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Data Article

# Data on energy and economic evaluation and microbial assessment of anaerobic co-digestion of fruit rind of *Telfairia occidentalis* (Fluted pumpkin) and poultry manure

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A R T I C L E  I N F O

A B S T R A C T

The data described in this article was obtained in an experiment designed for the generation of biogas from the anaerobic co-digestion of *Telfairia occidentalis* (Fluted pumpkin) fruit rind and poultry manure both of which currently constitute an environmental nuisance in the localities where they are found. The data presented in this article is on the use of combined heat and power (CHP) system to assess the energy and economic feasibility of applying thermo-alkali pretreatment procedures to one of the substrates (Fluted pumpkin) prior to anaerobic digestion. Also, the microbial characterization and succession pattern of important microbes during the anaerobic digestion process was evaluated and the data reported in this paper.

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### Specifications table

| | |
|---|---|
| Subject area | Microbiology and Biotechnology |
| More specific subject area | Environmental Biotechnology |
| Type of data | Tables |
| How data was acquired | Combined Heat and Power (CHP) System, Analytical Profile Index (API) kits (BioMerieux, Leon, France) |
| Data format | Analysed |
| Experimental factors | Produced thermal energy, produced electrical energy, thermal energy gain, thermal energy requirement, net thermal energy, electrical energy gain, electrical energy requirement, net electrical energy |
| Experimental features | Energy and Economic evaluation of anaerobic co-digestion of pre-treated and non-pretreated fruit rind of *Telfairia occidentalis* (Fluted Pumpkin) and Poultry Manure |
| Data source location | Omu-Aran, Kwara State |
| Data accessibility | The data is available within the article body |

### Values of the data

- The data presented in this article reveals the energy and economic evaluation of the anaerobic co-digestion of fruit rind of *Telfairia occidentalis* (Fluted Pumpkin) and Poultry manure for biogas generation
- The data will serve as a precursor for further research on the economic assessment of biomass pretreatment prior to anaerobic digestion processes
- The data give further exposure on the necessity and feasibility of pretreatment of biomass prior to anaerobic digestion.
- More robust heat and power systems can be used to further explore the generated data from this study in order to apply the processes in industrial scale experiments.

## 1. Data

The combined heat and power (CHP) system was used to assess the energy balance and the economic feasibility of applying thermal and alkaline pre-treatment to *T. occidentalis* fruit rind using a 50 and 30% thermal and electrical efficiencies respectively (Table 1). Therefore, to determine the thermal energy requirement (TER) for thermal and alkaline pre-treatments of *T. occidentalis* fruit rind, the energy needed to raise the temperature of 35 g TS $L^{-1}$ *T. occidentalis* fruit rind mixture from 25 to 55 °C was determined using the specific heat of water i.e. 4.18 kJ $kg^{-1}$ °$C^{-1}$ in order to evaluate the specific heat of the mixture while neglecting heat loss [1–3].

To assess the electrical energy, only the electric energy used for the substrate mixing was considered neglecting the energy used during mechanical treatment since this was also done for the experiment without thermal and alkaline pre-treatment [4]. Table 2 shows the heat balance of different biomass previously anaerobically digested with thermal and alkaline pre-treatments procedures [5–9].

In the co-digestion of *Telfairia occidentalis* fruit rind and poultry manure, various aerobic and anaerobes bacteria, fungi and methanogens were isolated and characterized (Table 3).

**Table 1**
Energy and economic evaluation for the anaerobic co-digestion of *Telfairia occidentalis* fruit rind and poultry manure.

