Biogas from Liquid Waste Arising in Liver and Beef Extract Production

T.Y. Yeole, D.R. Ranade and R.V. Gadre
Department of Microbiology, M.A.C.S. Research Institute
Law College Road, Pune 411 004, India

ABSTRACT

Anaerobic digestion of the liquid waste produced from the liver and beef extract manufacturing process was carried out at ambient temperature in 200 litres capacity laboratory scale biogas plant of floating dome design. Different hydraulic retention times (HRTs), viz. 10, 20, 30 and 40 days, were studied. The data collected over a period of 90 days showed that maximum biogas production viz. 88 litres day^{-1} corresponding to 897 litres kg^{-1} TS destroyed day^{-1}, and 709 litres kg^{-1} COD destroyed day^{-1} was obtained at 30 days HRT. The removal rates of organic matter in terms of BOD_5, COD and VS were 91, 89 and 74% respectively. At higher loading rates corresponding to a shorter HRT, the fermenting mass turned acidic, and adversely affected biogas production.

INTRODUCTION

Liver and beef extracts are important pharmaceutical products of biological origin. In their preparation, animal liver and meat are disintegrated physically and then hydrolysed enzymatically. The soup, thus prepared, is filtered through a filter-press and the soluble extract is recovered. The residual solids are disposed off as solid waste. The filter press is washed with water to remove solid particles adhering to the filters. This generates large volume of wash-water carrying finely suspended solids of the animal tissue with a small amount of dissolved organic compounds. Considering the high strength of the waste and possible presence of easily putrecible biopolymers, anaerobic digestion was considered to be a suitable mode of treatment. Anaerobic digestion of slaughter house waste, a similar waste in nature, has been studied in detail earlier [1-4].

The present paper describes anaerobic digestion of the liquid waste arising from liver and beef extract production.

MATERIALS AND METHODS

Characteristics of the Waste

Composite samples of the filter-press wash-water were prepared by collecting 50 ml aliquots, every hour, from the stream for a period of 24 hour. The waste was stored at 4°C and brought to the laboratory for chemical analysis. Chemical analysis of four composite samples was done in four subsequent weeks which included estimation of Total Solids (TS), Volatile Solids (VS), Biological Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Kjeldahl's nitrogen, Crude Fat and Volatile Fatty Acids (VFA).

Anaerobic Digestion

Four 200 litre capacity anaerobic digesters of floating dome design [5] (Fig. 1) were filled with fermenting slurry of a field scale cattle dung (CD) digester. They were fed daily with CD slurry (5% TS) for 40 days to have initial stabilization. The plants were then run at 40 days hydraulic retention time (HRT) on an admixture of CD and the waste. The percentage of the waste in the mixture was increased from 25% to 100% progressively. The digesters were run at ambient temperature, exclusively on the waste (2% TS) for a period of 40 days to reach a steady-state digestion. The volumes of ingoing waste were then changed to have 10, 20, 30 and 40 days HRTs in four different digesters. The biogas produced daily was measured and analyzed for its methane content. TS, VS, BOD, COD and VFA of the influent and effluent were estimated twice a week for the last 50 days of the experiment. Temperature (minimum and maximum) and pH of the fermenting slurry were recorded daily.

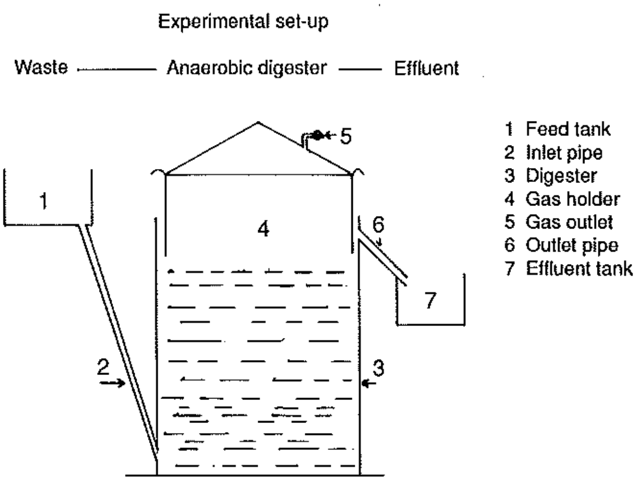

Fig. 1. 200 litre anaerobic digester.

