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The Hohenheim Biogas Yield Test

Comparison of Different Laboratory Techniques for the Digestion of Biomass

For the planning of agricultural biogas plants, the achievable biogas yields of the substrates used must be known. The Hohenheim biogas yield test is a novel technique for the determination of the methane yield of organic substance, which can be carried out with the aid of commercial laboratory equipment. Extensive exemplary studies based on cattle slurry, grass silage, and kitchen waste as substrates proved that the results achieved with a simple experimental set-up were at least as good as those obtained using the systems employed otherwise.

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Different organic substances are used as fermentation substrates in agricultural biogas plants. The planning of these plants in particular requires precise knowledge of the achievable methane yields of the existing substrates. For this purpose, generally discontinuous fermentation experiments are carried out in the laboratory in order to determine the maximum biogas yield potential. The standard technique according to DIN 38414, part 8, has been designed for thin substrates with little gas formation potential from waste water processing. For the fermentation substrates common in agriculture with their significantly higher percentage of organic substances, this technique is hardly suitable. Therefore, the research institutions which study biogas techniques employ different experimental set-ups for the determination of the gas formation potential. These set-ups are generally built by the individual institutes in a labour-intensive process [1, 5].

Goals

The goal during the development of the Hohenheim biogas yield test was to simplify the experimental set-up and to reduce its size in order to be able to carry out more repetitions or analyses at the same time and to avoid potential sources of error, such as leaks in the gas pipes. The labour required to set up the laboratory equipment, the time needed for supervision during the experiments, and the quantity of test substrate were intended to be reduced. The objective was to design the new technique such that it can be carried out using commercial laboratory equipment.

The reduction of the quantity of inoculated liquid manure was intended to make it easier for one to cultivate the inoculated substrate oneself. Altogether, the technique must provide reproducible results which can be compared with conventional methods.

Material and Method

Based on the approach of the Hohenheim feed value test, 100 ml glass syringes (flask samplers) with a 1/1 graduation as well as a capillary extension as shown in *figure 1* are used as fermenters. A gas-tight hose is put onto the capillary extension, which can be closed with the aid of a hose clamp. Lubricating grease inert against anaerobic degradation is used to seal the gap between the stopper and the glass flask. Approximately 60 flask samplers are put into a motor-driven rotor. The rotation of the flasks results in the mixing of the substrate. The entire unit is built into an incubator, where the desired fermentation temperature can be chosen [4].

Since the quantity of test substrate required for a fermenter is less than one gram, sampling and sample processing are of particular importance. Depending on the dry matter content, a representative sample is taken from approximately one kilogram of fresh mass. The sample is examined for the content of dry matter, organic substance, and ashes. Subsequently, it is gently dried in a drying oven at 50 to 60∞C for 48 hours. Afterwards, the sample is comminuted such that it is able pass through a one-millimetre sieve. The processing of the sample allows the fermenter to be filled with a representative weighed-in quantity of 500 mg of test

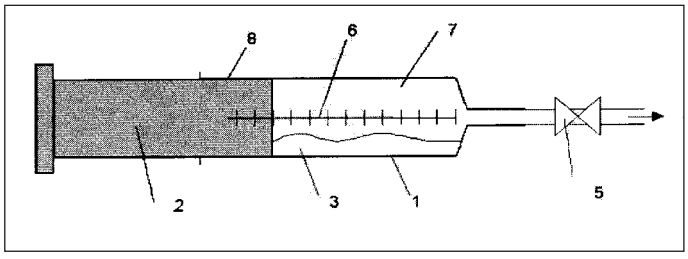

Fig. 1: Retort sampler with 1) glass syringe, 2) stopper, 3) fermentationsubstrate, 4) opening for gas analysis, 5)tube clip, 6) graduation 1/1, 7) gas chamber, 8) sliding and sealing mean

substrate. This combination of drying and comminution is also identical with the common processing method for feed examinations [3].

For the experiment, approximately 30 ml of inoculated substrate is first put into the prepared flask, and the weighed-in quantity is determined with a precision of 1/100 gram. Subsequently, 500 mg of the test substrate is weighed in with a precision of 1/1000 gram using an analytical balance. With the aid of the greased stopper, residual air is evacuated from the flask, and the latter is closed gas-tight. For each test substrate, at least three repetitions are scheduled, and at least three flasks are filled with pure inoculated substrate as a zero variant. In order to secure the results further, reference substrates are digested at the same time.

