BIOGAS PRODUCTION POTENTIAL FROM AGRICULTURAL RESIDUES IN LATVIA

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Abstract. It is needed to evaluate the biogas and energy potential from different biomass, including manure, wastewater sludge, energy plants, and food and biofuel processing waste in Latvia. Biogas output from different biomass was investigated in laboratory scale digesters operated at 38 ºC. Biomass mixed with inoculums (fermented cow manure) was investigated for biogas production in fifteen digesters, operated in batch mode at temperature 38 ± 1.0 ºC. Average methane yield per unit of dry organic matter added (dom) from ryegrass silage was 316 $l \cdot kg_{dom}^{-1}$ and average methane (CH_4) content was 58.36 %. Average methane yield from oat middlings was 244 $l \cdot kg_{dom}^{-1}$ and average methane content was 60.72 %. Average methane yield from jam was 728 $l \cdot kg_{dom}^{-1}$ and average methane content was 62.77 %. All investigated biomass can be successfully cultivated for energy production in Latvia.

Keywords: agricultural waste, anaerobic digestion, biogas, energy crops, methane.

Introduction

Latvia cannot provide the country with own produced energy and fossil energy resources are imported from other countries. There are 368500 ha of unused agriculture land in Latvia. Effective use of this land could help to obtain a significant amount of energy. One of the most advanced methods of energy production from biomass is anaerobic digestion [3]. Biogas is a product of great value and its production technology does not increase carbon dioxide emission and is environmentally friendly. In recent years the biogas production is booming also in Latvia. There is a need to use different raw materials in biogas plants. Biogas potential investigation results from agricultural waste are very important for calculating the right loading rate and maintaining a stable anaerobic digestion process at any plant [1].

1. Ryegrass silage (GPS)

Materials and methods

Investigations on laboratory equipment with different raw materials were carried out using one method. The ryegrass silage was used for the first investigations.

The average substrate was taken and the Latvia University of Agriculture, the Bioenergy Laboratory determined the composition of the substrate using ISO 6496:1999. The substrates from each type of raw materials were analysed for dry matter, organic matter, ash content and chemical composition. The analysis was measured by using standardized methods [2].

All digesters were connected to the gas storage facilities and taps; the digesters were operating in continuous mode at temperature from 38 ± 0.5 ºC. The data of the gas volume and composition were registered every day. Also the digestate was weighed and the pH value, dry matter, ash content and organic matter composition were determined.

Fermented cow manure was used as inoculum in all 15 reactors. Only inoculum was filled in reactor R inoculum (control), which was different for each raw material. Biogas or methane volumes obtainable from inoculum in reactor R inoculum were used for evaluation of net biogas or methane obtainable from the added biomass. The biogas volume produced from the added biomass calculates as follows:

$$V_{BA} = \frac{V_{BS} - V_{BIN}}{M_{domA}} \tag{1}$$

where V_{BA} – biogas produced from dry organic matter (dom) of added biomass, $l \cdot kg_{dom}^{-1}$;
V_{BS} – biogas produced from dom of substrate in anaerobic fermentation process, l;
V_{BIN} – biogas volume produced from dom of inoculum in the anaerobic fermentation process, l;

M_{domA} – mass of volatile solids in added biomass, kg_{dom}.

The methane volume produced from the added biomass calculates as follows:

$$V_{CH4A} = \frac{V_{CH4S} - V_{CH4IN}}{M_{domA}} \tag{2}$$

where V_{CH4A} – methane produced from dry organic matter (dom) of added biomass, $l \cdot kg_{dom}^{-1}$;
V_{CH4S} – methane produced from dom of substrate in anaerobic fermentation process, l;
V_{CH4IN} – methane produced from dom of inoculum in the anaerobic fermentation process, l.

All 15 bioreactors were positioned in a heated camera having automatic temperature control at 38 ± 1 ºC. Fermentation was provided in a period up to 30 days or until no biogas was released from the reactors.

The dry matter, ashes content and pH level were measured before and after the anaerobic fermentation process. Biomass weight was measured on the scales Kern16KO2 FKB having accuracy ± 0.2 g. Measurement of pH level was provided by help of the equipment PP-50. By help of a specialized unit Shimadzu the biomass samples were dried for moisture and total solid content at temperature 120 ºC with mass weighting accuracy ± 0.001 g. Ashes for volatile solid content evaluation were measured by help of the oven Nabertherm at temperature 550 ºC. Biogas from every reactor was guided into external storage bags for gas volume measurement and analysis of gas composition. The gas composition, e.g., methane, carbon dioxide, oxygen and hydrogen sulphide content, was measured with the gas analyser GA 2000. Standard error was estimated by help of standardized data processing tools for each group of digesters.

Results and discussion

The results of the analysis of raw materials are shown in Table 1, digestate in Table 2. The biogas and methane yields are shown in Table 3 and Fig. 1. The results of digestate analysis are shown in Table 2.

