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Biobutanol from wheat straw

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Introduction

As a result of the current policies on reduction of CO_2 emissions and increasing energy security, new technologies to ensure sufficient supply of diesel-compatible biofuels from cheap biomass are needed. The acetone- butanol- ethanol (ABE) fermentation process can make a major contribution to reach this goal, since butanol represents an interesting precursor for diesel-fuel additives and other platform chemicals.

Wheat straw source and treatment

Wheat straw was collected in Groningen (The Netherlands) and stored in 25 kg-bales at room temperature.
Three wheat straw hydrolysates (WSH) were prepared.
Firstly, all wheat straw was mechanically refined and subsequently treated as follows:
- Enzymatic hydrolysis (WSH I)
- Alkali ($Ca(OH)_2$) and enzymatic hydrolysis (WSH II)
- Alkali (NAOH), washing and enzymatic hydrolysis (WSH III)

In all cases, the enzyme mixture used was GC220.

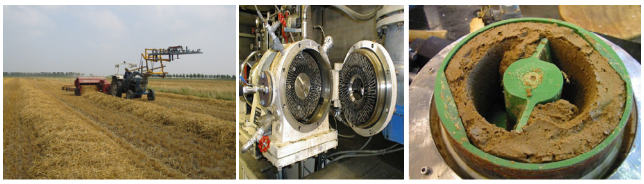

Fig 1. Collection of wheat straw in the field (left), mechanical disc refiner (middle) and pre-treated wheat straw before enzymatic hydrolysis (right)

Fermentation of wheat straw hydrolysates

Due to the mild conditions used in pretreatment and hydrolysis, the WSH contained very low concentrations of HMF or furfural (below 15 mg/L).
Other potential inhibitors such as fenolic acids (coumaric- , syringic- and ferulic acids) and organic acids (levulinic-, formic- and fumaric acids) were absent or in very low concentrations in all three hydrolysates.
The sugars present in the hydrolysates are shown in Figure 2.

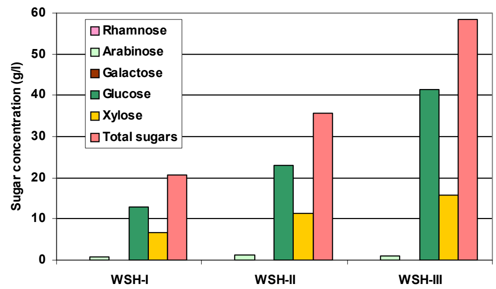

Figure 2. Sugar concentration in WSH for ABE fermentation

C. acetobutylicum ATCC 824 and *C. beijerinckii* NCIMB 8052 were grown on the hydrolysates with and without addition of extra nutrients (see Table 2).

Table 1. Fermentation of WSH by C.acetobutylicum and C. beijerinckii. *In each series, Clostridium Medium (CM, semi-synthetic medium) with a total sugar concentration of 20, 35 or 60 g/L, as indicated, was used as control. WSH was supplemented with nutrients as in CM medium (N) or with yeast extract at 2.5 g/L (YE) as indicated.*

	C. acetobutylicum			*C. beijerinckii*		
Medium	BuOH (g/L)	ABE (g/L)	Y (gABE/gS)	BuOH (g/L)	ABE (g/L)	Y (gABE/gS)
WSH-I	4	6.1	0.33	2.6	3.7	0.36
WSH-I-N	3.4	4.6	0.33	3.4	4.5	0.36
CM- 20	0.5	0.5	0.05	4.6	6.2	0.33
WSH-II	6.8	10.3	0.35	2.7	4.1	0.43
WSH-II-N	4.9	7.3	0.29	7.1	9.8	0.45
CM- 35	4.3	6.2	0.45	9	11.6	0.41
WSH-III	No growth			No growth		
WSH-III-N	10	15.5	0.44	9.3	13.4	0.44
WSH-III-YE	8.6	13.8	0.5	No growth		
CM-60	10.2	15.3	0.35	10.3	13.6	0.3

Conclusions

Wheat straw hydrolysates prepared with mild alkaline pre-treatments were fermentable by both strains tested.

Nutrient requirements and product yields are different for each of the strains, indicating the high importance of the choice of strain to be used in a large scale process.

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