In order to examine the applicability of the Hohenheim biogas yield test to established fermentation techniques and to examine the reliability of the test further, discontinuous comparative tests were carried out in the biogas laboratory of the State Institute for Agricultural Engineering and Farm Building and the Institute of Agricultural Engineering of Hohenheim University. For comparison, the substrates, pure inoculated liquid manure, cattle slurry, grass silage, and kitchen waste, were digested in a raw and a processed form in eudiometers according to DIN 38414, part 8, and in lying and standing laboratory gas fermenters with a digestion chamber volume of of 16 or 32 litres (standard fermenters used in Hohenheim). The different fermenter types were filled with the same chamber load.

Results

All fermenters used exhibited initially strong methane production, which slowly declined after approximately ten days. *Figure 2* shows exemplary sum graphs of the methane yields of three variants with kitchen waste and the corresponding inoculated liquid manure. The final values of kitchen waste digestion in the standing fermenters show that processing does not influence the methane yield. The results of the three repetitions with processed kitchen waste, however, are scattered less than those of raw kitchen waste. This is caused by the special processing of the substrate samples. Even though very small quantities are used, the sample can be divided representatively. In this case, the repetitions exhibit virtually no differences, which means a significant improvement in the results. For both inoculated liquid manure and processed kitchen waste, the measurable standard methane yield during digestion according to the Hohenheim biogas yield test was slightly higher than the yield obtained in the standing fermenters (variation coefficient [CV]: 7.1 %). The other substrates used showed even smaller differences between the different fermenter types (slurry 3.3%, grass silage 2.3%).

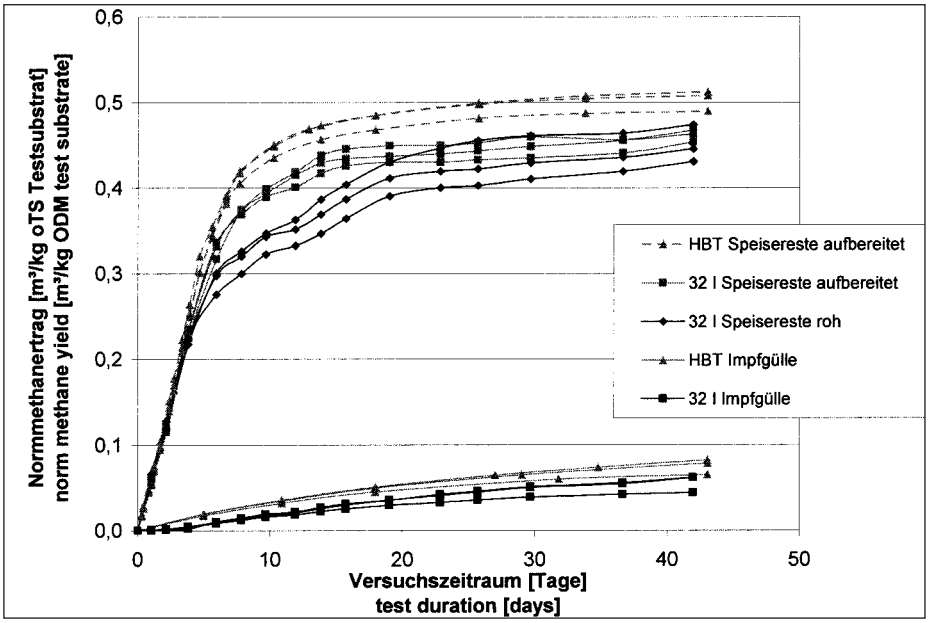

Fig. 2: Sum graphs of each of three independent repetitions of digesting processed and non-processed kitchen wastes and the liquid manures for inoculation ; digestion in different fermenter types

Conclusions

Thanks to the prior processing of the test substrates, the Hohenheim biogas yield test is very suitable for the determination of the substrate-specific methane yield of organic substances. Repetitions exhibit only small differences. A comparison of the different digestion methods also provided highly consistent results. This also applies if different fermentation substrates, such as cattle slurry, grass silage, and kitchen waste are used. The examination of maize silage and other fermentation substrates also provided plausible results [2].

The Hohenheim biogas yield test marks progress in the field of fermentation experiments because it simplifies conventional experimental set-ups based on standard techniques. Technical simplification increases the efficiency of the laboratory while at the same time error potential and personnel requirements are reduced.

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