UNIVERSITY of OTAGO

Te Whare Wānanga o Otāgo

Otago Energy Research Centre

Anaerobic co-digestion of defatted hydrolysed meat processing dissolved air flotation sludge and meat processing stockyard waste

Oseweuba Valentine **Okoro**[1] , Zhifa Sun[1*], John Birch[2]

[1]Department of Physics, Otago University , [2]Department of Food Science Otago University

*Email address: zhifa.sun@otago.ac.nz; Phone: 479 7812

Contents

- A review of the background and motivation of this study.
- Investigating co-substrate digestion anaerobic process: methodology.
- Research results we have obtained.
- On-going research.

Motivation for utilising meat processing waste as a feedstock biochemicals and biofuel production

- Significant masses of dissolved air flotation (DAF) sludge, with ~2.8×10^6 tonnes of wet DAF sludge, generated annually by New Zealand meat processing plants.

- This DAF waste stream remains a significant issue (Richard Stapel, personal communication, 2015).

- Limitations of current waste management approaches such as the generation of unpleasant smells from direct land disposal and sludge composting and the high energy drying operations prior to waste incineration.

- Sustainable biomass supply for biochemical and biofuel production in the absence of associated costs of cultivation, harvesting or agricultural land for biomass production.

New paradigm – integrated biofuel and biochemical production using organic meat processing waste

