Renewable biofuel production avoids competition with food resources

January 29 2015

The efficient production of both biofuel and animal feed from one crop is now possible, and can be done on a farm without the need for off-site processes. The research, published in the open access journal *Biotechnology for Biofuels*, demonstrates the practical potential of an alternative to fossil fuels that does not compete with food resources.

'First-generation' biofuels include ethanol produced from food sources such as corn and sugarcane. While recognized as a renewable energy source with potential to improve fuel security, their production has caused controversy over competing land-use for food and increased grain prices. The fermentation of non-food sources such as straw and wood, known as 'second generation' biofuels, has been promoted as a promising alternative, but also has its limitations.

First author Mitsuo Horita from the National Institute for Agro-Environmental Sciences, Japan, said: "Generally, the bottlenecks in second generation biofuel production include the need for large facilities, bulky material transport and complicated treatment processes, all of which are costly and consume a great deal of energy.

"What we've now demonstrated is a complete and scaled-up system which shows its potential in a practical on-farm situation. Instead of a complicated process requiring special facilities, our system simply builds upon traditional processes already used by farmers for producing silage for animal feed. It results in a high yield of ethanol while producing good quality feed, with zero waste."

The process, known as 'solid-state fermentation', involves packing harvested whole rice plants with yeast and enzymes into a round bale wrapped in impermeable film. During incubation, sugars and starch in the rice plant are converted by yeast to ethanol, which accumulates and is then drained and distilled for fuel, leaving a bale of high quality animal feed in the form of silage.

In the tests, the process yielded up to 12.4 kg of pure ethanol per bale, after six months of incubation - ten times more ethanol than would result from natural silage production. A steady amount of ethanol also continuously drained out in the effluent from the bale during the test, resulting in an additional 1.7 kg of ethanol that could be easily collected without extraction.

The remaining bale material was found to be comparable to normal silage for animal feed, containing a similar amount of lactic acid and sugars, and high crude protein content - an essential dietary component for cattle.

Although the system requires a relatively long time for fermentation, no energy needs to be supplied into the system. The use of a vacuum distiller allowed the extraction of a total of 86% of the ethanol that accumulated in the bale. The ethanol also contained no insoluble particles, and could therefore be easily dehydrated and concentrated for use as automotive fuel.

The research shows the potential for complementary food and biofuel production, circumventing issues related to land-use competition. The system could be deployed at a local level by individual farmers, providing sustainable biofuel production, and could be particularly beneficial to farmers in the developing world.

The authors note that further studies into improving the ethanol yield

and recovery ratio, and an environmental assessment of the system's complete life cycle, should also be carried out before the system is widely established in rural areas.

More information: On-farm solid state simultaneous saccharification and fermentation of whole crop forage rice in wrapped round bale for ethanol production. Mitsuo Horita, Hiroko Kitamoto, Tetsuo Kawaide, Yasuhiro Tachibana and Yukiko Shinozaki , *Biotechnology for Biofuels* 2015 . DOI: 10.1186/s13068-014-0192-9

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