Influence of catalyst type and temperature on the enzymatic hydrolysis of extrusion pretreated barley straw

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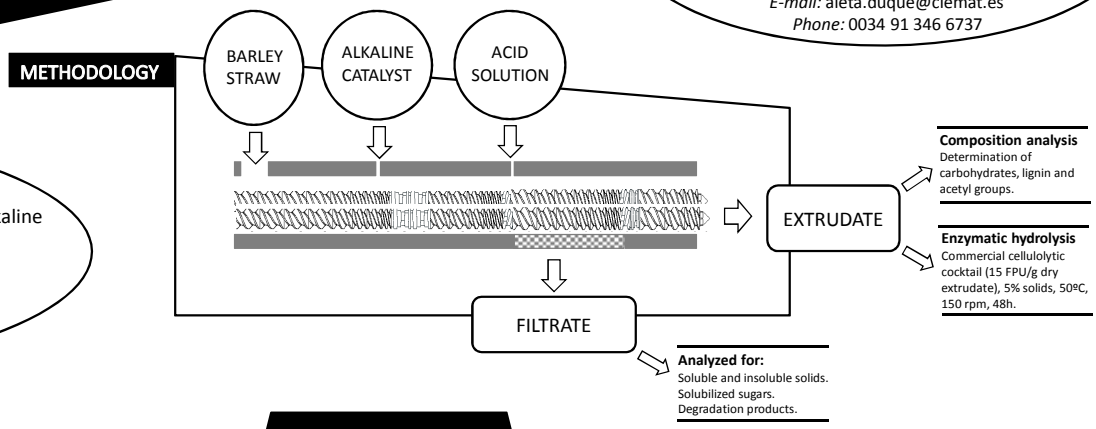
OBJECTIVE

To compare the performance of two alkaline reagents in extrusion of barley straw at different temperatures in terms of composition and sugar production by enzymatic hydrolysis.

METHODOLOGY



RESULTS

NaOH

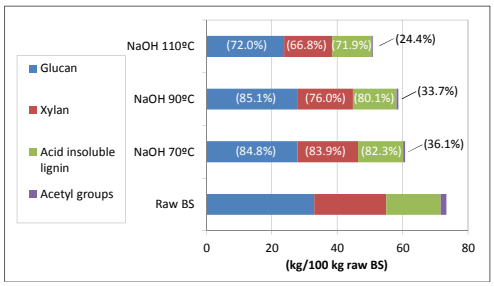


Fig. 1a – Mass balance for glucan, xylan , acid insoluble lignin and acetyl groups in the solid extrudate produced at different temperatures with NaOH and comparison to 100 kg of raw barley straw (BS). In brackets, % recovery in the extrudate over the same compound in raw BS.

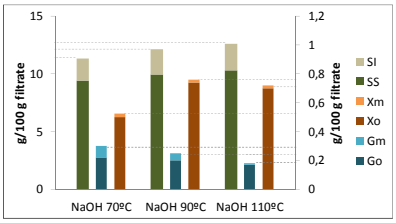


Fig. 2a – Composition of filtrate in g per 100 g of soluble solids (SS), insoluble solids (IS), monomeric glucose (Gm), oligomeric glucose (Go), monomeric xylose (Xm) and oligomeric xylose (Xo).

- No furfural or hidroxi-methyl furfural detected in the filtrates.
- Acetic acid between 4.8 and 6.6 g/l.

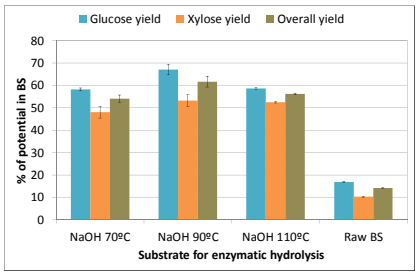


Fig. 3a – Glucose, xylose and overall (glucose + xylose) yields of NaOH extrudates submitted to enzymatic hydrolysis compared to hydrolysis of untreated BS. Yields are calculated as the amount of sugars produced by hydrolysis of the extrudate divided by the initial amount of glucose, xylose or glucose plus xylose in 100 kg of raw BS.

KOH

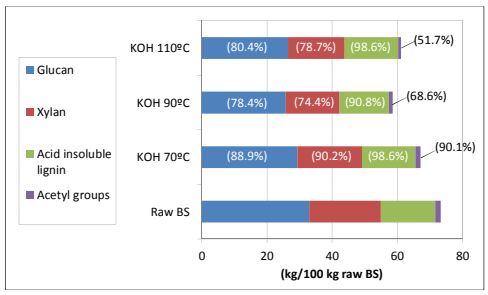


Fig. 1b – Mass balance for glucan, xylan , acid insoluble lignin and acetyl groups in the solid extrudate produced at different temperatures with KOH and comparison to 100 kg of raw barley straw (BS). In brackets, % recovery in the extrudate over the same compound in raw BS.

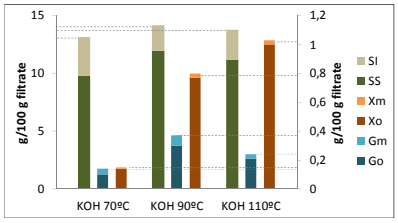


Fig. 2b – Composition of filtrate in g per 100 g of soluble solids (SS), insoluble solids (IS), monomeric glucose (Gm), oligomeric glucose (Go), monomeric xylose (Xm) and oligomeric xylose (Xo).

- No furfural or hidroxi-methyl furfural detected in the filtrates.
- Acetic acid between 5.2 and 6 g/l.

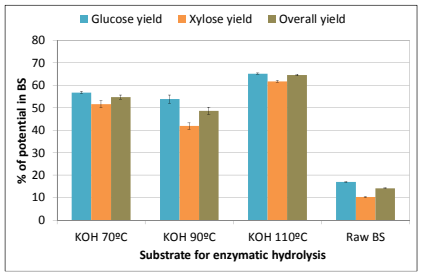


Fig. 3b – Glucose, xylose and overall yield of KOH extrudates submitted to enzymatic hydrolysis compared to hydrolysis of untreated BS. Yields are calculated as the amount of sugars produced by hydrolysis of the extrudate divided by the initial amount of glucose, xylose or glucose plus xylose in 100 kg of raw BS.

CONCLUSIONS:

- The lignocellulosic structure of barley straw is altered by extrusion and the result is more susceptible to the enzymatick attack.
- NaOH causes much higher deacetylation of hemicelluloses and, in general, lower sugar and lignin recoveries in the extrudate than KOH.
- Increasing the temperature of extrusion results in a higher solubilization. In the case of xylose the effect is noticeable, with a significant increase of xylose concentration in the filtrate, whereas that does not happen so for glucose.
- No furfural or hydroxi-methyl furfural were detected in the filtrates. A variable concentration of acetic acid, coming from the deacetylation of hemicelluloses was nevertheless measured in the liquid.
- Extrusion temperature positively affects the digestibility of extrudates but, since the mass losses have to be considered and the solubilization potential of the two alklais is different, the highest sugar yields are obtained at 90ºC with NaOH and at 110ºC with KOH.
- Similar overall yields are attained at the best conditions with NaOH and KOH, but the lower temperature is preferred. Thus, the extrudate produced with NaOH at 90ºC is selected as the best substrate for sugar production. In these conditions, the overall yield was 62% and the glucose and xylose production were increased by 4 and 5 times, respectively, over that of the untreated BS.

Acknowledgements: This work has been co-funded by the European Commission in the Horizon 2020 Programme (Project No. 654365).