substrate for biomass productivity of Black Solider Fly Larvae *M.V.Sc. thesis*, Kerala Veterinary and Animal Sciences University, Pookode, 84p.

Roy, M., Das, R., Debsarcar, A., Sen, P.K. and Mukherjee, J. 2015. Conversion of rural abattoir wastes to an organic fertilizer and its application in the field cultivation of tomato in India. *Renew. Agric. Food Syst.* **31**: 350-360.

Roy, M., Karmakar, S., Debsarcar, A., Sen, P.K. and Mukherjee, J. 2013. Application of rural slaughterhouse waste as an organic fertilizer for pot cultivation of solanaceous vegetables in India. *Int. J. Recycling Org. Waste Agric.* **2**: 6-23.

Salminen, E. and Rintala, J. 2002. Anaerobic digestion of organic solid poultry slaughterhouse waste–a review. *Bioresour. Technol.* **83**: 13-26.

Sankar, K.J., Vasudevan, V.N., Sunil, B., Latha, A., Irshad, A., Mathew, D.K. and Saifuddeen, S.M. 2022. Development of organic briquettes from slaughterhouse waste as nutrient source for plant growth. *Waste Biomass Valorization,* **13**: 599-608.

Sharma, V.K., Canditelli, M., Fortuna, F. and Cornacchia, G. 1997. Processing of urban and agro-industrial residues by aerobic composting. *Energy Convers. Mgmt*. **38**: 453-478.

Shilpa, P. and Girija, D. 2021. Microbial consortium for efficient composting of biosolid waste. *J. Trop. Agric*. **59**: 21-23.

Solaimalai, A., Baskar, M. and Ramesh, P.T. 2003. Environmentally safe disposal of waste waters. *Environ. Pollut. Mgmt.* **8**: 11-15.

Souza, H.A.D., Melo, M.D., Primo, A.A., Vieira, L.V., Pompeu, R.C.F.F., Guedes, F.L. and Natale, W. 2016. Use of organic compost containing waste from small ruminants in corn production. *Revista Brasileira de Ciência do Solo*.**18**: 34-40.

Tesfaye, T., Sithole, B. and Ramjugernath, D. 2017. Valorisation of chicken feathers: a review on recycling and recovery route—current status and future prospects. *Clean. Technol. Environ. Policy,* **192**: 363-378.

Thomas, G.V., Palaniswami, C., Prabhu, S.R., Gopal, M. and Gupta, A. 2013. Co-composting of coconut coir pith with solid poultry manure. *Curr. Sci.* **5**: 245-250.

Tronina, P. and Fabiola, B. 2008. Food industry waste composting in a rotational reactor. *Pol. J. Chem. Technol*. **2**: 37-42.

Wilson, D. 1992. Methods of disposal of paunch contents with emphasis on composting. In Inedible Meat by-Products *Springer Sci*. *Rev*. **331**: 265-281

■