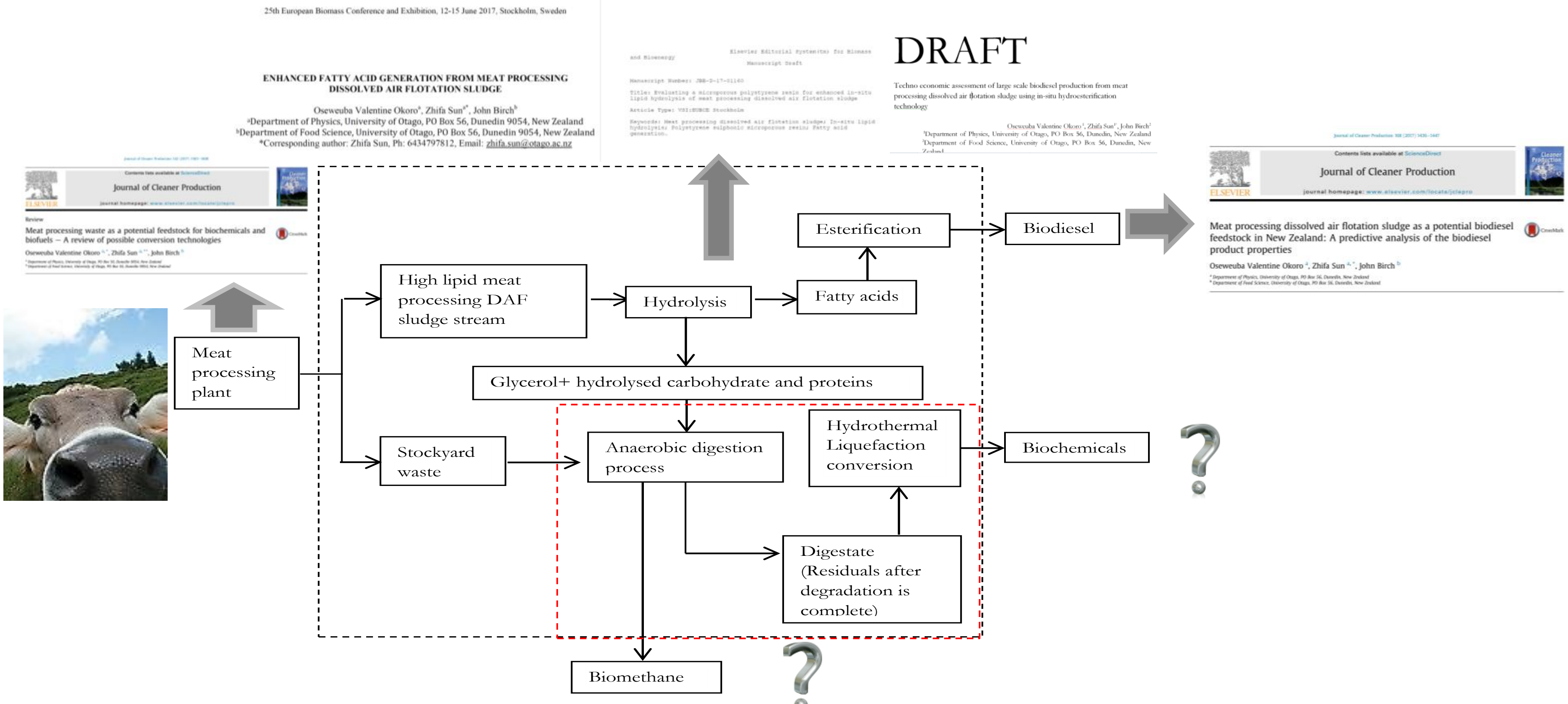


Figure 1: Biorefinery design for meat processing waste conversion to biofuels and biochemicals.

Anaerobic co-digestion of DAF sludge in-situ hydrolysis residue and stockyard waste

- ❑ Anaerobic co-digestion enables the cheap production of biomethane. Biomethane can serve as a cheap fuel for:

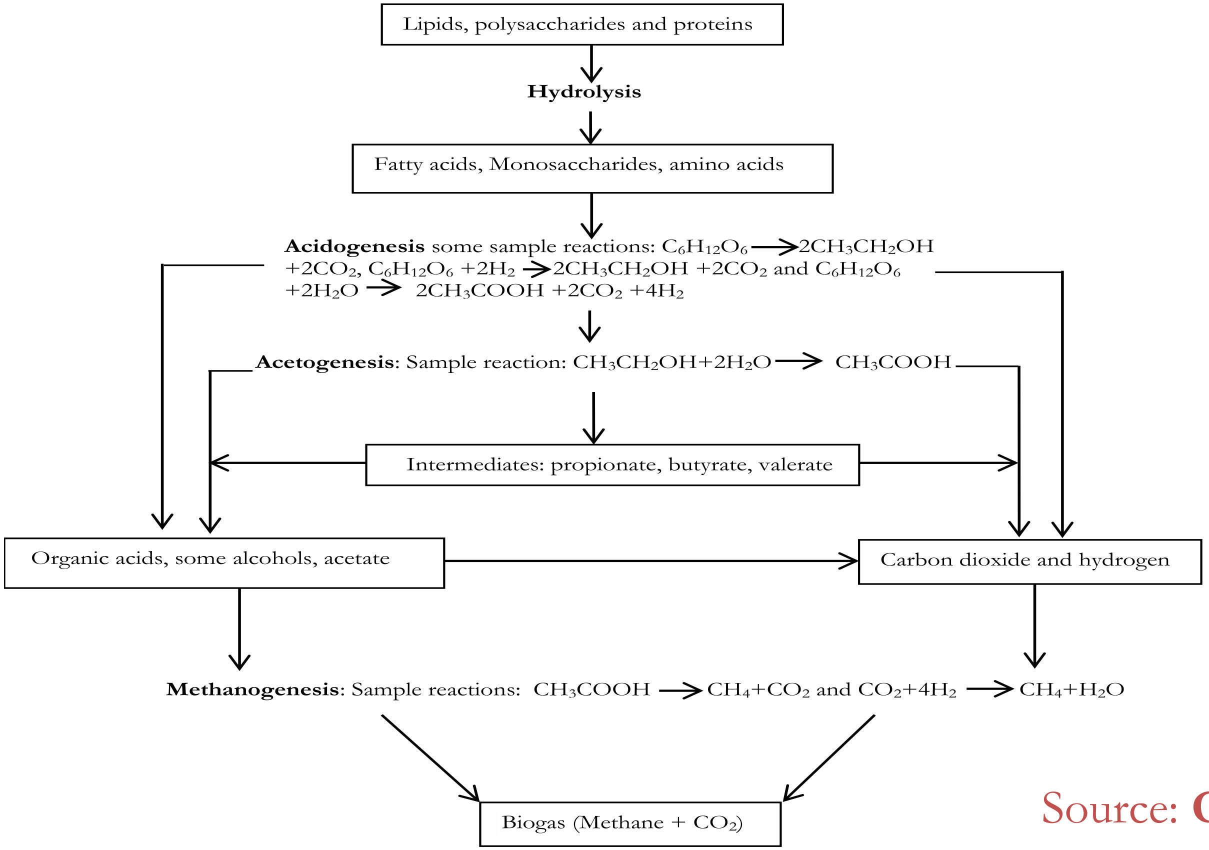
[A] Domestic heating

[B] Transportation

[C] Industrially for combined heating and power generation

Figure 2: Applications of bio methane.

