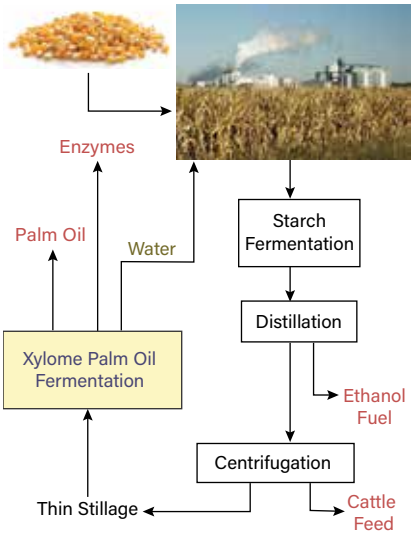
Engineered Oils from Agricultural Byproducts

Each year, the roughly 200 industrial ethanol plants in the U.S. collectively produce about 30 million metric tons (m.t.) of a low-value wastewater stream called stillage, which contains water-soluble organics and corn fiber residues. Disposing of stillage is problematic. However, Xylome, a small business based in Madison, WI, has developed a way to use the waste stream as a consistent, stable feedstock for conversion to valuable products. The company has genetically engineered a novel yeast to enable this transformation.

Based on market surveys with ethanol producers and potential end users, Xylome found an opportunity to create a new North American industry based on stillage: production of a palm oil substitute. Currently, palm oil is produced almost exclusively in environmentally sensitive tropical regions at unsustainable rates, yet it is found in nearly half of all food products.



▲ Current industrial ethanol fermentations recover fuel and cattle feed from corn. Xylome's novel technology enables recovery of a palm oil biosimilar from stillage waste byproducts.

Typically, ethanol producers recover residual protein and corn oil after the distillation process and sell these for supplemental income. However, the stillage stream cannot as easily serve as a source of supplemental income. Stillage solubles are evaporated to a syrup and sprayed back onto distiller's dried grains; the net value of such a process is only about $0.02/lb. Xylome's technology enables ethanol producers to convert the stillage waste stream into a high-value, marketable palm oil biosimilar.

Xylome's technology could diversify the products generated in dry-grind ethanol plants while increasing income, reducing water and disposal problems, and sparing tropical forests. The dissolved solids and fiber alone in U.S. stillage streams could produce about 2 million m.t. of palm oil biosimilar. If this stream were supplemented with additional carbon from starch or cellulosic feedstocks, it could produce more than 25 million m.t. of palm oil. Palm oil plantations have an average yield of 3.3 tons per hectare per year, so Xylome's process could spare up to 7.7 million hectares of rain forest.

Xylome's technology is based on *Lipomyces starkeyi*, a yeast known for 75 years and generally recognized as safe (GRAS). The native *L. starkeyi* readily consumes a wide range of carbon feedstocks, including amylodextrins, glycerol, xylose, and oligosaccharides found in stillage. The company's scientists engineered the strain to have a high capacity to produce yeast oil purer than palm oil with properties that would allow the yeast oil to serve as a replacement for palm oil.

A combination of genetic tools and fermentation technologies created by Xylome scientists with NSF support have enabled the company to dramatically increase *L. starkeyi's* capacity for lipid production, alter its lipid profile to create higher-value products, and facilitate downstream oil recovery processes.

Xylome scientists implemented a two-stage bioprocessing approach that includes a rapid growth phase followed by a lipogenic phase. In fed-batch fermentations, engineered *L. starkeyi* accumulates 85% of its weight as yeast oil with conversion rates up to 85% of the theoretical maximum. The engineered strains can consume all of the organics present in stillage, including the sugars released by enzymatic saccharification of fiber derived from corn hulls and stover. This technology has the potential to double the production of vegetable oils in the U.S. without cultivating or harvesting any additional grain.

The company has developed a scalable process for recovering highly purified palm oil substitute and has initiated the commercial manufacture of specialized lipid body products for cosmetic applications. Now, Xylome is collaborating with major fuel ethanol producers for scaleup and commercialization. Their initial grassroots facility will have a capacity of 3–4 million gal/yr of oil. The palm oil biosimilar is in demand from the largest users of tropical palm oil, so Xylome is seeking backers for the first commercial-scale demonstration plant. It was recently awarded U.S. Patent 10,662,448-B2 on the genetically modified yeast and is currently developing commercial production of specialty products based on this technology. CEP

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