BIOGAS PRODUCTION POTENTIAL FROM AGRICULTURAL BIOMASS AND ORGANIC RESIDUES IN LATVIA

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Abstract
The biogas and energy potential from different biomasses is needed to be evaluated, including manure, wastewater sludge, energy plants, and food und biofuel processing wastes in Latvia. Energy crops growing on unused agricultural area are the most important biomass feedstock and its share is around 88% of whole biogas potential in Latvia. Biogas output from different biomass was investigated in laboratory scale digesters operated at 38°C. Biomass mixed with inoculums (fermented cow manure) was investigated for biogas production in sixteen digesters, operated in batch mode at temperature 38±1.0°C. The average methane yield from old grass silage was 248 $l \cdot kg_{DOMadd}^{-1}$ and the average methane content was 48.9%. The average methane yield from chopped oats was 303 $l \cdot kg_{DOMadd}^{-1}$ and the average methane content was 63.1%. The average methane yield from dry fraction of pigs manure was 342 $l \cdot kg_{DOMadd}^{-1}$ and the average methane content was 54.53%. All the investigated biomasses can be successfully cultivated for energy production in Latvia.
Key words: agricultural wastes, anaerobic digestion, biogas, energy crops, methane.

Introduction

In accordance with the National Renewable Energy Action Plan, in 2020 the biogas energy potential should reach 92MW (Support programmes for.., 2012). For the success, it is important to clarify the potential of biogas production from various raw materials, using available and cheaper raw materials first. The Bioenergy Laboratory of Latvia University of Agriculture continues investigation of the potential of biogas production from various raw materials (Biogas Production and.., 2011), and three investigations are shown in this research paper.

1. Old grass silage

Materials, methods and investigation process

The substrates from each type of raw materials and inoculums were analyzed for dry matter, organic matter, ash content and chemical composition. The investigation was measured by using standardized methods (Methodenhandbuch Energetische biomassenutzung.., 2010) (VDI 4630). The raw materials and inoculums were carefully weighed and thoroughly mixed. For all substrates, the same inoculums were used – digestate from a continuous digester. All digesters were connected to the gas storage facilities and taps; the digesters were operating in continuous mode at temperature from 38 to 38.5 °C. Data of gas volume and composition were registered every day. The digesters were agitated every day to reduce the floating layer. The process of fermentation was measured in a single loading mode until the biogas stopped evolving. Also the digestate was weighed and the pH value, dry matter, ash content and organic matter composition were determined.

The raw material used for the investigation was old grass silage that was kept in a trench for more than a year. The scientists (Anaerobic Digestion of.., 2011) and workers stressed that the digesters should be filled in with the silage of good quality like the cows should be fed with it. However, for various reasons, the quality of silage was not suitable for cattle feeding. Therefore, it was important to investigate the yield of biogas that could be obtained from the last year's grass silage.

0.7 l digesters were filled in with 20 g of old grass silage and 0.5 l of inoculums (the accuracy of the measurements was ±0.2 g). All data were entered into the research journal and computer.

Facilities

The dry matter was determined by the Shimazu facility at temperature 120°C, the organic matter was determined by the Nabertherm drying oven at temperature 550°C. As digesters, standard 0.75l vessels were used. The exsiccator Memmert obtained a stable temperature. All-purpose (Universal) exsiccator Memmert (two items) **(**temperature to 100°C, volume 300 l). The composition of gas was determined by the gas analyzer *GA 2000*. The concentration of methane, oxygen, carbon dioxide and hydrogen sulphide in the biogas, pressure and normal calculated volume of gas were measured. The weighing scales (Kern 16KO2 FKB) were used to determine weights of raw materials and digestate; the pH stationary meter (PP-50) was used to determine the pH value.

Results

The results are shown in Table 1.

The table results show that silage has low contents of dry matter (17.27%) and organic matter.

The optimum contents of dry matter and organic matter for this type of silage is about 30% and 85-93%, respectively.

The results of digestate investigation are shown in Table 2.

