Methane yield - a new DLG-test scheme for silage additives

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1. Introduction

Biogas production based on energy crops is very common in Germany. The degradation of organic matter in the biogas fermenters (“concrete cows”) is often compared with the processes in the rumen, but there are important differences. In practice silage additives are offered to improve the biogas yield (Banemann et al. 2010). The question is whether ensiling with silage additives and producing different fermentation pathways (homo- or heterofermentative) affects fermentation losses, aerobic stability, and therefore the specific and absolute methane yield and chemical kinetics in the biogas fermenter. The DLG seal of quality for silage additives has been providing impartial advice on using such additives for feed crops for about 30 years now. The new possibilities of using silage additives in biogas production make it expedient to develop a reasonable test scheme that can verify their promised “improvements in biogas yield”. The new test scheme should focus on all processes – from harvesting energy crops, through silage fermentation, including all losses (McDonald et al. 1991) with or without air stress (Honig 1990), to the processes in the biogas reactor. Similarly, the test scheme should be able to work with small quantities of silage in order to run the silage tests on a laboratory scale.

2. Material and methods

In biogas fermenters acetic acid is one of the precursors of methane. Therefore it was first tested whether the specific methane yields produced from the main fermentation products of silage differ significantly. In that case, the biogas potential of silages could in principle be estimated from their contents of fermentation products. A possibly different biogas potential of lactic acid compared with acetic acid would be most relevant, as Nussbaum (2009) found that significant differences exist between most fermentation products with the exception of lactic acid and acetic acid. A repetition of these investigations (Nussbaum, 2010, unpublished), revealed the same ranking of the biogas potential, for instance lactic and acetic acid< butyric acid< 1,2-propanediol <<ethanol. Similar results were published by Pieper and Korn (2010). From these findings it can be concluded that a testing system for silage additives must in principle measure the respective yields of methane from the individual silages, which have received different treatments. The evaluation of additives with respect to gas yield must include complete accounting with all losses, from the crop at ensiling up to the silages prepared under optimal as well as suboptimal conditions.

The Hohenheim Biogas Yield Test (HBT) was developed at the University of Hohenheim (Stuttgart, Germany) for measuring biogas yield at different steps of the process. Typically 400 mg dried silage are incubated together with 30 grams of biogas slurry over 35 days at 37 °C (Helffrich and Oechsner 2003). However, this approach of analyzing dry substrates does not consider the losses of volatile substances occurring during the drying procedure of silage samples. The accompanying losses must be taken into account because considerable amounts of alcohols, (e.g. 1,2-propanediole, ethanol) are produced during ensiling, especially if heterofermentative lactic acid bacteria are used. Consequently it was tested whether the HBT method is suitable for non-dried silages also. This required homogenizing of the silage without heating up the sample. A hand-operated meat mincer was used for this purpose and 1200 mg of the resulting homogenates were incubated in triplicate for the HBT. The results (Nussbaum, 2011, unpublished) showed that the HBT also works successfully with fresh silage and mirrors the effects of silage treatments. However, only some of them were statistically significant. This was attributed to the insufficient homogeneity of the sample, which caused too large variations in gas yield. This problem was overcome by increasing the initial size of the sample from 50 to 100 g FM and homogenizing in a special blender (Thermomix TM 31, www.thermomix.de). This equipment disintegrates all types of deep-frozen silages (-18 °C) within 20 seconds without increasing their temperature above 0 °C. Four replicates of the thoroughly mixed homogenate were incubated for the HBT. The results of the test are presented in a separate contribution (Nussbaum, 2012).

3. Results and discussion

Figure 1 shows the newly developed testing scheme. It allows testing of quite different silage additives under different ensiling conditions (with or without air challenge treatment), which can be completed by determining aerobic instability. Silages can be prepared routinely on laboratory scale (Pflaum et al. 1996). Losses are recorded by weighing. Stability tests require periodic temperature measurements. The correction of the dry matter content for volatile substances is highly important (Weissbach, 2008). Methane yields can be recorded by batch tests such as the HBT. This requires proper homogenization of the silages without excessive heating of the previously frozen material, which can be reliably achieved with the Thermomix TM31.

The accounting for the evaluation of silage additives includes losses as well as specific gas yields. The benchmark is the methane yield of the material prior to ensiling.

Test scheme on a laboratory scale:

No.	Target parameter	Method
1	Losses (fermentation)	Weighing
2	Losses (aerobic stability)	Weighing and temperature rise
3	Biogas yield	Biogas batch test (HBT)

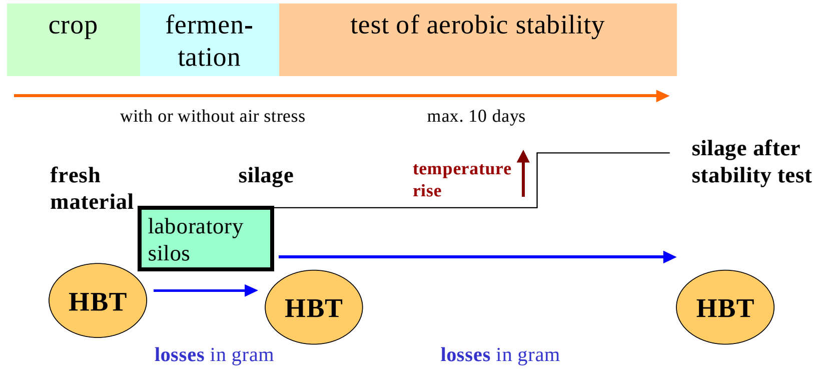

Figure 1. Test scheme over time from harvest to feed out period, showing the target parameters and test methods.

4. Conclusions

A new testing scheme to predict methane yield of silages has been established. The new test scheme includes a procedure working directly with fresh silage to avoid the neglect of volatile fatty acids and alcohols during the drying process of samples. Novel methods for processing and homogenizing small quantities of frozen silage samples (50 to 100 g) were developed. The new test will be operated from 2012.

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