THE EFFECT OF ORGANIC RESIDUES' CO-FERMENTATION ON BIOGAS POTENTIAL OF DIFFERENT SIZED ECONOMICAL UNITS

LASZLO SALLAI

University of Szeged, Faculty of Agriculture
Institute of Plant Science and Environmental Protection
Hódmezővásárhely 6800 Andrássy St. 15.
sallai@mgk.u-szeged.hu

ABSTRACT
The degradable biomass potential is available in diverse and different combination in the establishing firms' environment in Hungary. In the case of proper preparation the biogas production and utilization operating for energy recovery in all sizes of agricultural enterprises will improve the economy, on the other hand, it is a powerful tool of the waste management. My investigations were running on the pilot farm of the MGK to define the conditions of deconstruction of the wastes of agricultural production on family economical level, the renewable energy options the decomposition of the by-products on micro-regional level. I determined the biogas production potential of biomass with partly measured, partly based on literature data of the 50 dairy cow farm, respectively the sample utilized for pilot farm, and then I completed the same on sub-regional level. On the size of pilot farm the composition of the substrat were expanding of cheese factory wastewater and pig straw manure additives. The large-scale manure production modelling of biogas experiments used liquid pig slurry as raw material. The additives: bran, mushroom compost, maize silage. The industrial by-products and wastes suitable for biogas production are defined by the dry matter, organic matter, nitrogen content, C: N ratio, specific gas yield.

Keywords: biogas potential, organic waste, different sized agricultural farming

INTRODUCTION

Biogas technology is spreading primarily in wet version for the liquid slurry technology with big investments by big investors, while the new environmental regulations make it possible for small farms only the straw farming methods. My goal is to prove that the straw manure - washing water of milking parlour substrate utilizable for energy purposes.

Among certain structural conditions of a given small region is important the energy utilization of manure and other waste by-products because the serious impact on the environment, significantly increases the profit-making ability of agricultural investments. The efficient operation of the breeding of pigs particularly requires the increasing of the plant size, leading to a significant increase of environmental damage. The multiple beneficial use of biogas (energy production + environmental + investment + biomanure production of hazardous waste management and utilization) is possible if the potential additives energy-producing ability previously modelled experimentally and the operating conditions are similar. The experiments with varying load were simulating varying substrate compositions, respectively the changing of manure production. The intensity of the methane production is the direct measure of the activity of the methanogenic bacteria and the digester performance is a highly sensitive, specific criteria (ROSS ET AL, 1996). The produced gas composition and yield are features that are useful in assessing the stability of the anaerobic system. The results of the tests are essential, and the territory of the investments and operational areas bring practical benefits.

MATERIAL AND METHOD

The straw manure experiments was running with 50dm^3 volume/fermentor, mesophilic temperature (38°C), batch process, first manually mixing, then finished with mixing machine, built-in digester system in the building of the SZTE MGK. The formed biogas emptied daily, I measured the amount of gas and its methane content.

At the Engineering and Agricultural Faculty of Szolnok College is available an appropriate, semi-automatic experimental system, representing the operating circumstances, providing similar conditions. It is suitable for the formation process of the biogas, changing of influencing factors and all of necessary measurements of typical data. I dosed 50 dm^3 of liquid dung mixture for treatment to take the factors in connection with the capacity of the fermentor into account. I applied the continuous (filling up) system, which is most widespread in the practice (ARTHURSON, 2009). It can be reproduced the process sections, as the launching, load change, receipt change. According to certain expert opinions each single daily measurement combination for a separate experiment can be qualified.

The technology of continuous fermentation experiments

We may split the process of the fermentation into sections according to Table 1.

Table 1. Technology of co-fermentation experiments

serial number	1.	2.	3.	4.
period of the process	stabilization	refilling period with fresh substance	Running-up period	Comparative experiments
treatment		running-up period with fresh substance		
duration time	7 days	14 days	21 days	21 days

Source: Kalmár ET AL (2007)

Calculation of the impact of the co-fermentation of the pig manure and wheat bran enhancing biogas production at sub-regional level

I calculated with 5t/ha yield of wheat for 15000 wheat area in the Hódmezővásárhely micro region that means 75000 t crops. 20% bran production can be calculated approx. in the industrial grain processing. The total amount of wheat grain processing industry appr.15000 t bran was formed.