Table 1

Results of raw materials investigation

Raw material/digester	pH substr.	TS %	TS g	T %	DOM %	DOM g	Weight g	Total DOM g
Silage GPS R5	7.01	17.27	3.45	27.0	73.0	2.52	520	18.18
Silage GPS R6	7.01	17.27	3.45	27.0	73.0	2.52	520	18.18
Silage GPS R7	7.01	17.27	3.45	27.0	73.0	2.52	520	18.18
Silage GPS R8	7.01	17.27	3.45	27.0	73.0	2.52	520	18.18
Inoculum	7.78	3.77	18.85	16.94	83.06	15.66	500	15.66

Table 2

Results of digestate investigation

Raw material/digester	pH	TS %	TS g	T %	DOM %	DOM g	Weight g
R5	7.39	3.46	17,4	20.71	79.29	13.79	502.80
R6	7.33	4.02	20,6	17.68	82.32	16.96	512.40
R7	7.2	3.85	19,47	21.43	78.57	15.3	505.80
R8	7.2	3.99	20,05	19.52	80.48	16.14	502.60
Inoculum	7.14	3.39	16,81	21.86	78.14	13.13	495.9

Table 3

Biogas and methane yield

Raw material	Biogas, l	Biogas, l/g DOM	Methane max %	Methane l without inoculum	Methane l/g DOM filled in	Notes
Silage R5	1.5	0.294	48.3	0.494	0.196	
Silage R6	1.32	0.222	41.0	0.177	0.07	tp
Silage R7	2.13	0.544	48.9	0.626	0.248	
SilageR8	2.3	0.611	49.0	0.755	0.299	
Inoculum	0.76	0.048	31.3	0.168	0.011	
Average	1.977	0.483		0.625	0.248	

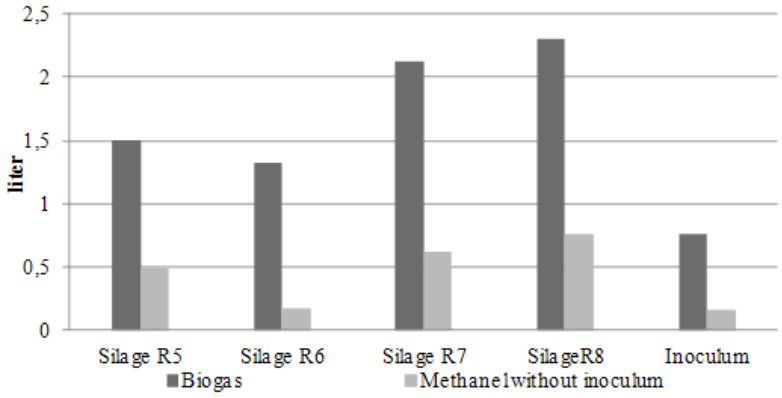

Figure 1. **Biogas and methane yield obtained from old grass silage, l**

The yield of methane and biogas is shown in Table 3 and figures. Results of R6 digester are not reliable and significant due to the technical problems (unregistered gas leak).

The average methane yield obtained from old grass silage is $0.248_{-0,052}^{+0,051}$l/gDOM.

Since the old grass silage quality was bad, it was still possible to obtain a significant amount of methane.

2. Biogas obtaining potential from chopped oats

Materials, methods and investigation process

The oat bran was used as raw material. The bran was carefully shredded and its size did not exceed 1 mm. The process of investigation and facilities are described in the previous investigation.

Results

The results of raw material investigation are shown in Table 4.

The results of digestate investigation are shown in Table 5.

The yield of methane and biogas is shown in Table 6 and figures.

The average methane yield obtained from chopped oats is $0.303_{-0.073}^{+0.062}$l/g DOM.

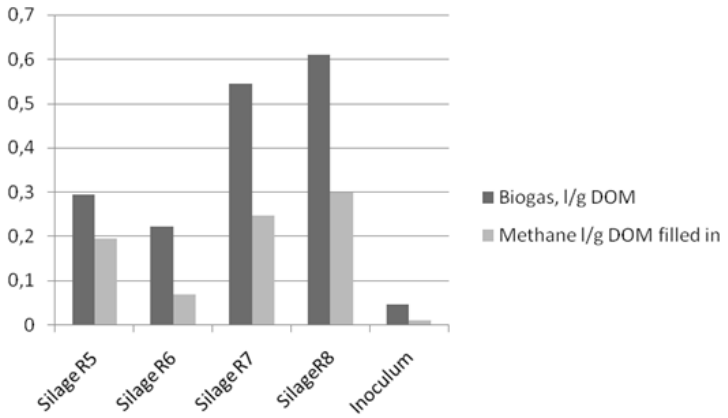

Figure 2. **Biogas and methane l/g DOM obtained from old grass silage**

Table 4

Results of raw material investigation

Raw material/digester	pHsubstr.	TS %	TS g	T %	DOM %	DOM g	Weight g	Total DOM g
Chopped oats R9	7.73	86.6	17.32	4.78	95.22	16.49	520	32.15
Chopped oats R10	7.73	86.6	17.32	4.78	95.22	16.49	520	32.15
Chopped oats R11	7.73	86.6	17.32	4.78	95.22	16.49	520	32.15
Chopped oats R12	7.73	86.6	17.32	4.78	95.22	16.49	520	32.15
Inoculum	7.78	3.77	18.85	16.94	83.06	15.66	500	15.66

