Sugar beet can raise your spirits

The prospect of farmers growing their own fuel for vehicles is looking rosier, thanks to the invention of a new process for fermenting sugary crops to make alcohol. The new technique promises to save money and reduce pollution.

The process involves fermenting the sugar without adding water; the crop simply 'brews in its own juice'.

Solid-phase fermentation, as it is called, has long been applied to certain materials including, familiarly, garden compost, but Mr Kevin Kirby and Mr Chris Mardon, of the CSIRO Division of Chemical Technology, believe they are the first to apply it to crops for the production of ethanol.

Distilleries at present use large quantities of water to extract sugar from the raw crop. For every litre of alcohol produced, 10 to 20 litres of turbid effluent leave the factory to pollute the environment or undergo expensive treatment. Indeed, the disposal of effluent is a major problem at all distilleries in Australia and overseas.

In the new process the plant material is simply chopped into a pulp and fermented by yeast without the addition of water. The smaller quantity of effluent (about 5 litres for each litre of alcohol produced) should minimize the threat to the environment, especially since it would probably come from several small factories dotted about the countryside, not from one big conventional distillery.

The researchers hit on their idea after being asked by a group of Tasmanian farmers to investigate the prospects of producing ethanol from sugar beet, which has a high sugar content.

Encouraging results

The results of laboratory trials were most encouraging. The yield was much the same as from conventional processing, with 90% of the sugar in the beet pulp converted to alcohol. Approximately 95% of the alcohol was extracted, and 85% of the yeast was recovered to be used again.

The researchers adjusted the pH to 4·5 before adding the yeast, but found that no pretreatment of the beet, such as sterilizing or adding nutrients, was necessary. The only liquid effluent from this process is the beet juice from which the fermented sugar has been removed.

Sugar beet.

Mr Kirby and Mr Mardon believe solid-phase fermentation will be at its most economical in plants producing from 1 to 5 megalitres of alcohol a year. (A megalitre is a million litres.) By contrast, the minimum economical capacity of a conventional distillery is about 50 Ml a year.

The secret is the relative simplicity of the new process. It would cost much less to set up a solid-phase plant than a conventional one and operating costs would be lower. No farm would be very far from a distillery, and so transport bills would be kept down.

The laboratory experiments suggest that a distillery could produce 4 Ml of alcohol a year for about 24 cents a litre, selling the fuel at perhaps 27 cents. The actual prices would depend on the cost of the beet; these figures were based on a yield of 70 tonnes a hectare and a price of $14 a tonne for the roots (equivalent to $26.50 a tonne for the whole plant).

The federal government announced last January that alcohol would be exempt from excise when used on farms and as a transport fuel.

Pilot plant

Naturally, the CSIRO scientists are keen to try out their ideas. Northern Tasmania has the right climate for growing beet, and farmers there are looking for an extra crop to include in their rotation, so that seems an ideal place for a pilot plant, especially as local sawmills could supply sawdust as fuel. Now the researchers are looking for financial backing for such a plant.

Under the proposal, farmers would keep the tops (foliage) of the beets as fodder. They would also feed to animals the fibrous residue from the factory.

In districts where sawdust or another fuel is not locally available, both the tops and the residue could be fermented to make biogas (largely methane), which would provide all the energy the distillery needed.

However, the tops would be more valuable as fodder than as fuel. Digesting the waste fibre alone would provide only about three-quarters of the necessary energy, but more heat-efficient units being designed overseas may well find this energy source sufficient.

Sugar beet is grown in the cool to temperate areas of the world, and grows successfully in warm climates with irrigation. It can be harvested over a period of 6–7 months.

Unfortunately, nobody has yet found a way to store the crop through an Australian summer without dehydration, fungal attack, and breakdown of the sugar. Beet is successfully stored in Europe, so this question is an obvious candidate for research.

A second crop would prevent factories from lying idle for the other 5 months. The researchers suggest that in irrigated areas of northern Victoria, for example, sugar beet and sweet sorghum would keep distilleries busy all the year round.

The CSIRO scientists have applied for a patent to cover both sugary crops, like beet and sweet sorghum, and plants rich in starch, such as potatoes and cassava. Starch presents an extra problem. It must be converted to sugars before it can be fermented, and the scientists hope to achieve this using commercially available enzymes without adding water.

The two processes, hydrolysis of starch and fermentation of the resulting sugars, may even go on simultaneously.

Let us imagine that several farmers have formed a cooperative and want to build a distillery. Armed with a govern-

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ment licence, they make alcohol — or, more precisely, the mixture of 95% ethanol and 5% water that is produced by distillation. In Brazil and the United States this mixture would be taken for expensive commercial conversion to 100% alcohol and then usually blended with petrol to make gasohol.

Modifying engines

Production costs will be held down if our farmers can use 95% alcohol directly. One way is by modifying petrol engines to run on the alcohol; another is by blending it with diesel fuel for diesel engines.

It is the water in the alcohol that creates problems. Although water mixes perfectly with alcohol, it reacts to petrol or diesel fuel much as vinegar does to oil in a salad dressing: two separate layers form. If only a small proportion of water is present, there is no difficulty. Petrol generally contains some accidental water, for example, and will dissolve about 0·3% water at ordinary temperatures.

If petrol is blended with more than a fairly small proportion of 95% alcohol, layers form, with the water taking the alcohol into a separate layer from the petrol.

The answer is to add a surfactant — that is, a compound that encourages the water and petrol to form a single, clear solution.

On the other hand, diesel engines seem to perform best if diesel fuel and 95% alcohol are emulsified. You see an emulsion when you shake oil and vinegar together vigorously. The result is a milky liquid, in which one layer is broken up into tiny droplets and distributed throughout the other layer.

Researchers at the CSIRO Division of Mechanical Engineering will be testing various fuel blends on an engine test-bed recently installed at the Division.

John Seymour

More about the topic

Intermediate scale ethanol production. K. D. Kirby and C. J. Mardon. *Proceedings of the Fuel Ethanol Research and Development Workshop, Canberra, February 1980* (in press).