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CO-FERMENTATION OF AGRICULTURAL ORGANIC WASTE, MAIN AND BY-PRODUCTS

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ABSTRACT
My research work proposes the study of the impact of the biogas production by co-fermentation of agricultural products. The basic substance is the dangerous liquid pig manure of the concentrated stock of big pig farms. The utilization of these materials as an energy source spells large income for the agricultural enterprises, saving the replacement of plant nutrition utilization of bio-manure, to increase the performance of the plant production, making harmless the dung which means a big environmental load. Because of the profitability of bioenergy utilization depends on the local conditions it is necessary to do experiments to try the available composition of organic wastes in the ratio of the production in advance. We measured the quantity and the methane and CO_2 content of the biogas released from the substrate. The experiment simulated real biogas plant conditions, in mesophile temperature, in continuous biodegradation process. It can be considered, as a semi-industrial size.

Keywords: sustainable agriculture, environmental protection, increasing the profitability of the agricultural production

INTRODUCTION

It can be provable based on my research and literature references, that the qualitative and the quantitative properties of the biogas releasing in the biogas plants largely depends on the portioned liquid dung, the additives, and the features of the applied technology. Our experiments justified the yield improving effect of the agricultural main and by-products and wastes because of the low organic matter content of the liquid pig manure (ARTHURSON, 2009). It may be hypothesized, that these additives and the technological parameters of the biogas production influence on a favourable direction the features of the fermented manure and through this the opportunities of the recirculation.

My experiments aimed the increasing of the proportion of the renewable energy sources of application, to increase the methane quantity originating from the various organic matters, to increase the intensity of the formation, to produce stabile gas content. Making the organic matters polluting the environment harmless is the indirect result of the application of the technology (GOTTSCHALK, 1979). The biogas increasing the greenhouse effect with big methane content means concentrated environmental load and source of danger and on the other hand unutilized energy source in a farming area where the use of the external power sources is considerable anyway. While the economy size is its principle from below, the relatively little energy content of the biomass in the view of the transportation expense from above limits the firm concentration (GERARDI, 2003). Because of this, it is necessary to examine the energetic utilization of all possible organic waste at least with laboratory or half-firm methods.

MATERIAL AND METHOD

At the Engineering and Agricultural Faculty of Szolnok College, a semi-automatic laboratory system is available, simulating the regular operating circumstances, providing similar conditions suitable for the releasing process of the biogas, adjusting the influencing factors and all the necessary measurements of typical data. Liquid pig manure was used during the biogas production experiments as basic substance.

The supreme features of industrial by-products and wastes suitable for the examination of the biogas production:

- dry matter,
- organic matter,
- nitrogen content,
- C:N proportion,
- specific gas yield.

The technology of fermentation experiments, the process of the experiments is:

a) Loading of laboratory digesters, setting of the treatment combinations
b) Sampling.
c) Measurements, examined parameters

The technology of the co-fermentation experiments
We divided the process of the fermentation into sections according to the *Table 2*.

Table 2. Technology of co-fermentation experiments

<table>
<tr><th rowspan="2">No.</th><th rowspan="2">Process period</th><th rowspan="2">Duration time</th><th colspan="2">Treatments, fermenters</th><th rowspan="2">Comment</th></tr>
<tr><th>1.</th><th>2-8.</th></tr>
<tr><td>1.</td><td>stabilization</td><td>7 days</td><td colspan="2">Composition: fresh liquid slurry, in certain cases, wastewater or water</td><td rowspan="2">Same circumstances</td></tr>
<tr><td>2.</td><td>refilling period with fresh substance</td><td>14 days</td><td colspan="2">7 vol. % refilling with fresh substance daily</td></tr>
<tr><td rowspan="2">3.</td><td rowspan="2">refilling with fresh substance daily (running up period)</td><td rowspan="2">21 days</td><td colspan="2">4.4 vol. % refilling with fresh substance daily</td><td rowspan="4">32 – 37 °C different process</td></tr>
<tr><td>control</td><td>different amounts of additives</td></tr>
<tr><td rowspan="2">4.</td><td rowspan="2">refilling with fresh substance daily (comparative experiments)</td><td rowspan="2">21 days</td><td colspan="2">4.4 vol.% refilling with fresh substance daily</td></tr>
<tr><td>control</td><td>different amounts of additives</td></tr>
</table>

We dosed ~50 dm^3 of liquid dung mixture pro treatment to take the factors in connection with the capacity of the fermenters into account (SALLAI, 2016). We applied the continuous (filling up) system, which is most widespread in the practice, 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 (KALMÁR ET AL., 2003).