Table 5

Results of digestate investigation

Raw material/digester	pH	TS%	TSg	T%	DOM%	DOMg	Weight g
R9	7.11	4.41	22.27	16.56	83.44	18.59	505.1
R10	7.11	4.64	23.09	18.19	81.81	18.89	497.8
R11	7.07	4.82	24.22	16.02	83.98	20.34	502.4
R12	7.1	5.16	25.77	15.96	84.04	21.66	499.4
Inoculum	7.14	3.39	16.64	21.86	78.14	13.0	490.9

3. Biogas obtaining potential from the dry fraction of pigs manure

Materials, methods and investigation process

The dry fraction of pigs manure was used as raw material. This fraction was obtained using the FAN Press Screw Separator. The process of investigation is described in the first investigation.

Results

The results of raw materials investigation are shown in Table 7.

The results of digestate investigation are shown in Table 8.

The yield of biogas and methane is shown in Table 9 and figures.

The average methane yield obtained from the dry fraction of pigs manure is $0.342_{-0.189}^{+0.146}$ l/g DOM.

Table 6

Biogas and methane yield

Raw material	Biogas l	Biogas l/g DOM	Methane max %	Methane l without inoculums	Methane l/g DOM filled in
Chopped oats R9	6.95	0.378	62.4	3.771	0.230
Chopped oats R10	12.0	0.686	62.1	5.970	0.365
Chopped oats R11	7.87	0.433	62.3	4.315	0.263
Chopped oats R12	12.15	0.695	65.6	5.788	0.353
Inoculum	0.76	0.048	31.3	0.168	0.011
Average	9.743	0.548		4.961	0.303

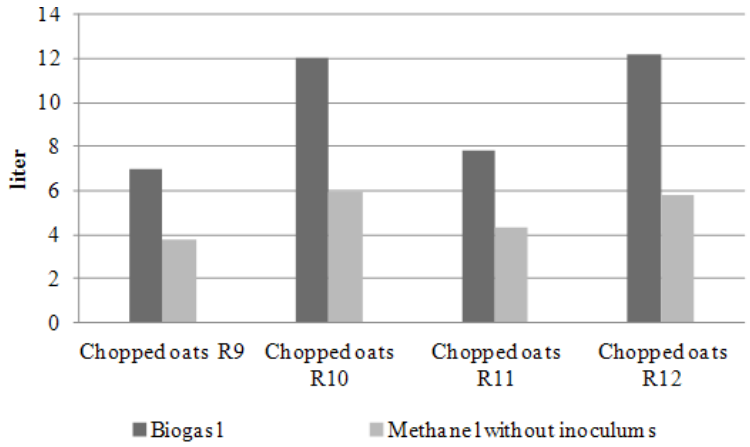

Figure 3. **Biogas and methane yield obtained from chopped oats, l**

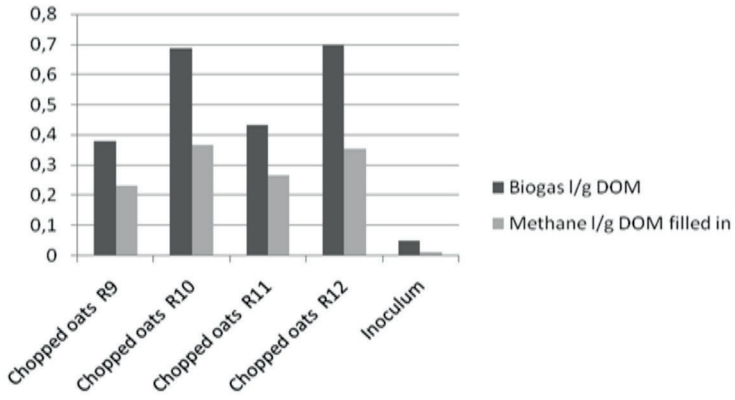

Figure 4. **Biogas and methane yield l/g DOM obtained from chopped oats**

Table 7

Results of raw materials investigation

Raw material/digester	pH substr.	TS %	TS g	T %	DOM %	DOM g	Weight g	Total DOM g
Pig manure R13	7.74	21.16	4.23	8.79	91.21	3.86	520	19.52
Pig manure R14	7.74	21.16	4.23	8.79	91.21	3.86	520	19.52
Pig manure R15	7.74	21.16	4.23	8.79	91.21	3.86	520	19.52
Pig manure R16	7.74	21.16	4.23	8.79	91.21	3.86	520	19.52
Inoculum	7.78	3.77	18.85	16.94	83.06	15.66	500	15.66