Major stages of the anaerobic digestion of organics



Source: **Okoro** et al., 2017

Figure 3: Major anaerobic digestion stages

Anaerobic co-digestion of DAF sludge in-situ hydrolysis residue and stockyard waste

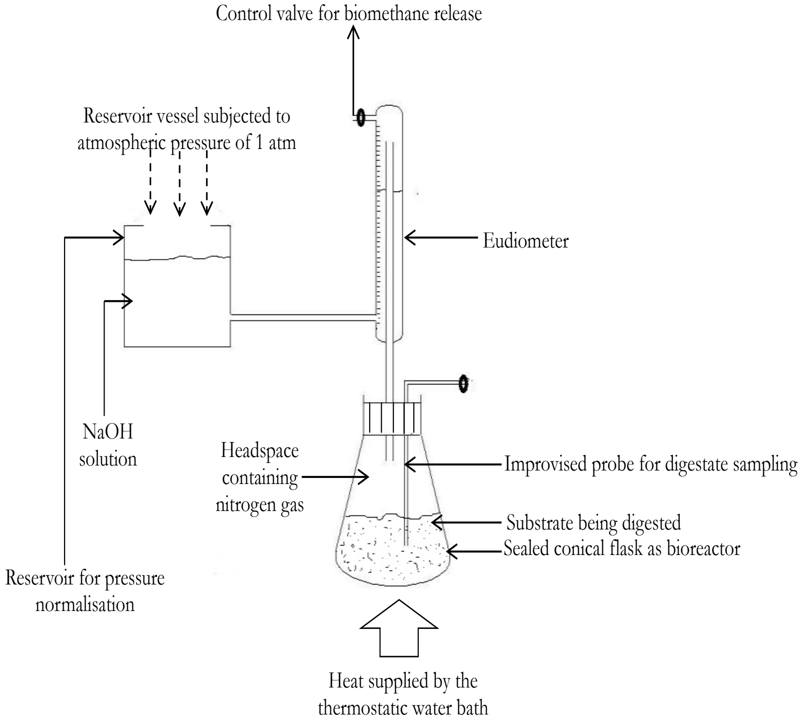


Figure 4: A simplified illustration of the experimental set-up.