We measured the quantity and the methane content of the releasing biogas, the dry matter and organic matter content, pH value ratio of C/N of the substrate during experiments by co-fermentation of liquid pig slurry and by-products of food industry and bio-fuel industry.

Statistical methods used for the evaluation of co-fermentation experiments

For the statistical analysis, we used Excel spreadsheet and SPSS for Windows 18.0. The data were analysed by variance with independent two-T sample. We examined the homogeneity with Levene test. By the group pair comparison, we used Tamhane test in the case of heterogeneity, and LSD test in the case of homogeneity (SALLAI, 2014). The relationship between variables was performed with correlation analysis tests (Pearson's correlation coefficient) and linear regression analysis.

RESULTS

Gas releasing in the case of mushroom compost and controls

By the slurry-based controls, the bigger dry matter content (3.4 - 4.6%) increased the average gas releasing (16.98 - 23.04 dm^3/day) and 35% average dry matter content increased nearly 35% in the amount of gas (*Table 2*). The 30 g (dry matter content) yielded mushroom compost additive in approx. 2000 g dry matter pro digester of liquid pig manure containing increased 70% in production (16.98 << 29.00 Ndm^3/day) and decreased 4.4% methane content (58.9 > 54.5%). This is 60% excess amount of energy produced in the methane production (*Table 2*).

Table 2. Parameters of gas releasing in the case of mushroom compost and controls

Load of digester/day; dry matter, treatment	Average dry matter content (%)	Gas releasing (Ndm^3/ day)	Methane content (%)	Specific digester volume referred	
				biogas-production	methane-production
Control I.	3.40	16.98	58.92	0.34	0.20
Control II.	4.59	23.04	59.07	0.46	0.28
30 g DMC (0.06-0.07%)	3.80	29.00	54.50	0.58	0.32

Among the organic matter additives, whole plant additives produced the lowest methane production (hemp, Sucrosorgho 506, C_{36}, Berény sugar sorghum, C_{35} (0.4, 0.4, 0.45 dm^3 methane/dm^3/day) (*Table 3*).

Table 3. Parameters of gas releasing in the case of whole plant additives

Reactors, treatment: liquid pig slurry (4% DMC) + additives	refilling with fresh substance (V/V %/day)	DMC of additive (g/day)	average biogas yield (dm^3/ d)	methane content (%)	methane production related to specific reactor volume (dm^3/dm^3 d)	
1. digester (control)	4.4		21.0	60.5	0.42	0.25
2. digester: Berény sugar sorghum, C35, 30 g d.m./ day	4.4	30	42.2	53.6	0.84	0.45
3. digester: Sucrosorgho 506 sugar sorghum k, 30g d.m./ day	4.4	30	33.8	59.2	0.68	0.40
4. digester: hemp, 30 g d.m./ day	4.4	30	36.1	54.8	0.72	0.40

The specific methane yield of sugar sorghum press residue (100 g DMC. loading) was the most intensive (Reno, Berény, Runa - bacteria treated, 1.0, 0.96, 0.93 dm^3 methane/dm^3/day) but the bacteria treatment did not increase the digestion (*Table 4*).

Table 4. Parameters of gas releasing in the case of different species sugar sorghum press residue

Reactors, treatment: liquid pig slurry (4% DMC) + additives	refilling with fresh substance (V/V %/day)	DMC. of additive (g/day)	average biogas yield (dm^3/d)	methane content (%)	methane production related to specific reactor volume (dm^3/dm^3 d)	
control	5		35.2	55.2	0.70	0.39
Berény sugar sorghum, press residue	5	100	86.1	55.5	1.72	0.96
Róna sugar sorghum, press residue	5	100	90.0	55.4	1.8	1.00
Róna sugar sorghum press residue +bacteria	5	100	82.9	55.8	1.66	0.93

The co-fermentation of the yielded mushroom compost and the maize silage provided the best equipment – energy utilization even without bacteria treatment (0.73 dm^3 methane / dm^3/day), while the addition of bran itself resulted similar specific methane yield (0.72 dm^3 methane / dm^3/day). In this case, the utilisation of the bacteria does not increase methane production (0.65 dm^3 methane/dm^3/day) related to the reactor volume (*Table 5*).