| Energy parameters | Experiment A | Experiment B | Experiment C |
|---|---|---|---|
| Produced electrical and thermal energy from combined heat and power (CHP) | 1785 ± 0.01 | 1699 ± 0.02 | 1155 ± 0.02 |
| Produced thermal energy (kWh t$^{-1}$ TS) | 1645 ± 0.02 | 1547 ± 0.01 | 498 ± 0.01 |
| Produced electrical energy (kWh t$^{-1}$ TS) | 770 ± 0.01 | 563 ± 0.02 | 340 ± 0.02 |
| **Thermal balance** | | | |
| *Thermal energy gain (kWh t$^{-1}$ TS) | 1147 ± 0.01 | 1049 ± 0.03 | – |
| Thermal energy requirement (kWh t$^{-1}$ TS) | 1088 ± 0.02 | 1109 ± 0.03 | – |
| Thermal energy requirement with 80% of heat recovery (kWh t$^{-1}$ TS) | 218 ± 0.02 | 210 ± 0.01 | – |
| #Net thermal energy (kWh t$^{-1}$ TS) | 59 ± 0.02 | −60 ± 0.02 | – |
| Net thermal energy with 80% of heat recovery (kWh t$^{-1}$ TS) | −929 ± 0.02 | −839 ± 0.03 | – |
| **Electrical balance** | | | |
| $Electrical energy gain | 430 ± 0.01 | 223 ± 0.02 | – |
| Energy for mixing during pretreatment | – | – | – |
| Net electrical energy | 430 ± 0.01 | 223 ± 0.01 | |
| **Economic evaluation** | | | |
| Cost of NaOH (€ t$^{-1}$ TS) | | | |

**Remark**: * = difference of thermal energies produced by the pretreated experiment minus the untreated; # = difference between the thermal energy gain and the thermal energy requirement for the thermo-alkaline pretreatment; a $ = difference of electricity energies produced by pretreated experiment minus the untreated.

## 2. Experimental design, materials and methods

### 2.1. Materials and method

Data was obtained from the evaluation of pretreatment application to fruit rind of *Telfairia occidentalis* and the possibility of gaining back the investment (obtaining of chemicals and heat) into the pretreatment procedure through the sale of additional energy gained.

### 2.2. Experimental design

A simple computational equation was used to first determine the thermal energy required (TER) in kWh t$^{-1}$ TS for raising the temperature of one ton TS of *T. occidentalis* fruit rind from 25 to 55 °C during pre-treatment [14–16].

### 2.3. Microbial enumeration

The aerobic organisms (Bacteria and fungi) associated with the fermenting substrates were isolated and enumerated weekly using standard methods [17–19]. Facultative anaerobes were serially isolated using specialized media in an anoxic condition at 37 °C for 5 to 7 days as earlier reported [20,21]. Confirmation of the presumptive isolates was done with corresponding rapid Analytical Profile Index (API) kits [22] while a basal medium was used for identifying methanogens [23,24].