Table 1

Raw material analyses

Raw/digester	pH substr.	TS, %	TS, g	Ash, %	Dom, %	Dom, g	Weight, g	Dom Tot, g
Silage GPS R1 - 4	6.86	24.13	4.83	6.8	93.2	4.5	520	21.83
Inoculum	7.44	4.28	21.4	19.0	81.0	17.33	500	17.33

Table 2

Average results of digestate analyses

Raw/digester	pH substr.	TS, %	TS, g	Ash, %	Dom, %	Dom, g	Weight, g
R1 - 4	7.3	3.40	17.28	23.10	76.90	13.28 ± 0.47	508.8 ± 4.7
Inoculum	7.48	3.13	15.29	24.9	75.10	11.49	488.6

Table 3

Biogas and methane yield

Raw material	Biogas, l	Biogas, $l \cdot kg_{dom}^{-1}$	METHANE, %	Methane without inoculum, l	Methane, $l \cdot kg_{dom}^{-1}$ add	Notes
Inoculum	2.22	-	43.2	0.735	-	-
Average R1 - 4	2.44	0.543	58.36	1.424	0.316	-

Average methane yield was 0.316 ± 0.035 $l \cdot kg_{dom}^{-1}$.

In this study, the results of individual bioreactors were little change values, so it was able to fill the reactor with very similar materials and leavening. Although the weight of the raw materials is the same, the bacterial composition and the composition of equity cannot always be achieved.

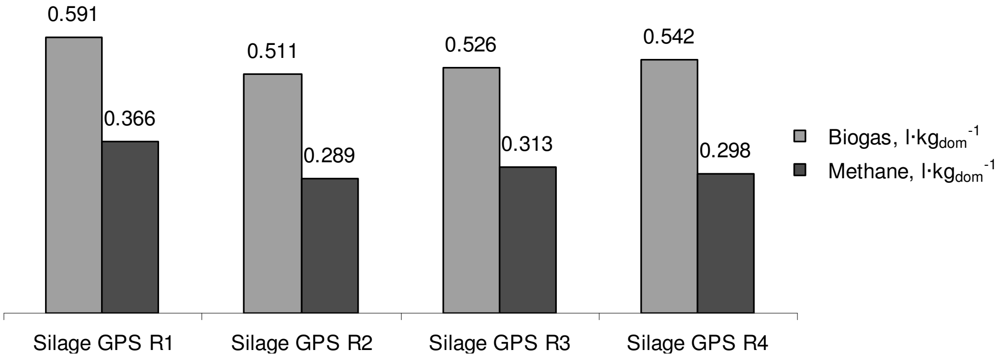

Fig. 1. **Biogas and methane $l \cdot kg_{dom}^{-1}$ from ryegrass silage**

Conclusions

1. The methane yield 0.316 $l \cdot kg_{dom}^{-1}$ from GPS silage shows that it is well used for the production of biogas in Latvia.
2. In comparison with the literature data (Faustzahlen biogas KTBL, FNR 2007) the results are average.

2. Oat middlings

Materials and methods

Oat middlings, sieved grains were used for the investigations. The methods and work pace are the same as described in the investigation 1. 0.7 l digesters were filled with 20 g oat middlings and 0.5 l inoculum.

Results and discussion

The results of the analyses of raw materials are shown in Table 4, digestate in Table 5. The biogas and methane yields are shown in Table 6 and Fig. 2.

Table 4

Analyses of raw materials

Raw/digester	pH substr.	TS, %	TS, g	Ash, %	Dom, %	Dom, g	Weight, g	Total, g dom
Oat middlings R1-4	7.38	88.91	17.77	13.38	86.62	15.4	520.99	31.22
Inoculum	7.32	4.1	20.5	32.81	77.19	15.82	500	15.82

Table 5

Digestate analyses results

Raw/digester	pH substr.	TS, %	TS, g	Ash, %	Dom, %	Dom, g	Weight, g
R1-4	7.1	3.65	18.03	20.29	79.71	14.37	493.5 ± 3.4
Inoculum	7.1	3.4	16.72	22.03	77.97	13.04	491.8

Table 6

Biogas and methane yield

Raw material	Biogas, l	Biogas, $l \cdot kg_{dom}^{-1}$	METHANE, %	Methane without inoculum, l	Methane, $l \cdot kg_{dom}^{-1}$ add	Notes
Inoculum	1.	-	-	0.47	-	-
Average	6.185	0.401	60.72	3.756	0.244	-

Average methane yield was 0.244 ± 0.01 $l \cdot kg_{dom}^{-1}$.