Table 5. Parameters of gas yield in the case of mushroom production by-products

Reactors, treatment: liquid pig slurry (4% DMC) +additives	refilling with fresh substance (V/V %/day)	DMC of additive (g/day)	average biogas yield (dm^3/d)	methane content (%)	methane production related to specific reactor volume (dm^3/dm^3 d)	
control (3.4% DMC)	5		17	58.9	0.34	0.20
control (4.59% DMC)	5		23.	59.7	0.46	0.28
100% mushroom compost, without bacteria	5	30	29.	54.5	0.58	0.32
100% mushroom compost, 1.31 bacteria treatment	5	100	63.3	50.5	1.27	0.64
75% mushroom compost + 25% frozen, Berény sugar sorghum press residue (PSSPR)	5	60	48.7	55.1	0.97	0.54
75% mushroom compost + 25% dried, (PSSPR), 1.31 bacteria treatment	5	100	66.	50.3	1.32	0.66
50% mushroom compost + 50% dried, (PSSPR), 1.31 bacteria treatment	5	100	71.3	50.3	1.43	0.72
75% mushroom compost + 25% corn silage	5	100	74.47	48.9	1.49	0.73
50% mushroom compost + 50% corn silage	5	100	58.16	40.4	1.16	0.47

We tested the capability of use and the biogas release influencing impact of sunflower pellet and the maize pomace in the consideration of quantity and methane content with and without bacteria treatment. In the case of properly selected germs were not only the quantity of the forming gas increasing remarkably, but the methane content too, which wasn't noticed in the case of neither additives nor additives bacteria treatment (*Table 6*).

Table 6. Parameters of gas yield in the case of bio-fuel production by-products

Reactors, treatment: liquid pig slurry (4% DMC) +additives	refilling with fresh substance (V/V %/day)	DMC of additive (g/day)	average biogas yield (dm^3/d)	methane content (%)	methane production related to specific reactor volume (dm^3/dm^3 d)	
control	5		41.83	57.	0.84	0.48
sunflower granulate	5	100	72.56	57.6	1.45	0.84
corn pomace	5	100	74.55	54.5	1.49	0.81
sunflower granulate, + bacteria	5	100	58.1	54.5	1.16	0.63
corn pomace + bacteria	5	100	82.89	58.	1.66	0.96
bran + 1*bacteria, bacteria treatment 3	6.6	45/60	55.1	58.6	1.10	0.65
bran	6.6	45/60	62.7	57.	1.25	0.72

The water-based, pure bran starting treatment for biogas production is special bacteria was able to increase. The relative effectiveness of recirculation technology here refers to the slowing degradation. The liquid pig manure based on 6.6 V / V% loading, dry matter content. 45 g / day of wheat bran in dosing gas production more than doubled the methane content to 5%, the influence of the bacterial treatment increased by 7.5%. Generally, the methane content of by-products was reduced by the bacterial treatment, the gas production was increasing, but in the case of wheat bran, we didn't notice. The bacterial treatment didn't increase the performance of the bran additive, but the methane content was growing, which has been unique among the experiments (*Table 7*).

Table 1. The average gas production of the fermentors in the course of the comparative experiments, with wheat bran additive

Reactors, treatment: liquid pig slurry (4% DMC) +additives	refilling with fresh substance (V/V %/day)	DMC. of additive (g/day)	average biogas yield (dm^3/d)	methane content (%)	methane production related to specific reactor volume (dm^3/dm^3 d)	
bran + bac. treatment 3 recycling technology	6.6	45/62	40.9	57.7	0.82	0.47
bran, recycling technology	6.6	45/62	42.0	57.62	0.84	0.48
control, recycling technology	6.6		10.1	62.38	0.20	0.13
bran + water +2* bac. treat., recycling	6.61	45/60	22.9	46.29	0.46	0.21

CONCLUSIONS

The biogas production based on the pork liquid dung, and the other wastes of agricultural main product of processing known, and accepted technological procedure in the EU's member states, as the result of this biogas and fermented manure is produced. The quantity and the quality of the raw materials and additives, the parameters of the applied technology and the biogas forming are strongly depending.

At the end of the comparative experiments we can determine, that the utilization of the different additives increases the biogas production of the liquid pig slurry, and the difference of this significantly bigger, than the decreasing of the methane content. The justification of the relation between the connection of the maturation degree and the value of the sugar content and another properties of the different additives needs further investigations.

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