Table 8

Results of digestate investigation

Raw material/digester	pH	TS%	TS g	T%	DOM%	DOMg	Weight g
R13	7.08	3.58	18.32	20.23	79.77	14.62	511.80
R14	7.12	3.57	18.38	21.87	78.13	14.36	515.00
R15	7.06	3.84	19.78	17.55	82.45	16.3	515.00
R16	7.08	3.57	18.34	18.45	81.55	14.96	513.80
Inoculum	7.14	3.39	16.64	21.86	78.14	13.0	490.9

Table 9

Biogas and methane yield

Raw material	Biogas l	Biogas l/g DOM	Methane max %	Methane l without inoculums	Methane l/g DOM filled in
Pig manure R13	2.95	0.567	56.8	1.369	0.354
Pig manure R14	4.05	0.852	57.2	1.883	0.488
Pig manure R15	2.33	0.407	49.6	0.706	0.183
Pig manure R16	2.87	0.545	56.0	0.442	0.342
Inoculum	0.76	0.048	31.3	0.168	0.011
Average		0.609		1.319	0.342

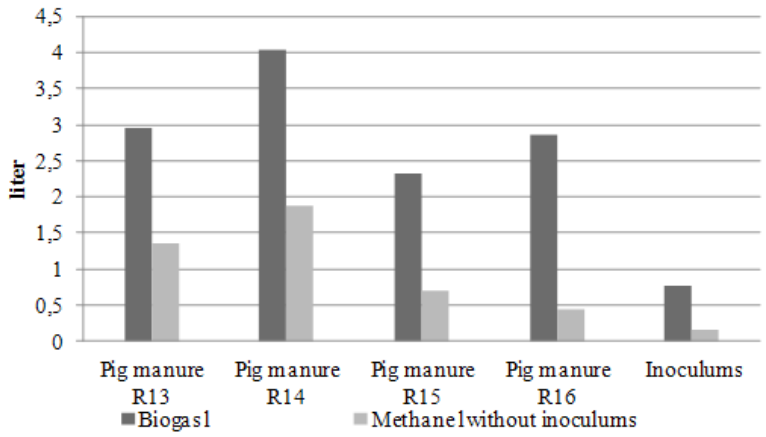

Figure 5. **Biogas and methane yield obtained from the dry fraction of pigs manure, l**

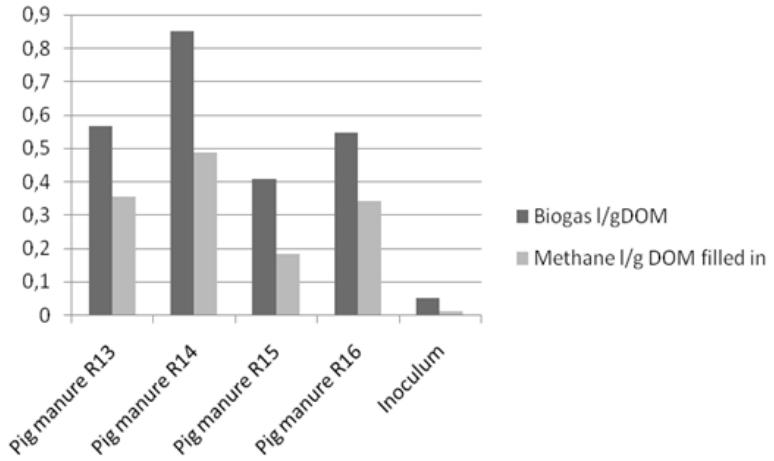

Figure 6. **Biogas and methane yield l/g DOM obtained from the dry fraction of pigs manure**

Conclusions

The investigation shows that good quality silage should be used for biogas production.

If silage quality (silage of lower quality) is not suitable for cattle feeding, it could be used for biogas production, however, the amount of yield will be less than with good quality silage.

Chopped oat bran is a good raw material for biogas production.

The methane yield of 0.303 l/ g DOM is a significant result in comparison with a theoretical optimum.

The methane yield 0.342 l/g DOM obtained from the dry fraction of pigs manure is a good result. This result outperforms the average methane yield from normal pig manure.

It is worth to transport the dry fraction of pigs manure to long distances.

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