# Impact of water content on the hydrogen production from lignocellulosic residues by dark fermentation

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# IMPACT OF WATER CONTENT ON BIOHYDROGEN PRODUCTION FROM LIGNOCELLULOSIC RESIDUES

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SUMMARY: Biohydrogen production from lignocellulosic residues is restricted by several factors that limit industrial application of this process. Among them, the reactor size reduces the economical feasibility of the process. Dry ananerobic processes operates with low water quantity and could allow treating more waste. This study investigates the hydrogen production from wheat straw under several dryness conditions (sixtotal solid (TS) content). The results showed a hydrogen production of 14 NmlH2.gVS-1 in semi dry consitions (9.5-14.2 %TS). For dry medium (18.8 to 28.1 %TS), the hydrogen production decreases to lower value of 6-7 NmlH2.gVS-1. Finally, in highly dry conditions (28.1 to 33.2%) the hydrogen production is reduced to 3-4 NmlH2.gVS-1. The study reveals that hydrogen can be produced in semi-dry conditions in similar proportion than saturated conditions. However, dry and particularly highly-dry conditions are not favourable to hydrogen production.



## 1. INTRODUCTION

It is well established that bioenergy production from solid waste can be an attractive alternative to fossil fuels. Biogas, such as methane or hydrogen, can be produced by anaerobic digestion from lignocellulosic substrates. At industrial scale, anaerobic digestion processes treating municipal and agricultural residues are widely used in dry conditions (De Baere, 2000). This technology presents many advantages such as compact reactor, high solid concentration in the inlet, less energy for heating and less water addition. So far, hydrogen production by dark fermentation has usually been investigated under saturated water conditions (Guo, Trably, Latrille, Carrère, & Steyer, 2010; Nasirian, Almassi, Minaei, & Widmann, 2011; Ren, Wang, Cao, Xu, & Gao, 2009). All the advantages of dry processes could overcome the low productivity of biohydrogen production. The objective of this study is to investigate the impact of water content on fermentation of lignocellulosic biomass.

## 2. MATERIAL AND METHOD

Wheat straw (*Triticum aestivum*) harvested in summer 2010 was grinded to 1 mm. This wheat straw contains 95.6 % of total solids and 88.9 % of organic matter. It was used as substrate to be

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degraded in mesophilic conditions under limited water content conditions. The range of total solid (TS) content covered the semi-dry (9.5 and 14.2 % TS) and dry fermentation conditions (18.8 to 33.2 % TS). Four replicates were performed for each operating condition. A protocol for the assessment of biohydrogen production was adapted to supply the different dryness conditions (Fang, Li, & Zhang, 2006): same quantity of susbstrate, trace element and MES buffer (2-(N-morpholino)ethanesulfonic acid) substrate fixed to inoculum ratio of 20 on volatil solid basis. Biogas volume and composition were analyzed automatically by pressure measurement and gas microchromatography (VARIAN 580). Solid and liquid samples were analyzed at the beginning and the end of the experiment.

## 3. RESULT AND DISCUSSION

The results indicate a strong influence of the TS content on biohydrogen production from wheat straw. The figure 1 represents the cumulative biogas production among the experiment. The table 1 shows the characteristic values concerning the hydrogen production.

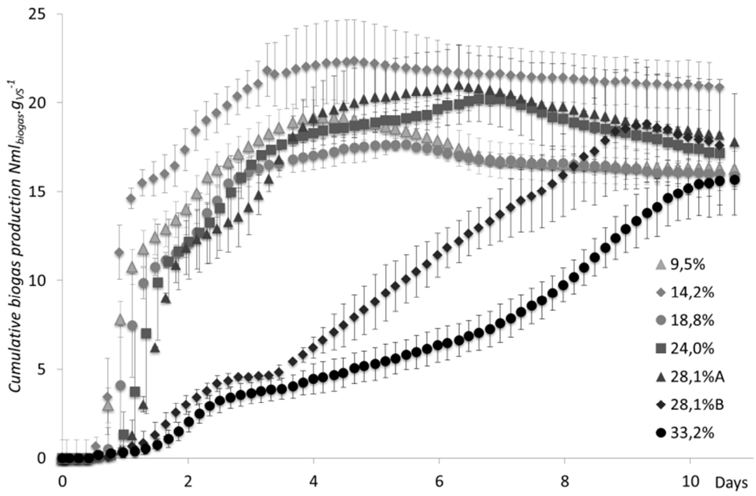


Figure 1. Biogas production over experiment time

At 9.5 and 14.2 % TS, the biogas production was fast and the hydrogen yield equalled the standard value obtained in saturated water conditions (≈ 14 Nml $H_2$/ gVS) (Quéméneur et al., 2012). For higher TS contents (18.8 and 24.0 % TS), the biogas production remained similar to the previous ones, but the hydrogen productivity decreased significantly (> 6 Nml $H_2$/ gVS). At 30% TS, two different behaviours were observed on the four replicates. Two replicates, named group 30a, had a rapid hydrogen production (3.7 day to reach 90% of maximal $H_2$ value); while the two other replicates, named group 30b, had a slow hydrogen production (8.0 day to reach the mawimal biohydrogen production). Moreover, in these two different groups the maximal hydrogen production was 7.2 and 4.3 Nml H2/ gVS respectively. The higher TS content tested (35 % TS) showed a slow profile of biogas production (8.4 day to reach 90% of maximal $H_2$ production) with a low hydrogen yield (2.6 Nml H2/ gVS). This observation is consistent with hydrolysis rates previously reported under similar conditions (Abbassi-Guendouz et al., 2012).

Table 1. Hydrogen production from wheat straw at various TS contents (based on four replicates)

| Condition (% of TS) | Hydrogen production (Nml $H_2$/ gVS) | Time to reach 90 % of the total $H_2$ production (days) |
|---|---|---|
| 9.5% | 14.5 ± 1.4 | 2.6 ± 0.5 |
| 14.2% | 13.9 ± 0.6 | 2.5 ± 0.4 |
| 18.8% | 6.5 ± 0.3 | 2.5 ± 0.1 |
| 24.0% | 6.4 ± 0.2 | 3.6 ± 0.6 |
| 28.1%a | 7.2 ± 0.1 | 3.7 ± 0.1 |
| 28.1%b | 4.3 ± 0.9 | 8.0 ± 0.1 |
| 33.2% | 2.6 ± 0.6 | 8.4 ± 0.7 |

## 4. CONCLUSIONS

As a conclusion, this work demonstrated that dry processes could be applied for hydrogen production from lignocellulosic biomass. Furthermore, these results open the perspective of a two stage dry process coupling hydrogen and methane production. Further studies are in progress to better understand the microbial processes involved in this kind of ecosystems.



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