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BIOGAS PRODUCTION BY CO-FERMENTATION OF FODDER AND SUGAR BEET AS PART OF A HOLISTIC ENERGY CONCEPT IN A NEW GREENHOUSE GENERATION

BIODUJŲ GAMYBA FERMENTACIJOS BŪDU IŠ PAŠARINIŲ IR CUKRINIŲ RUNKELIŲ YRA NAUJOS ENERGIJOS KONCEPCIJA APLINKOSAUGOJE

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The feasibility of the co-fermentation of sugar beet silage with maize silage within a holistic energy strategy for a novel type greenhouse is investigated. Therefore, the influence of organic dry matter total solids (dTS) of sugar beet as part of a substrate blend with maize is analysed. A synergy effect and the advantages of co-fermentation of sugar beet with maize silage compared to mono-fermentation of sugar beet could be observed in the study.

Biogas, energy concept, greenhouse, maize silage, sugar beet silage.

Introduction

In mediterranean regions greenhouses foils are widely used. The consumption of water and environmental pollution are high, the control of in house climate impossible and the system is largely depending on weather conditions resulting in quality and quantity fluctuations.

These disadvantages may be significantly reduced with a closed greenhouse system which provides a selective optimization of all of the relevant parameter to cultivate plants. Therefore, a resource efficient, novel type greenhouse with a holistic energy concept will be developed.

One aspect represents the integration of thermal solar energy and biogas from different biogenous resources.

Several biogenous resources are available: energy crops, sugar beet, fodder, sea weed and residues from extraction processes and horticultural waste at which we focus on fodder and sugar beet due to its availability and properties 2, 4, 6.

Fodder and sugar beet for biogas production are more and more applied in Germany. The organic dry matter yields at the level of silage. Due to a very easy digestibility of both materials an economic biogas production is possible.

Usually, sugar beets are used as co-substrate in combination with maize and other energy crops 3, 8.

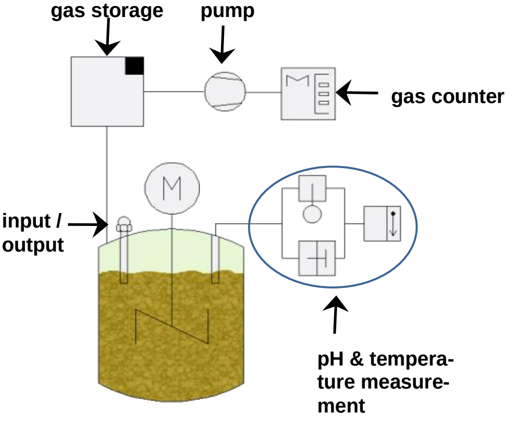
In this study the influence of organic dry matter Total Solids (oTS) of sugar beet as part of a substrate blend on continuous fermentation process is investigated.

Object, methods and results

A double experiment was used to investigate the biogas production of fodder and sugar beet as co-substrates. A stable fermentation of maize silage under practical conditions was chosen as initial point of the testing.

The biogas experiments were carried out at a laboratory scale of 20 L (Fig. 1).

The biogas digesters could be used continuously or as batch test. The compound of gas quantity and composition were determined once a day. The amount of gas was measured with a gas meter from Ritter Company while the gas composition was measured with a biogas monitor BM2000 from Ansyco Company. The biogas was analyzed for the content of methane, carbon dioxide, hydrogen sulfide and oxygen. The experiments and analyses were performed according to the guidelines VDI 4630 and DIN 38414-8.