RESULTS

CO-FERMENTATION OF ORGANIC WASTE OF FAMILY-SIZED DAIRY FARM

In the first experiment it was postulated that the milking parlour, milk cooling equipment used cleaning laundry disinfectant in water prevents the rich manure anaerobic metabolism, reduces the methane formation. The rate of formation of the fermentor can be found in most types of organic waste generated by weight, but assuming different situations, multiple assembly is simulated. According to the data shown in the second Table the 11% higher dry matter content of the fermentation substrate caused 6.91% higher gas releasing, or 8.48% more methane content resulted. The literature (10Ndm^3/d/om.kg) compared to 57, respectively 52% higher gas production is found. Dry weight basis did not increase the efficiency of investment, however, for improved utilization of the device (0.29 <0.32 Ndm^{3}methane/dm^3 digester / day) (*Table 2*). 5.43% dry matter content of the substrate, the maximum daily production of biogas 85Ndm^3/d, methane content 56%, and 6.03% dry matter content of the substrate, the maximum daily production of biogas 73 Ndm^3/d, 49% methane content.

Table 2. Results of experiments for energetic utilization of organic wastes of SZTE MGK organic waste

Measured and calculated parameters		organic waste of pilot farm		organic waste of family sized dairy farm	
		cattle straw manure: 14,5kg; *pig straw manure:*8,2kg; *waste water of cheese firm (*without whey*):* 23,4kg; *waste water of milking parlour:* 3,9kg		*cattle straw manure:* (dmc.: 21,3%; omc.: 12,9%);	
				3. reactor	4. reactor
				12734 g;	14137 g;
				waste water of parlour: dm.c..: 1,52 g/l; omc..: 0,592 g/l;	
		stored	fresh	37266g;	35863g;
dry matter content (dmc.) (%)		9,51	9,92	5,43%	6,03%
organic matter content (omc.)(%)		6,21	6,41	3,30%	3,66%
average gas production (Ndm^3/ day)	biogas	27,2	56,04	26,05	27,85
	methane	14,69	27,46	14,63	15,87
average methane content (%)		54	49	56,18%	57,0%
theoretical biogas production (Ndm^3/day)*		48,2	48,2	16,5	18,3
average gasyield referred on specific fermentor volume (Ndm^3/dm^3/day)	biogas	0,54	1,12	0,52	0,56
	methane	0,29	0,55	0,29	0,32

**referred on 20 days fermentation; mezophilic, intermittent method, 200Ndm^3/20days cattle, 445Ndm^3/20days pig manure referred on organic matter content.,* [KALTWASSER (1983)]

BIOGAS PRODUCTION OF CO-FERMENTATION CONSIDERED BY ORGANIC WASTES OF PILOT PLANT

The fermentation experiments designed to demonstrate the biogas technology can find a solution for common problems (waste management, energy supply, etc) of small family-sized farms be located on a certain district. The gas releasing of the room temperature stored, partially out of the reach the air of the pilot farm recipe of organic waste compared to the performance of fresh manure (1.12 Ndm^3 / dm^3/nap), less than half (0.54 Ndm^3 / dm^3/nap) produced, because of the degradation processes have been started. The anaerobic conditions have developed rapidly since the methane is also a surge in the second and third day has been completed (*Figure 1*). The highest gas formation of the stored manure was 63 Ndm^3/day (1.26 Ndm^3/dm^{3}fermentor/day), while the fresh manure 94 Ndm^3/day (1.808 Ndm^3/dm^3 fermentor/day).The average methane content of fresh manure mixture (49%) five percent had less than a year and a half contained substrate (*Table 2, Figure 2*)

