Straw from oilseed as a new source of biofuels

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This image shows the Pilot Steam Explosion Unit at the Biorefinery Centre at the Institute of Food Research. Credit: IFR

The bright yellow fields of oilseed rape are a familiar sight at this time of year, but for scientists what lies beneath is just as exciting.

Researchers at the Institute of Food Research are looking at how to turn straw from oilseed rape into biofuel. Preliminary findings are pointing at ways the process could be made more efficient, as well as how the straw itself could be improved.

Straw from crops such as wheat, barley, oats and oilseed rape is seen as a potential source of biomass for second generation biofuel production. Currently the UK produces around 12 million tonnes of straw. Although much is used for animal bedding, mushroom compost and energy generation, there still exists a vast surplus.

Straw contains a mix of sugars that could be used as a source of biofuels that do not compete with food production but instead represent a sustainable way of utilising waste. However, the sugars are in a form that makes them inaccessible to the enzymes that release them for conversion into biofuels, so pre-treatments are needed. The pre-treatments make the complex carbohydrates more accessible to enzymes that convert them to glucose, in a process called saccharification. This is then fermented by yeast into ethanol.

Using the facilities at the Biorefinery Centre on the Norwich Research Park, Professor Keith Waldron and his team have been looking at the steps needed to unlock the sugars tied up in the tough straw structure. In particular, they have looked at the pre-treatment stage, focusing on steam explosion, which involves 'pressure-cooking' the biomass, to drive a number of chemical reactions. A rapid pressure-release then causes the material to be ripped open, to further improve accessibility.

They varied the temperature and duration of steam explosion and then used a variety of physical and biochemical techniques to characterise

what effects varying the pre-treatments had on the different types of sugars before and after saccharification.

The amount of cellulose converted to glucose increased with the severity of the pretreatment. Saccharification efficiency is also associated with the loss of specific sugars, and subsequent formation of sugar breakdown products.

In a further study funded by the BBSRC / EPSRC Integrated Biorefining Research and Technology Club, the scientists discovered the key factors that determine the efficiency of saccharification. One particular compound, uronic acid, limited the rate at which enzymes worked. The final sugar yield was closely related to the removal of xylan, a common component of plant cell walls. The abundance of lignin, a 'woody' cell wall component, was positively related to the amount of available sugars.

These findings will help improve the efficiency by which straw can be converted to biofuels. For example, adding enzymes that more effectively remove xylan should improve yield. Controlling the level of lignin in the material should also help.

It may even be possible to improve the straw itself, for example to reduce the uronic acid content in the biomass, as suggested by these findings. In the main, oilseed rape has been bred to improve oilseed yield and disease resistance, without paying much attention to the straw. The IFR is working with colleagues at the University of York and the John Innes Centre to see whether there are ways of breeding more "biofuel-ready" varieties of oilseed rape, with the same yields of oilseed but with more amenable straw. In addition, a full understanding of the polysaccharides and other compounds made available during pretreatment may mean other valuable co-products, like platform chemicals, may be viably produced from the surplus straw.

More information: Steam explosion of oilseed rape straw: Establishing key determinants of saccharification efficiency, *Bioresource Technology* 162, 175-183 DOI: 10.1016/j.biortech.2014.03.115

Changes in the composition of the main polysaccharide groups of oil seed rape straw following steam explosion and saccharification, *Biomass and Bioenergy* 61 121-130 DOI: 10.1016/j.biombioe.2013.12.003

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