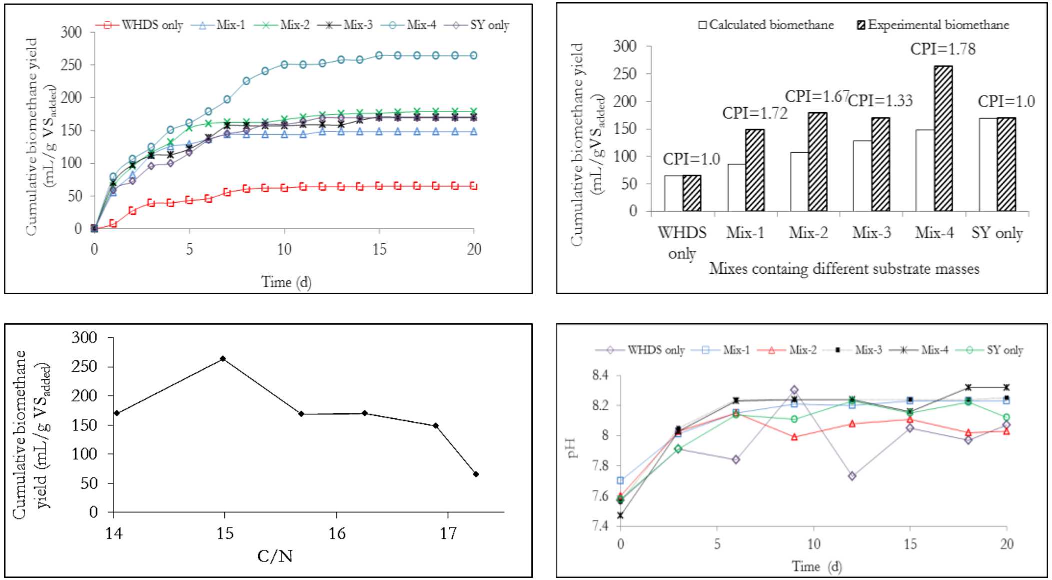


Figure 5: Crucial experimental results from the co-digestion system.

Anaerobic co-digestion of DAF sludge in-situ hydrolysis residue and stockyard waste

- It is crucial to identify the appropriate kinetic model that describes biomethane production for future system integration, system modelling and optimisation.
- The three major kinetic models, modified gompertz model, cone model and exponential (first order) model, were therefore employed and tested.
- Curve fitting was achieved using nonlinear least squares regression tool in Matlab computing package.

Anaerobic co-digestion of DAF sludge in-situ hydrolysis residue and stockyard waste

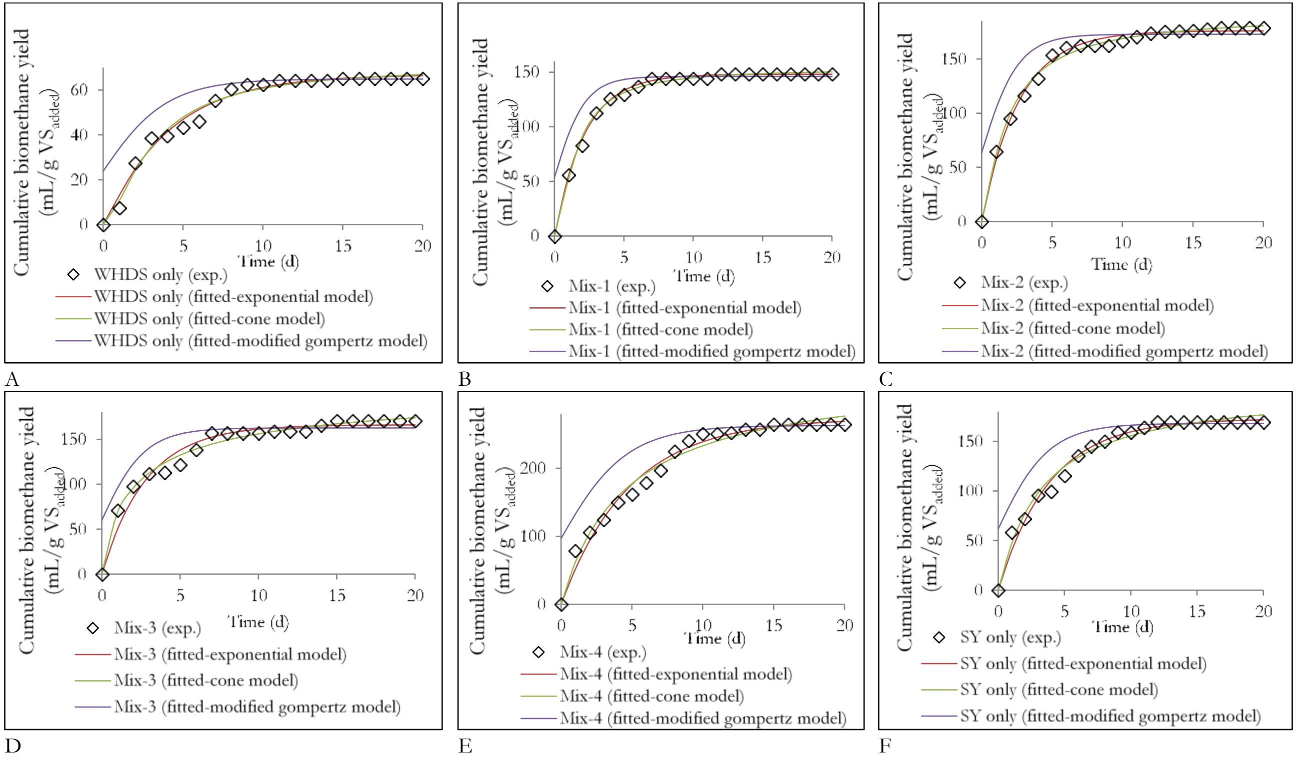


Figure 6: Plots showing kinetic model fits for the cumulative biomethane yield from the AD of the different substrate mixtures.