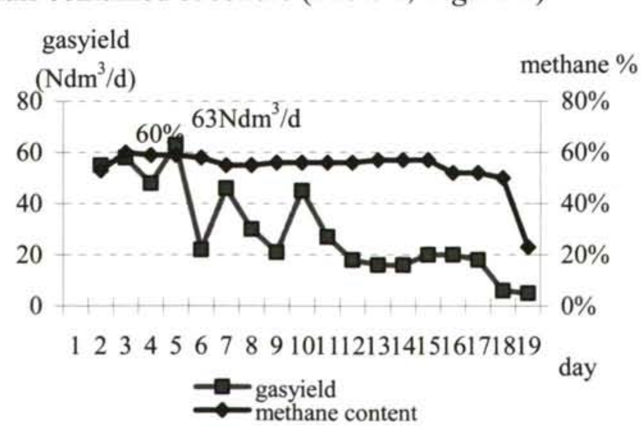

Figure 1. Formation of biogas from straw manure stored at room temperature

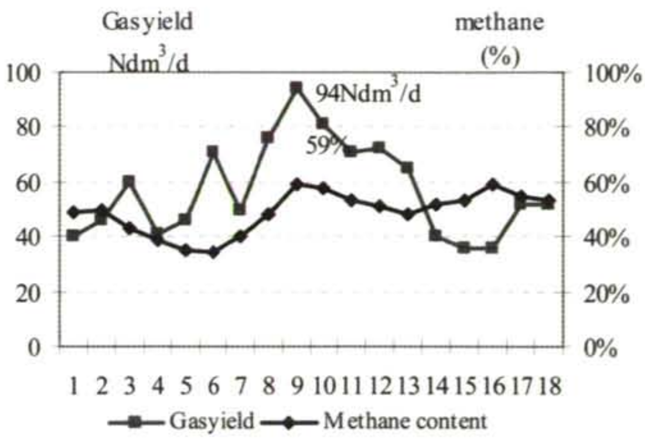

Figure 2. Formation of biogas from fresh straw manure

Wheat bran usability testing for biogas yield enhancement

The first test phase: overloading technology, new material loading (15 days, from the 37. days till the 51. days):

Two reactors daily charged with 6.6 vol. % fresh slurry and into the second no. 60g bran per day were dosed frequently. The gas production of the untreated (control) reactor (third digester) was much less than the other liquid pig slurry-based biomass in that given period. In most cases did not reach the half of the gas production of the treated reactor. The average gas production was 24 Ndm^3 biogas/dm^3/day in the control reactor. The mill bran dosed second digester's gas production is in the over filled period more or less different. The reason can be the changing of the dry matter content of the fresh organic manure. Operating conditions to model the different dry matter content of fresh slurry was applied. The filling used in low solids fresh organic manure occasionally caused fluctuations in gas production.

Table 3. The average gas production with the addition of wheat bran

Second fermentor: 6.6 vol.% of fresh slurry + 60 g bran; third (control) fermentor: 6.6 vol.% of fresh manure;

Measured value, technology		Average gasyield (dm^3/day)/ specific values *(Ndm^{3}gas/day, Ndm^{3}gas/dm^3/day)*				
		2. sz. fermentor *(+60g dm.. bran)*	3. control	Gasyield referred to control	2. fer-mentor	3. control
		6,6 vol. % fresh liquid manure			specific fermentor volume referred gasyield(dm^3/ dm^3/day)	
biogas	Fresh substrat load	62,7 Ndm^3/day	24,2 Ndm^3/day	2,59	1,25	0,48
biogas	recirculation technology	42 Ndm^3/day	10,1 Ndm^3/day	4,16	0,84	0,20
Methane yield	Fresh substrat load *Ndm^3/day*	35,9 Ndm^3/day (57,26%)	13,2 Ndm^3/day (54,54%)	2,72	0,72	0,26
Methane yield	recirculation technology	24,2 Ndm^3/day; (57,62%)	6,3 Ndm^3/day; (62,38%)	3,84	0,48	0,13

The gas production of the No. 2. digester in the second test period already reached the 50 day dm^3/day production, and an average of 62.6 dm^3 biogas produced per day (Table 3, Figure 3).

The methane content of biogas reactors was produced in all cases exceeded 50% and sometimes even 60% (*Table 3, Figure 4*).

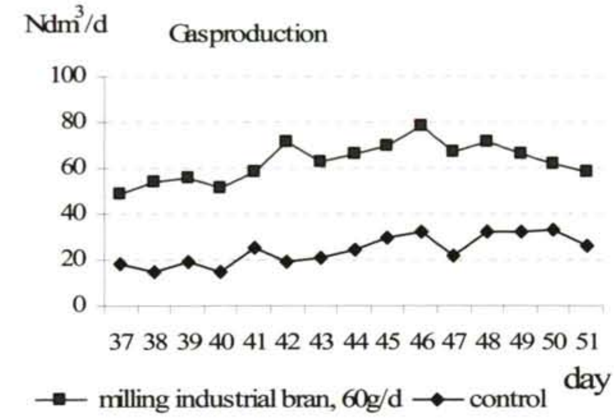

Figure 3. Gas production during fresh material loading technology (15 days, from the 37. days till 51. days)

