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Seaweed as Biofuel? Metabolic Engineering Makes It a Viable Option

Is red seaweed a viable future biofuel? Now that a University of Illinois metabolic engineer has developed a strain of yeast that can make short work of fermenting galactose, the answer is an unequivocal yes.

"When Americans think about biofuel crops, they think of corn, miscanthus, and switchgrass. In small island or peninsular nations, though, the natural, obvious choice is marine biomass," said Yong-Su Jin, a U of I Assistant Professor of Microbial Genomics and a Faculty Member in its Institute for Genomic Biology.

Producers of biofuels made from terrestrial biomass crops have had difficulty breaking down recalcitrant fibers and extracting fermentable sugars. The harsh pretreatment processes used to release the sugars also resulted in toxic byproducts, inhibiting subsequent microbial fermentation, he said.

But marine biomass can be easily degraded to fermentable sugars, and production rates and range of distribution are higher than terrestrial biomass, he said.

"However, making biofuels from red seaweed has been problematic because the process yields both glucose and galactose, and until now galactose fermentation has been very inefficient," he said.

But Jin and his colleagues have recently identified three genes in Saccharomyces cerevisiae, the microbe most often used to ferment the sugars, whose overexpression increased galactose fermentation by 250 percent when compared to a control strain.

"This discovery greatly improves the economic viability of marine biofuels," he said.

Overexpression of one gene in particular, a truncated form of the TUP1 gene, sent galactose fermentation numbers soaring. The new strain consumed both sugars (glucose and galactose) almost three times faster than the control strain -- 8 versus 24 hours, he said.

"When we targeted this protein, the metabolic enzymes in galactose became very active. We can see that this gene is part of a regulating or controlling system," he said.

According to Jin, galactose is one of the most abundant sugars in marine biomass so its enhanced fermentation will be industrially useful for seaweed biofuel producers.

Marine biomass is an attractive renewable source for the production of biofuels for three reasons:

* production yields of marine plant biomass per unit area are much higher than those of terrestrial biomass

* marine biomass can be depolymerized relatively easily compared to other biomass crops because it does not contain recalcitrant lignin and cellulose crystalline structures

* the rate of carbon dioxide fixation by marine biomass is much higher than by terrestrial biomass, making it an appealing option for sequestration and recycling of carbon dioxide, he said.

Co-authors are Suk-Jin Ha of the U of I's Institute of Genomic Biology; Ki-Sung Lee, Min-Eui Hong, Suk-Chae Jung, and Dae-Hyuk Kweon of Sungkyunkwan University; Byoung Jo Yu, Hyun Min Koo, Sung-Min Park, and Jae Chan Park of the Samsung Advanced Institute of Technology; and Jin-Ho Seo of Seoul National University. Funding was provided by the Samsung Advanced Institute of Technology; the BioGreen 21 Program, Rural Development Administration, Republic of Korea; and the Korea Research Foundation.

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