Coupling hydrothermal liquefaction as a Post-AcoD resource recovery technology

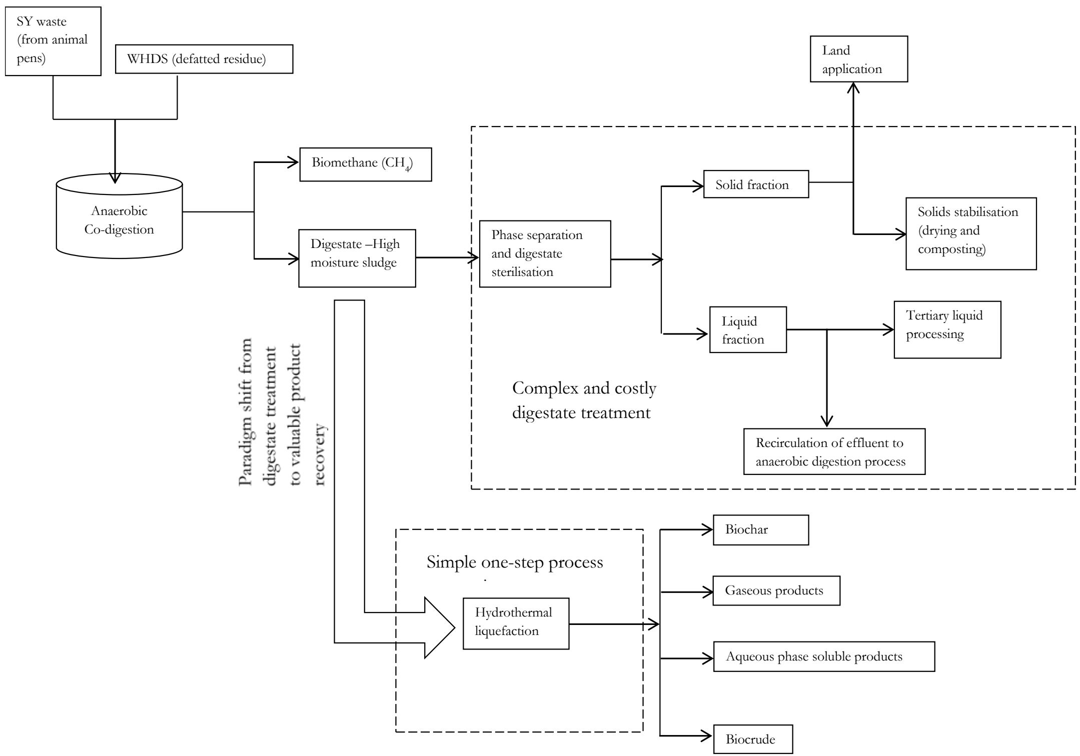


Figure 7: Proposed technological modification.

Assessment of the HTL of the digestate residue

- A multiphase component model was used to predict HTL product yields based on the physicochemical of the digestate residue
- Energy recovery (*ER*) of the biocrude + biochar streams from the digestate was determined as follows,

$$ER = \frac{y_{Bio}\left(HHV_{Bio}\right) + y_{Char}\left(HHV_{Char}\right)}{HHV_{dig.}}$$

- Energy consumption ratio (*ECR*) of the HTL process was determined as follows,

$$ECR = \frac{(1-\gamma)\left[w\int_{298.15}^{T} c_w dT + (1-w)\int_{298.15}^{T} c_b dT\right]}{\varepsilon\left(\left[y_{Bio} \times HHV_{Bio} \times (1-w) \times 1000\right] + \left[y_{Char} \times HHV_{Char} \times (1-w) \times 1000\right]\right)}$$

HTL of the digestate residue, to be or not to be?