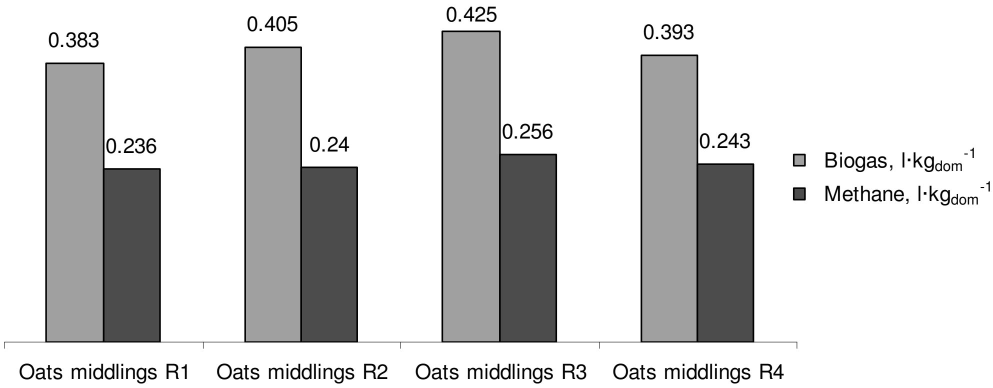

Fig. 2. **Biogas and methane l·kg$_{dom}^{-1}$ from oat middlings**

Conclusions

1. Oat sharps got 0.244 l·kg$_{dom}^{-1}$ methane, which is a good average result.
2. Oat middlings, if they are well enough no condition grain, is a good raw material for biogas production.

3. Jam

Materials and methods

Jam, which was not usable for food, was investigated. The methods and work pace are the same as described in the investigation 1. 0.7 l digesters were filled with 20 g jam and 0.5 l inoculum.

Results and discussion

The results of the analyses of raw materials are shown in Table 7, digestate in Table 8. The biogas and methane yields are shown in Table 9 and Fig. 3.

Table 7

Analyses of raw materials

Raw/digester	pH substr.	TS, %	TS, g	Ash, %	Dom, %	Dom, g	Weight, g	Total, g dom
Jam R7-10	3.42	46.72	9.33	13.84	86.16	8.03	519.4	23.85
Inoculum	7.32	4.1	20.5	32.81	77.19	15.82	500	15.82

Table 8

Digestate analyses results

Raw/digester	pH substr.	TS, %	TS, g	Ash, %	Dom, %	Dom, g	Weight, g
Jam R7-10	7.24	4.88	23.98	18.22	81.78	19.63	491.4 ± 2.4
Inoculum	7.1	3.44	16.88	21.93	78.07	13.17	490.6

Table 9

Biogas and methane yield

Raw material	Biogas, l	Biogas, l·kg$_{dom}^{-1}$	Methane, %	Methane without inoculum, l	Methane, l·kg$_{dom}^{-1}$ add	Notes
Inoculum	1.6	-	-	0.47	-	-
Average	9.343	0.961	62.77	5.865	0.728	-

Average methane yield was 0.728 ± 0.161 l·kg$_{dom}^{-1}$.

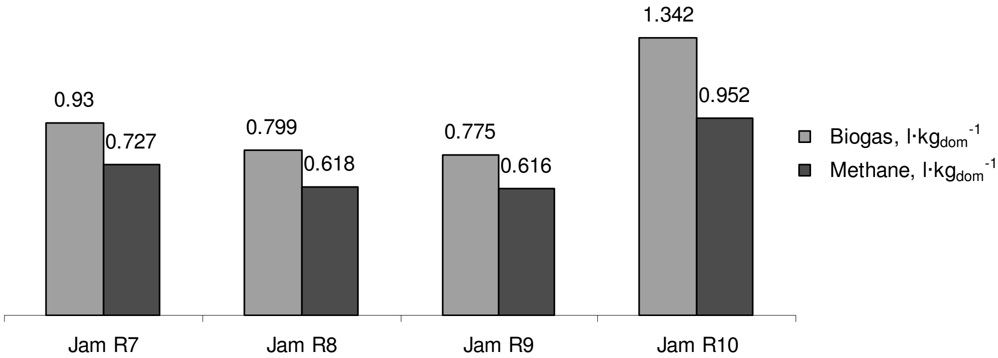

Fig. 3. **Biogas and methane $l \cdot kg_{dom}^{-1}$ from jam**

Conclusions

1. Damaged jam produced a lot of methane, 0.728 $l \cdot kg_{dom}^{-1}$.
2. The study shows that unfit for human consumption jam can be very well used for production of biogas.

References

1. Faustzahlen Biogas 2007 KTBL Darmstadt.
2. Methodenbuch Energetische biomassenutzung DBFZ version 1.1 2010. P 93.
3. Dubrovskis V., Plūme I., Koteļeņecs V., Zabarovskis Z. Biogas production and biogas potential from agricultural biomass and organic residues in Latvia. Proceedings of International Conference Biogas in Progress 2. 29.03 - 1.04. 2011. Part 2. pp. 80-83. ISBN: 978-3-940706-02-7.