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Bioprocessing of Brewer's grain into protein and lignin-rich intermediates

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Introduction / background

Brewer's grain (BG) is the major by-product of brewing with a worldwide annual production of about 30 million tons. Although it contains valuable compounds for human nutrition, it is mainly used as cattle feed with little or no profit to the breweries. BG contains ca. 23% of barley protein which could be valorized into a new food and beverage ingredients or high quality protein isolates. Lignin and other polyphenolics in BG are gaining interest as potential dietary fiber ingredients and raw materials for the production of high value chemicals. The resistant structure of Brewer's grain requires advanced technologies for its effective fractionation. BG lignin and protein are most extractable in alkaline conditions but strong interactions hinder their separation.

Aim of the study

To develop a pretreatment and fractionation technology for improved recovery of protein and lignin from BG.

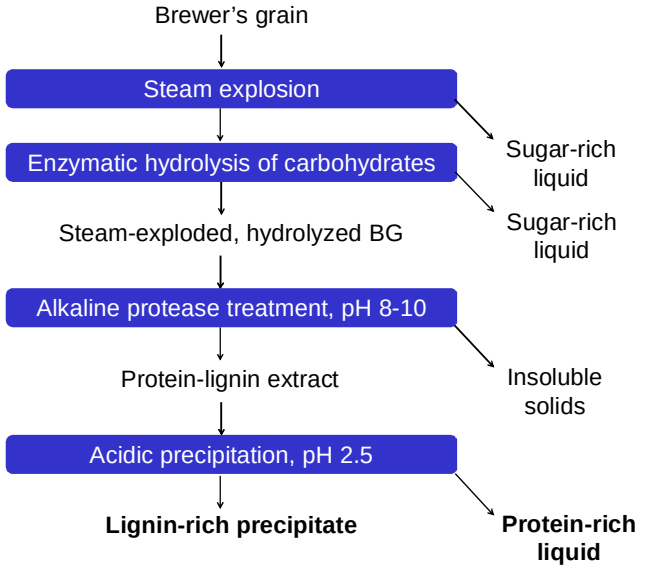

Figure 1. Bioprocessing or BG into intermediate fractions rich in sugars, lignin or protein.

Experimental

Pre-treatment. Brewer's grain from full malt brewing was obtained from a local Finnish brewery. The wet material was pre-treated by steam explosion at 200°C (Figure 1). The soluble sugar-rich fraction was removed by centrifugation, and the solids were treated with a mixture of carbohydrate hydrolysing enzymes. The soluble sugar-rich fraction was again removed to obtain pre-treated BG enriched in protein and lignin.

Extraction of protein and lignin. Pre-treated and untreated BG were subjected to alkaline protease treatment at pH 8-10. Extracts rich in protein and lignin were recovered by centrifugation. The extracts were acidified to pH 2.5 to obtain precipitates enriched in lignin and a liquid fraction rich in protein. Protein solubilisation was determined by total N analysis. Lignin solubilisation and precipitation were monitored by A_{280} measurements and Klason lignin analysis.

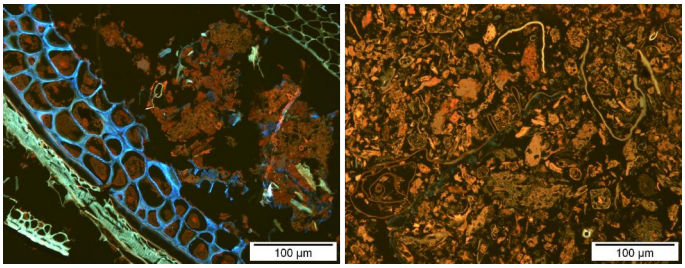

Figure 2. Micrographs of untreated (left) and pre-treated BSG after steam explosion and carbohydrate hydrolysis (right). The sections were stained to show proteins as red and cell wall glucans as blue.

Results

Steam explosion and enzymatic hydrolysis removed 84% of the carbohydrates and caused clear microstructural changes in BG (Figure 2). The pretreatments substantially facilitated the recovery of lignin from BG by alkaline protease treatment and acidic precipitation (Figure 3). Enzymatic hydrolysis of proteins into peptides resulted in nearly complete protein solubilisation from both untreated and pre-treated BG. Most of the extracted lignin concentrated into the acidic precipitate whereas the protein became enriched in the acid-soluble fraction.

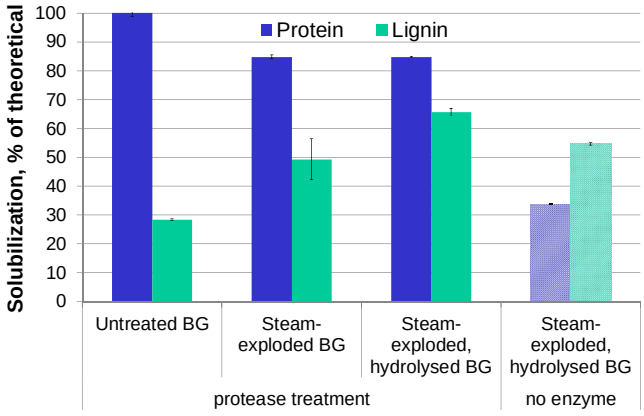

Figure 3. Solubilisation of protein and lignin from untreated and pre-treated BG during alkaline protease treatment or alkaline extraction without enzyme (no enzyme), as determined on the basis of total N and A_{280} analyses.

Conclusions

Pre-treatment of BG by steam explosion and enzymatic carbohydrate hydrolysis increased the subsequent recovery of lignin by enzyme-aided alkaline extraction. The presented technologies provide improved tools for the fractionation of BG components with an appropriate yield for new functional products.

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