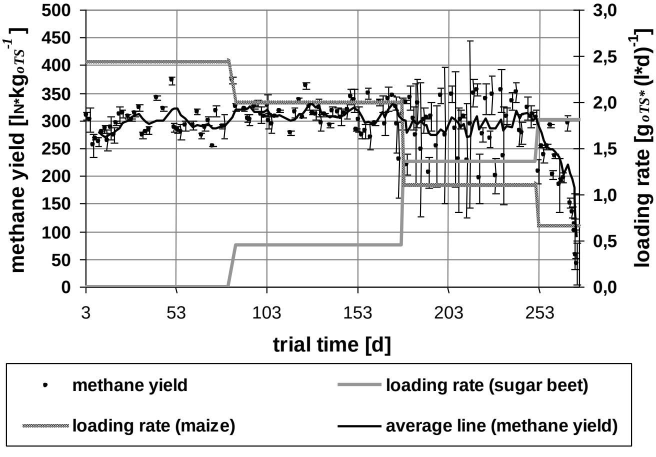
1 pav. Autoklavo schema įskaitant matavimo įrangą
Fig. 1. Scheme of a digester including measurement

According to Weißbach et al. 5 it is necessary to correct the values for dry matter, determined after DIN EN 12880, to take volatile substances into account. Based on these results, the dry organic matter was calculated.

During all experiments the loading rate of total loading rate of dry organic matter is kept constant at 2.5 g_{oTS} l^{-1} d^{-1} in the biogas digester.

Within the period of study the dry organic matter of maize silage is systematically substituted by sugar beet silage. The stepwise replacement of maize silage is shown in figure 2.

The fermentation of maize silage led to a stable methane production of (286 ± 52) l_N kg_{oTS}^{-1}. After the input of 20% sugar beet silage increased the methane yield to (315 ± 22) l_N kg_{oTS}^{-1}. The addition of sugar beet silage exhibits a positive effect of the stabilization of the fermentation process. The 20 % fraction of sugar beet in substrate blend results in an obviously increase of methane production as shown in figure 2.



2 pav. Metano išeiga po nepertraukiamos mišinio, sudaryto iš kukurūzų ir cukrinių runkelių siloso fermentacijos. Mišinio OTS sudėtis buvo keičiama bet įkrovos dažnis pastovus (kukurūzų ir cukrinių runkelių kartu), n=2 1

Fig. 2. Methane yields after continuous fermentation of a substrate blend consisting of maize and sugar beet silages. The composition of OTS was variable but the loading rate kept constant (sum of sugar beet and maize), n=2 1

A further increase of the substitution of sugar beet silage for maize up to 1.4 g_{oTS} l^{-1} d^{-1} had no influence of the stability of the fermentation process. However, the operating was close to the limit of acidification. The mean methane yield was determined with (293 ± 46) l_N kg_{oTS}^{-1}. An increase of the substitution fraction for more than 50% won't get any further improvement of the rate of yield. The fermentation process becomes more and more unstable at this organic loading rate associated with a strong dispersion of values of the methane yield. Even it could be diagnosed a marginal decrease accompanied by a strong raising measurement uncertainty.

The continuing increase of the rate of sugar beet silage to 1.8 g_{oTS} l^{-1} d^{-1} led to an acidification and a break-off of the process after 20 days.

Discussion

It is to be assumed that the degradation of easily fermentable substrate components in the beet silage (sugars, alcohols, carboxylic acids) leads to a strong acid formation. It is known that the acetogenesis is the rate determining step besides the methanogenesis when the fermented substrate can be easily hydrolyzed 7. Therefore the feeding of easily fermentable substrates has to be adapted to the turnover rates of methanogenic microorganisms. The much higher growth rate of the acidogenic microorganisms results in the acidification of the biogas fermenter and thus to an inhibition of the methanogens, which need a pH value of 6.8-8.2 8.

Therefore the biogas process will be overloaded by excessive feeding with beet silage. It was found that a proportion of 0.5 g_{oTS} l^{-1} d^{-1} beet at the total organic dry matter of the supplied substrate mixture increases the methane yield. An appropriately sized beet addition may influence the methane yield positively.

Due to this, a synergistic effect appears between the two substrates. This confirms the statement of Märländer et al. They found that the co-fermentation of sugar with corn silage always be considered more advantageously compared to mono-fermentation 6.

Comparing the results of co-fermentation sugar beet and maize silage with those from mono-fermentation show, the maximum proportion of sugar beet corresponds to the maximum loading rate of sugar beet used as mono-substrate. Thereby the ratio of sugar beet to input is crucial for the stability of fermentation.