**Table 2**
Energy balances of thermal and thermo-chemical pretreatment procedures as applied to different substrates.

| Substrate | Condition of pretreatment | Increase in methane yield ($m^3\ t^{-1}$ TS)/operation mode | Biogas conversion | Surplus thermal energy (kWh $t^{-1}$ TS) | Thermal pretreatment requirements (kWh $t^{-1}$ TS) | Net heat energy (kWh $t^{-1}$ TS) | References |
|---|---|---|---|---|---|---|---|
| *Telfairia occidentalis* fruit rind | Thermo-alkaline (55 °C; 4% NaOH (w/w); 24 h) Solid load: 35 g TS $L^{-1}$ | 40/Batch mode | CHP: 35% electricity; 50% heat | 1147 | 1088 | 59 | Current study |
| | Thermo-alkaline (55 °C; 4% KOH (w/w); 24 h) Solid load: 35 g TS $L^{-1}$ | 35/Batch mode | CHP: 35% electricity; 50% heat | 1049 | 1109 | −60 | Current study |
| *Tithonia diversifolia* shoot | Thermo-alkaline (55 °C; 4% NaOH (w/w); 24 h) Solid load: 35 g TS $L^{-1}$ | 53/Batch mode | CHP: 35% electricity; 50% heat | 1176 | 1068 | 108 | [10] |
| | Thermo-alkaline (55 °C; 4% KOH (w/w); 24 h) Solid load: 35 g TS $L^{-1}$ | 30/Batch mode | CHP: 35% electricity; 50% heat | 862 | 1150 | −288 | [10] |
| Peanut hull | Thermo-alkaline (55 °C; 4% NaOH (w/w); 24 h) Solid load: 35 g TS $L^{-1}$ | 70/Batch mode | CHP: 35% electricity; 50% heat | 761 | 1173 | −412 | [11] |
| Sunflower stalks | Thermo-alkaline (55 °C; 4% NaOH (w/w); 24 h) Solid load: 35 g TS $L^{-1}$ | 36/Continuous mode | CHP: 35% electricity; 50% heat | 185 | 1034 | −849 | [12] |
| | Thermo-alkaline (55 °C; 4% NaOH (w/w); 24 h) Solid load: 50 g TS $L^{-1}$ | 36/Continuous mode | CHP: 35% electricity; 50% heat | 185 | 733 | −548 | [12] |
| | hermo-alkaline (55 °C; 4% NaOH (w/w TS); 24 h) Solid load: 200 g TS $L^{-1}$ | 36/Continuous mode | CHP: 35% electricity; 50% heat | 185 | 210 | −25 | [12] |
| | Thermo-alkaline (55 °C; 4% NaOH (w/w); 24 h) Solid load: 50 g TS $L^{-1}$ 80% of heat recovery from pretreatment | 36/Continuous mode | CHP: 35% electricity; 50% heat | 185 | 147 | 38 | [12] |
| Sunflower Oil Cake | Thermal (170 °C; 1 h) Solid load: 50 g TS L Thermal (170 °C; 1 h)$^{-1}$ | 32/Batch mode | CHP: 35% electricity; 50% heat | 161 | 3535 | −3375 | [6] |
| | Solid load: 200 g TS L Thermal (170 °C; 1 h) Solid load: 200 g TS $L^{-1}$ | 32/Batch mode | CHP: 35% electricity; 50% heat | 161 | 1010 | −849 | [6] |
| | 80% of heat recovery from pretreatment $^{-1}$ | 32/Batch mode | CHP: 35% electricity; 50% heat | 161 | 152 | 9 | [6] |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Ensiled Sorghum Forage | Thermo-alkaline (100 °C; 30 min, 10% NaOH w/w) Solid load: 160 g TS L$^{-1}$ | 92/Batch mode | CHP: 40% electricity; 41% heat | 378 | 547 | − 169 | [13] |
| | Thermo-alkaline (100 °C; 30 min, 10% NaOH w/w) Solid load: 160 g TS L$^{-1}$ 80% of heat recovery from Pretreatment | 92/Batch mode | CHP: 40% electricity; 41% heat | 378 | 109 | 269 | [13] |
| Wheat straw | Thermo-alkaline (100 °C; 30 min, 10% NaOH w/w) Solid load: 160 g TS L$^{-1}$ | 137/Batch mode | CHP: 40% electricity; 41% heat | 577 | 547 | 30 | [13] |
| | Thermo-alkaline (100 °C; 30 min, 10% NaOH w/w) Solid load: 160 g TS L$^{-1}$ 80% of heat recovery from Pretreatment | 137/Batch mode | CHP: 40% electricity; 41% heat | 577 | 109 | 468 | [13] |
| Microalgae | Thermal (75 °C; 15 min) Solid load: 11.7 g TS L$^{-1}$ 85% of heat recovery from Pretreatment | 32/Batch mode | 100% heat conversion | 316 | 458 | − 142 | [7] |
| | Thermal (75 °C; 15 min) Solid load: 20 g TS L$^{-1}$ 85% of heat recovery from Pretreatment | 32/Batch mode | 100% heat conversion | 316 | 268 | 48 | [7] |
| | Thermal (75 °C; 15 min) Solid load: 30 g TS L$^{-1}$ 85% of heat recovery from Pretreatment | 32/Batch mode | 100% heat conversion | 316 | 173 | 143 | [7] |

**Table 3**
Microbial evaluation and succession in the anaerobic co-digestion of *Telfairia occidentalis* fruit rind+poultry manure.