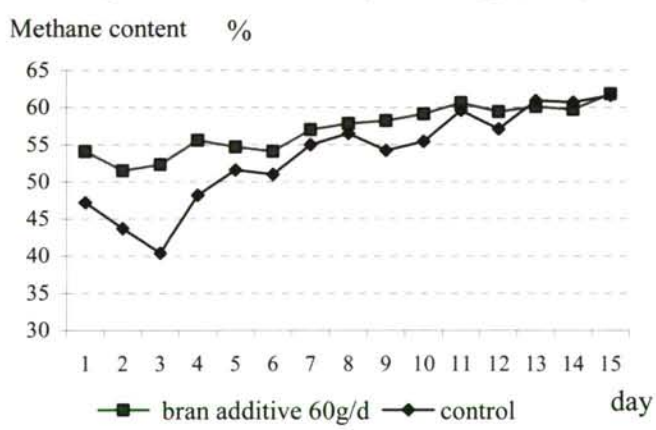

Figure 4. The methane content of biogas was produced in reactors, overloading technology, with new material

The estimated production of pig manure of Hódmezővásárhely micro region is 66,094 tonnes. The heating value of gas production is 71,480.4 GJ / year from this. This heat quantity can produce 7211.7 MWh / year of electricity. The increasing value of co-fermentation using 66,094 * 0.0012 = 79.3t bran produces 19,615.82 MWh / year electricity.

CONCLUSIONS OR DISCUSSION

The milking cattle manure and sewage of more than 50% higher gassing found compared to the data in the literature with two option (0.55 >> 0.32 Ndm^{3}methane/dm^3 fermentor volume / day). In relation to the wastewater of the milking parlour and the cheese factory, the cattle and pig manure dosing in proportion of the forming, the gas release of fresh manure is 16% higher then the data in the literature. The half-year stored manure has 43.6% less gas production compared the fresh. The study shows that 10.14 m^3 per day at the pilot farm plant scale size and 4.26 m^3 per day biogas formed at the dairy level. The improved thermal energy equivalent of biogas was 84.97 MJ/day at farm level, at the pilot farm level is 173.97 MJ / day. The electric power value is 0.34 kW, respectively 0,7 kW. The heating power which is the by-product of the digesting process is 0.23 kW, respectively 0.47 kW.

The wheat bran (by-product from the milling) increased biogas yield were examined. The 45g dmc./day/digester bran loading with 4% dmc liquid pig slurry basis, released 0.72 dm^3

methane/dm^3/day, which is almost tripled (2.72), compared to the methane production of the liquid pig manure control.

From the total amount of pig manure with the five-thousandth of the total wheat bran quantity co-fermented can be obtained 122,946 GJ /year of biogas heating value surplus, 12,404.12 MWh /year of electricity surplus at the micro-regional level.

REFERENCES

ARTHURSON, V. (2009): Closing the Global Energy and Nutrient Cycles through Application of Biogas Residue to Agricultural Land – Potential Benefits and Drawbacks. Energies 2, pp. 226-242.

http://data.hodmezovasarhely.hu/docs/strategiak_koncepciok/megujulo_energia/2_fejezet.pdf

KALTWASSER, B. J. (1983). Biogáz- előállítás és hasznosítás. Műszaki Könyvkiadó, Budapest, pp. 46-51.

KALMÁR, I. - KALMÁRNÉ, VASS E.– NAGY V. (2007). Üzemi körülményeket is reprezentáló kísérleti eszközrendszer továbbfejlesztése biogáz előállításhoz. Poszter, MTA AMB XXXI. Kutatási és Fejlesztési Tanácskozás, Gödöllő, 3. kötet pp. 118-122, CD issue

KALMÁR, I, K. L KOVÁCS, Z BAGI (2003). Sertés hígtrágyára alapozott biogáz referencia üzem. MTA AMB Kutatási és Fejlesztési Tanácskozása. Gödöllő, 2 pp. 82-86.

ROSS, C. C. - DRAKE, J. T. – WALSH, L. J. (1996): The Handbook of Biogas Utilization; Valley Authority, Tennessee, pp. 80-82.