The status of the R&D activities already proves the feasibility of the co-fermentation of sugar beet silage with maize silage as part of a holistic energy strategy for a novel type greenhouse. Thus, current and future activities focus on further development and including biogenous waste from up- and downstream processes to gain high-valuable substances from renewable resources.

Conclusions

The easily degradable carbohydrates and alcohols, which mainly come from the beet silage in the substrate mixture, are preferentially fermented. The oTS content of the beet silage in the mixture is therefore crucial for the maximum loading rate of the substrate feed. A beet fraction higher than 20 % leads to an overload of the biogas process, resulting in an inefficient fermentation with low biomass degradation.

Therefore, the beet substitute should be seen in context with other substrate components. If these substrate components contain high concentrations of easily degradable carbohydrates and alcohols as well, the beet proportion at the substrate mixture must be reduced.

Generally, the mixture with a high percentage of beets in the substrate requires a special attention from the plant operator.

References

1. Böttcher, R. (2013): *Untersuchungen zur effizienten Biogasproduktion aus Beta-Rüben*, Thesis.
2. Krautzer, B. (1992): *Produktion und Lagerung von Futterrüben*, BAL Veröffentlichungen 16, 1-11

3. Pirkelmann, H. (1990): *Silierung von Futterrüben mit saftbindenden Stoffen*, Die Milchpraxis 1/1990.
4. Herrmann, C.; Heiermann, M.; Idler, C. (2011): *Effects of ensiling, silage additives and storage period on methane formation of biogas crops,* Bioresource Technology 102 (8), 5153-5161.
5. Weißbach, F.; Strubelt, C. (2008): Die Korrektur des Trockensubstanzgehaltes von Zuckerrübensilagen als Substrat für Biogasanlagen, *Landtechnik* 6, 354–355.
6. Märländer, B., Augustin, D., Hartung, E., Hoffmann, C., Setzer, F., Stockfisch, N. (2010): *Biomasserüben - Die Zuckerrübe als Biogassubstrat,* 362, Fachzentrum Land- und Ernährungswirtschaft.
7. Bischofsberger, W., Dichtl, N., Rosenwinkel, K.-H., Seyfried, C. F. (2005): *Anaerobtechnik*, B. Böhnke, Springer-Verlag, Berlin Heidelberg.
8. Weiland, P. (2001): *Grundlagen der Methangärung - Biologie und Substrate*, VDI-Berichte Nr. 1620, Biogas als regenerative Energie - Stand und Perspektiven. VDI-Verlag, 19-32.

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Santrauka

Šiame tyrime analizuojama cukrinių runkelių siloso ir kukurūzų siloso fermentacios būdu išgaunama energija. Taip pat cukrinių runkelių organinės sausosios medžiagos kietųjų dalelių poveikis, kai dalis substrato yra sumaišoma su kukurūzais. Cukrinių runkelių sumaišytų su kukurūzų silosu fermentacijos įtaka ir privalumai, bei palyginimas su cukrinių runkelių fermentacijos duomenimis yra pateikti šiame tyrime.

Biodujos, energijos koncepcija, aplinkosauga, kukurūzų silosas, cukrinių runkelių silosasю

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НОВАЯ КОНЦЕПСИЯ ЭНЕРГЕТИКИ В ОКРУЖАЮЩЕЙ СРЕДЕ – ПРОИЗВОДСТВО БИОГАЗА ИЗ КОРМОВОЙ И САХАРНОЙ СВЕКЛЫ

Резюме

И исследоиях анализируются получеиие энергии способом ферментации из силоса сахарной свеклы и кукурузы. Также определются влияние твердых частиц сухого вещества сахарной свеклы, когда часть субстрата перемешива ются с кукурузами. В статье определются преимущества и влияние на ферментацию смеси силосов сахарной свеклы и кукурузы.

Биогаз, концепсия энергии, окружающая среда, силос из кукурузы, силос из сахарной свеклы.