| Day | Aerobes (Cfu/ml) | | Fungi (Cfu/ml) | | Anaerobes (Cfu/ml) | | Methanogens (Cfu/ml) | |
|---|---|---|---|---|---|---|---|---|
| | Organism | TAPC | Organism | TFC | Organism | TPC | Organism | TPC |
| 0 | *Bacillus* sp. *Serratia* sp. *Pseudomonas aeruginosa* *Proteus* sp. | $2.3 \times 10^{10}$ | *Aspergillus niger* *Aspergillus flavus* *Rhizopus* sp. *Mucor* sp. *Penicillum* sp. | $1.0 \times 10^{8}$ | *Fusobacterium* sp. *Bacteroides* sp. *Clostridium* sp. *Porphyromonas* sp. | $1.2 \times 10^{10}$ | *Methanosarcinales* sp. *Methanobacteriales* sp. *Methanomicrobiales* sp. *Aminobacteria* sp. | $1.2 \times 10^{10}$ |
| 6 6 | *Bacillus* sp. *Serratia* sp. *Pseudomonas aeruginosa* *Proteus* sp. | $1.4 \times 10^{8}$ | *Aspergillus niger* *Aspergillus flavus* *Rhizopus* sp. *Mucor* sp. *Penicillum* sp. | $1.2 \times 10^{8}$ | *Fusobacterium* sp. *Bacteroides* sp. *Clostridium* sp. *Porphyromonas* sp. | $1.0 \times 10^{6}$ | *Methanosarcinales* sp. *Methanobacteriales* sp. *Methanomicrobiales* sp. *Aminobacteria* sp. | $1.0 \times 10^{8}$ |
| 12 12 | Nil | Nil | *Aspergillus niger* *Aspergillus flavus* *Rhizopus* sp. *Mucor* sp. *Penicillum* sp. | $1.0 \times 10^{3}$ | *Fusobacterium* sp. *Bacteroides* sp. *Clostridium* sp. *Porphyromonas* sp. | $1.0 \times 10^{4}$ | *Methanosarcinales* sp. *Methanobacteriales* sp. *Methanomicrobiales* sp. *Aminobacteria* sp. | $1.0 \times 10^{5}$ |
| 18 18 | *Bacillus* sp. | $1.0 \times 10^{2}$ | *Aspergillus niger* | $1.0 \times 10^{2}$ | *Fusobacterium* sp. *Clostridium* sp. *Porphyromonas* sp. | $1.3 \times 10^{10}$ | *Methanosarcinales* sp. *Methanobacteriales* sp. *Methanomicrobiales* sp. *Aminobacteria* sp. | $1.0 \times 10^{10}$ |
| 24 24 | *Bacillus* sp. | $1.0 \times 10^{2}$ | *Aspergillus niger* | $1.0 \times 10^{2}$ | *Fusobacterium* sp. *Clostridium* sp. *Porphyromonas* sp. | $1.2 \times 10^{3}$ | *Methanosarcinales* sp. *Methanobacteriales* sp. *Methanomicrobiales* sp. *Aminobacteria* sp. | $1.7 \times 10^{10}$ |
| 30 30 | *Bacillus* sp. | $1.0 \times 10^{2}$ | *Aspergillus niger* | $1.0 \times 10^{2}$ | *Fusobacterium* sp. *Clostridium* sp. | $1.2 \times 10^{2}$ | *Methanosarcinales* sp. *Methanobacteriales* sp. *Methanomicrobiales* sp. *Aminobacteria* sp. | $2.7 \times 10^{12}$ |

**Remark**: *TAPC=Total aerobic plate count; TFC=Total fungal count; TPC=Mean Plate Count.*

## 2.4. Statistical data analysis

The paired sample t-tests were conducted to determine the significant difference in the means of three replicates.

## Acknowledgment

## Transparency document. Supporting information

Transparency data associated with this article can be found in the online version at https://doi.org/10.1016/j.dib.2018.09.065.

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