- ER of 98% was determined with the extent of energy recovery considered as crucial to favourable energetic performance.

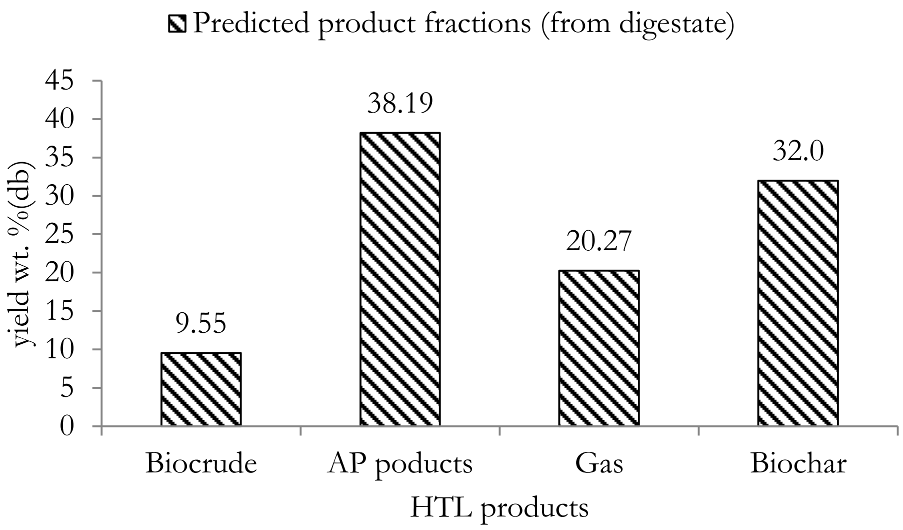


Figure 8: Predicted yields of HTL products and compared to reported yields from HTL processing as obtained from literature.

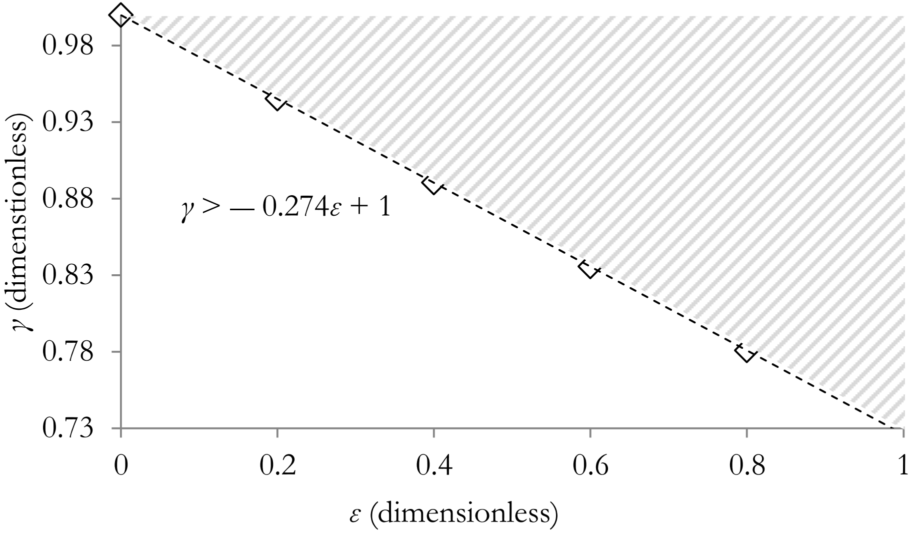


Figure 9: Condition for favourable energetic performance of the HTL of high moisture digestate.

HTL of the digestate residue, what has been done so far?