Analyses

The volume of the biogas produced was measured daily by a wet gas flow meter (Toshniwal, Madras) and analyzed for its methane content on a Chemito 3800 gas chromatograph [6]. TS, VS, BOD, COD and Kjeldahl's nitrogen were estimated by standard methods [7]. Crude fat was determined according to AOAC [8]. Volatile fatty acids were analyzed on a gas chromatograph (Chemito 3800) equipped with a flame ionization detector and S.S. column (2M; 2 mm ID) packed with 10% FFAP on Chromosorb W (HP) 80/100. The flow rates of nitrogen (carrier gas), hydrogen and air were adjusted to 40, 30 and 300 ml min^{-1} respectively. The injection port, oven and detector temperatures were adjusted to 200, 150 and 205°C, respectively. Quantitation was carried out using a Spectra-Physics 4270 integrator. Samples for VFA were acidified to pH 2-2.5 by phosphoric acid and centrifuged at 5000 rpm for 10 min. The supernatant was used for VFA estimation. Volatile fatty acids from Sigma Chemical Company, USA, were used to prepare a standard VFA mixture.

RESULTS AND DISCUSSION

The chemical analysis of the waste, given in Table 1, shows that it is a high strength waste rich in easily degradable biopolymers like fats and proteins. Most of the TS present in the waste are volatile (VS 96% of TS) and the BOD/COD ratio is 0.67 which indicates a high concentration of easily biodegradable organic compounds.

Table 1. Chemical characteristics of the waste[a].

Constituent		mg/l
Total Solids (TS)		20,000
Volatile Solids (VS)		19,200
COD		21,200
BOD_5		14,200
Crude Protein		14,300
Crude Fat		4,200
Volatile Fatty Acids (VFA)		1,460
pH	5.8	
Temperature	28°C	

a - average of 4 composite samples.

Table 2. Anaerobic digestion of the waste at different HRTs.

Parameters	HRT (days)		
	20	30	40
Loading rate kg TS m^{-3} day^{-1}	1.00	0.66	0.50
kg COD m^{-3} day^{-1}	1.06	0.70	0.53
pH effluent	7.20	7.50	7.60
Removal (%)			
TS	54.00	72.00	74.00
VS	62.00	74.00	78.00
BOD_5	83.00	91.00	96.40
COD	82.30	89.10	89.80
Biogas Production[a]			
Litres day^{-1}	83.20	88.0	66.10
Litres kg^{-1} TS destroyed day^{-1}	768.00	897.00	890.00
Litres kg^{-1} COD destroyod day^{-1}	477.00	709.00	694.00
m^3 m^{-3} digester day^{-1}	0.41	0.44	0.33
Methane % (V/V)	62.00	64.00	65.00
VFA effluent (mg/l)	590.00	460.00	390.00

a - Gas volume corrected to STP; Temperature range 24-32°C.

The results on anaerobic digestion in the last 50 days of the experiment are given in Table 2 and daily production of biogas from the waste at different HRTs are shown in Fig. 2.

The data showed that at 30 days HRT, maximum biogas yield (897 litres kg^{-1} TS destroyed day^{-1}) and highest productivity (0.44 m^3 m^{-3} day^{-1}) was achieved. The removal of organic load was also found to be satisfactory (72% TS and 74% VS) at this HRT. The BOD and COD removal was 89% and 91.0% respectively. VFA content of the effluent slurry was 460 mg $litre^{-1}$ which shows a stable digestion.

Despite the low pH of the feed (5.8), pH of the fermenting mass remained alkaline throughout the studies. Between 20 and 40 days HRT there was no accumulation of VFA. On the other hand, at 10 days HRT, the digester became rapidly sour, with high VFA accumulation and low pH (VFA 3800 mg $litre^{-1}$, pH 5.2) indicating totally disturbed digestion. The biogas production drastically dropped down, the methane content in the biogas came down to 15% and hence the experiment was terminated after 15 days (Fig. 2).

At shorter HRT, i.e. at 10 and 20 days, the digestion was not satisfactory as seen from the lower efficiency of TS, VS, BOD & COD removal. This may be due to the wash-out of microbial cell-mass. Toxicity due to ammonia, a common by-product of protein deterioration under anaerobic conditions also might have caused the disturbance in the digester at the shorter HRT, since the feed is rich in protein content.

Figure 2 shows that the biogas production was uniform over a long period (90 days) at all the three HRTs (20, 30 and 40) studied. The digestion reached a steady-state during the period of analysis, i.e., the last 50 days of the experiment.

