Research into Action

On-farm storage and bioreduction of non-ruminant livestock

This note highlights the key findings from a BPEX-funded research project carried out at Harper Adams University. The project investigated the feasibility of anaerobic digestion as a cost-effective, sustainable and biosecure method of on-farm storage and bioreduction of fallen livestock for the pig industry.

Currently, fallen pigs are collected and rendered or incinerated on-farm, both systems work well, but have negative aspects and pig producers are seeking a more sustainable long-term solution.

Anaerobic digestion (AD) occurs when bacteria feed on organic matter in an environment without oxygen. The digested organic matter is converted into substrates including volatile fatty acids (VFA) and biogas (methane and carbon dioxide). The advantage of this process is that the biogas produced can be used to generate heat, or, possibly, to operate the system and reduce both cost and carbon footprint of carcase disposal. A further advantage of AD is that it will hopefully provide a biosecure, cost-effective on-farm system of disposing of fallen livestock through the destruction of pathogens.

Small-scale experiments

Initially, three small-scale experiments demonstrated that pork meat could be digested anaerobically at mesophilic (35°C) and thermophilic (55°C) temperatures. However, the experiments demonstrated that pig slurry alone does not provide a sufficient bacterial starter culture. It was, therefore, decided that digestate from an anaerobic digester should be used to provide the bacterial starter culture in future experiments. Co-digestion with a carbon source, such as sugar beet pulp (SBP), was also shown to increase bacterial activity.

Work reported to date has investigated the use of pork meat; however the use of a macerated carcase that contains bones, intestinal contents and a higher proportion of blood which blood may produce different results. The objective of the next stage of the project was to use bench top digesters to investigate the effects of temperature and loading rates on AD of Pig Carcase Material (PCM), see below.

Benchtop experiments

Laboratory-scale digesters investigated semi-continuous feeding of PCM (which had been minced and homogenised) with SBP as a carbon source.

Experiment 1: Temperature and loading rate

This experiment investigated the effect of digester temperature (35°C or 55°C), substrate composition (SBP, PCM or mixed PCM and SBP) and substrate concentration (low or high) on the digestion characteristics of PCM, using anaerobic digestate as an inoculum derived from a food waste AD plant.

Biogas production and substrate disappearance were monitored over a 50-day digestion period. The following observations were noted:

- Methane yield was higher at 35°C than at 55°C
- Methane yield was higher at the lower dry matter concentration than the higher dry matter concentration
- Methane yield from SBP was relatively unaffected by temperature but methane yield from PCM and mixed substrate was severely reduced at 55°C
- At 35°C, the methane yield from PCM was higher than that from the mixed and SBP substrates
- Dry matter loss from all treatments was similar and ranged from 480–628g/kg.

The results suggest that AD can be used for storage and bioreduction of PCM with significant levels of methane being produced, in addition to significant dry matter losses. However, methane yield is compromised at the higher temperature and higher concentrations of PCM/loading rates. See Figures 1 and 2.

Experiment 1: Temperature and loading rate *continued*

Figure 1 Methane yield per kilogram of organic matter (OM) in relation to temperature

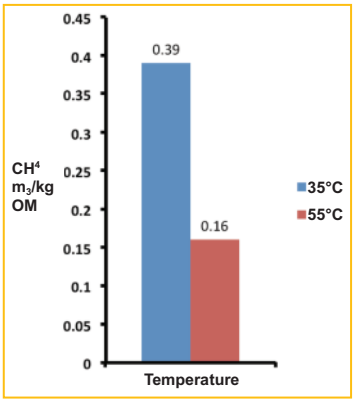
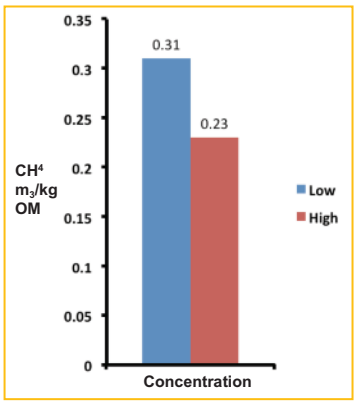


Figure 2 Methane yield per kilogram of organic matter (OM) in relation to PCM loading rate (concentration)



Experiment 2: Carcase pre-treatments and pathogen destruction

This experiment investigated the effects of digester temperature and substrate pre-treatment on the digestion characteristics and pathogen destruction of co-digested PCM, using inoculum derived from a food waste AD plant. The two temperatures were 35°C and 55°C, and the three pre-treatments were untreated, pasteurised (70°C for 1 hour) and pressure sterilised (133°C at 300kPa (Kilopascals) for 20 minutes).

The digesters were inoculated with:

- *Salmonella typhimurium, Clostridium perfringens, E. Coli K88, Ascaris suum* eggs (large roundworm) and *Porcine Parvovirus* (PPV).

The following observations were noted:

- Methane yields were similar between the three pre-treatments
- Pathogen destruction was higher at 55°C than at 35°C
- At both temperatures, 100,000-fold reductions in *S. typhimurium, E.coli* and *PPV* were achieved *
- Although a 100,000-fold reduction of *C. perfringens* was achieved at 55°C, only a 100-fold reduction was achieved at 35°C
- 100% of *A. suum* eggs were destroyed at 55°C, whereas 93% were destroyed at 35°C, although the remaining eggs appeared non-viable *
- Methane yields at 55°C were lower than at 35°C.

* Currently, AD plants which digest Category 3 materials must demonstrate a 100,000-fold reduction in *C. perfringens* and *E. faecalis* or *S. Senftenberg*, and a 1000-fold reduction in *A. suum* eggs and thermoresistant viruses such as PPV.

Conclusions

Both literature and experimental evidence suggest that significant levels of biogas can be produced from AD of PCM. However, AD of PCM was more efficient and stable at 35°C than at 55°C and at lower loading rates. Also, there was no significant effect of PCM pre-treatment on biogas production. In addition, AD has been shown to significantly reduce pathogen numbers, although pathogen destruction was greater at 55°C.

Preliminary analysis of the costs associated with AD suggest that small scale on-farm systems may be a cost-effective alternative to incineration or collection and disposal by rendering for some pig production sites. However, from these results it appears that there is a compromise between the optimum temperature for killing pathogens and the optimum temperature for producing methane.

Next steps

The next project, Stage 2, looks at quantifying the risks associated with on-farm AD of fallen pigs and developing protocols to optimise biogas production, bioreduction and pathogen destruction of PCM. This began at Harper Adams University in October 2013.

It is anticipated that the information derived from this project will provide an evidence base on the efficacy and safety of AD as an alternative system for containment of whole pig carcases. It is intended that this can be used in preparation for an application to the European Food Standards Agency (EFSA) to change legislation to incorporate this process as an on-farm bioreduction method.

Further information

A video about the project can be found on YouTube: http://www.youtube.com/watch?v=lPB1v8qnQbY
Project web page: http://www.bpex.org.uk/R-and-D/R-and-D/Bioreduction.aspx

For more information and advice, contact:

BPEX, Stoneleigh Park, Kenilworth, Warwickshire CV8 2TL
telephone: 0247 647 8792 • email: kt@bpex.ahdb.org.uk • website: www.bpex.org.uk