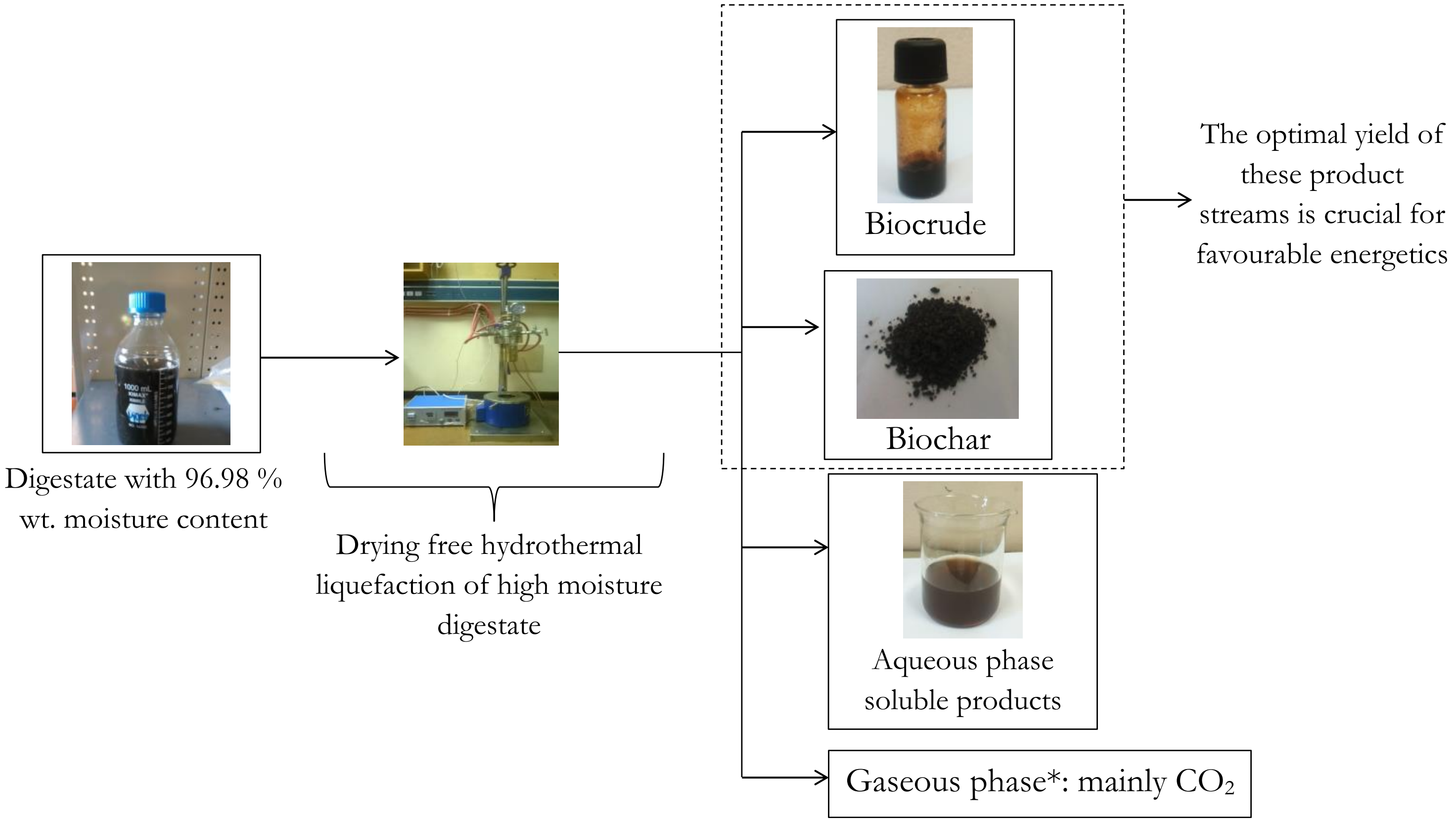


Figure 10: Experimental optimisation of the biocrude and biochar product streams.

Conclusions

- The anaerobic co-digestion of defatted meat processing waste residue and stockyard waste enhances biomethane generation.
- The preferred C/N ratio for the mix for improved biomethane generation from the co-digestion substrates is 15.
- Digestate generated can serve as a sustainable feedstock for useful biocrude and biochar production via the hydrothermal liquefaction process.
- The importance of optimal co-generation of the biochar and biocrude streams to an improved performance of a AcoD-HTL integrated system was established.
- A favourable economic performance of an integrated AcoD and HTL process is expected since the sale of biocrude+ biochar could provide a secondary income source.

Thank you

Questions