The liver and beef extract production plant discharges 2400 litres waste daily. A full-scale anaerobic digester run on this waste at 30 days HRT would yield around 32 m^3 biogas equivalent to 14.5 kg liquefied petroleum gas and could generate a revenue of Rs. 60 every day. Thus, the

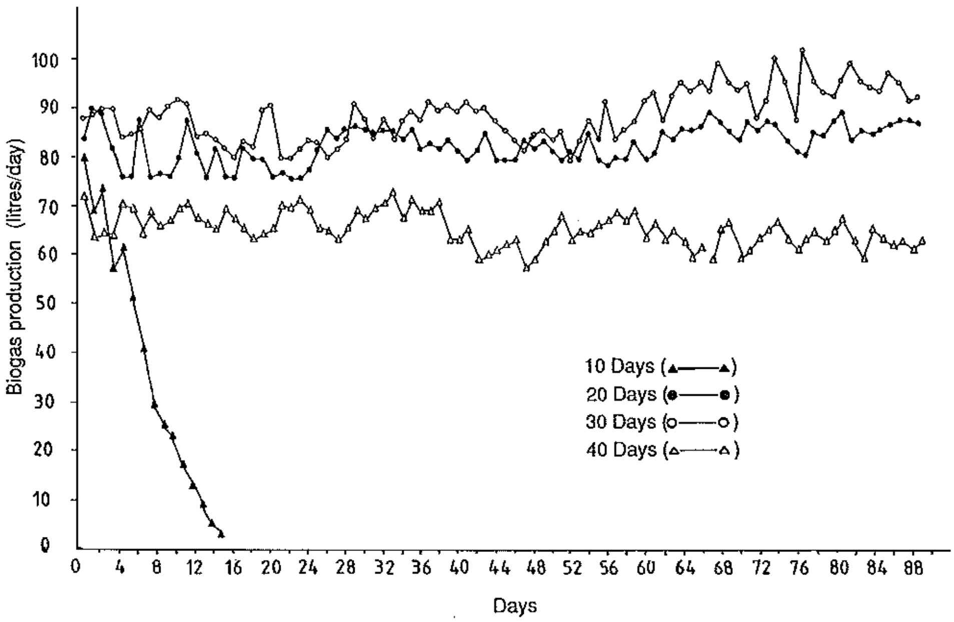

Fig. 2. Biogas production from liver and beef extract waste at different HRTs, 10 days (▲——▲), 20 days (•——•), 30 days (o——o), 40 days (Δ——Δ).

annual revenue generated would be Rs. 22,000 and, considering the cost of installation to be about Rs. 65,000, the payback period would be around three years. The biogas produced in this digester can be suitably utilized in the factory.

A variety of high rate digesters are being studied all over the world. However, only a few have reached the application stage. Conventional digesters have been applied in the field for a very long time. Their simplicity and low cost make them suitable for acceptance by the industry.

Considering the characteristics of the anaerobically treated waste, it is evident that it needs further treatment so as to meet the Water Pollution Prevention and Control Board's standards. A suitable aerobic treatment will have to be employed for this purpose.

CONCLUSIONS

The waste water arising from liver and beef extract production is a high strength waste, rich in easily biodegradable lipids and proteins and is amenable to anaerobic digestion. Of four HRTs studied, steady-state operation could be achieved at 20, 30 and 40 days HRT but not at 10 days HRT. The 30 days HRT was most suitable for anaerobic digestion since the productivity and yield of the biogas was maximum (897 litres kg^{-1} TS destroyed day^{-1}; 64% methane). The removal of organic load in terms of TS, VS, BOD and COD was 72, 74, 91 and 89% respectively at 30 days HRT. The anaerobically treated waste needs further treatment, so as to meet the Water Pollution and Control Board's standards.

ACKNOWLEDGEMENT

Grateful thanks are due to M/s Raptakos Brett and Co. Ltd., Thane for providing financial assistance to carry out this work.

REFERENCES

1. Hurdey, S.E. (1984), The Management of Waste Water from the Meat and Poultry Products Industry, *Surv. Ind. Wastewater Treat.*, Vol.1, p.128.
2. Saxena, K.L. (1986), Characteristics, Pollution Load of Meat Works Waste Water, *Indian Journal of Environmental Health*, Vol.28, No.2, pp.85-95.
3. Sayed, S.K.I., L. van Campen and G. Lettinga (1987), Anaerobic Treatment of Slaughter-House Waste Using a Granular Sludge UASB Reactor, *Biological Wastes*, Vol.21, No.1, pp.11-28.
4. Samesh, S., Jos van der Z., W. Rene and L. Gatzee (1988), Anaerobic Degradation of the Various Fractions of Slaughter House Waste Water, *Biological Wastes*, Vol.23, pp.117-142.
5. Dayal, M. (ed.) (1981), *Biogas Technology and Utilization - A Status Report*, Department of Science & Technology, Government of India, New Delhi.
6. Ranade, D.R., T.Y. Yeole and S.H. Godbole (1987), Production of Biogas from Market Waste, *Biomass*, Vol.13, pp.147-153.
7. APHA (1985), *Standard Methods for the Examination of Water and Waste-Water*, 16th edn., APHA, AWWA, WPCF, Washington, D.C.
8. AOAC (1960), *Official Methods of Analysis*, 9th edn., Association of Official Analytical Chemists, Washington, D.C.