

Microbes help turn Greek yogurt waste into fuel

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Photograph of bio-oil, made of caproic acid and caprylic acid, phase separates out at mildly acidic conditions. Credit: Lars Angenent, University of Tübingen

Consumers across the world enjoy Greek yogurt for its taste, texture, and protein-packed punch. Reaching that perfect formula, however, generates large volumes of food waste in the form of liquid whey. Now researchers in the United States and Germany have found a way to use bacteria to turn the leftover sugars and acids from Greek yogurt into molecules that could be used in biofuels or safe feedstock additives. Their work appears December 13 in the journal *Joule*.

"To be sustainable, you want to convert waste streams where they are made, and upstate New York is where the cows are, where the dairy farmers are, and where the Greek yogurt craze began in the United States with Chobani and FAGE," says senior author Lars Angenent, an environmental engineer and microbiologist at Cornell University (United States) and the University of Tübingen (Germany). "That's a lot of acid whey that right now has to be driven to faraway locations for land application, but we want to produce valuable chemicals from it instead."

Waste whey from Greek yogurt production is made up mostly of the familiar milk sugar lactose, the fruit sugar building block fructose, and the fermentation product lactic acid. The researchers use bacteria to turn this mixture into an extract containing two more useful compounds: caproic acid (n-hexanoic acid) and caprylic acid (n-octanoic acid). Both of these compounds are "green antimicrobials" that can be fed to livestock in lieu of antibiotics. Or, with energy needs in mind, further processing could stitch the six-, seven-, and eight-carbon backbones of the obtained molecules into the chains of up to 14 needed to qualify as "drop-in" biofuels for jet fuel.

Both options have economic and social allure. "The agricultural market might seem smaller, but it has a very large carbon footprint, and turning acid whey into a feedstock that animals can eat is an important example of the closed cycles that we need in a sustainable society," Angenent says. "The fuel market, of course, operates at a lower price, but its

demand is virtually unlimited."

Traditionally, suppressing oxygen while feeding biodegradable waste to microbes results in the production of methane-rich gas through anaerobic digestion. Instead, the researchers strung together two "open-culture" reactors—the first tuned for heat-loving microbes fond of temperatures of 50°C, the second set at a more welcoming 30°C mark. After seeding each reactor with a previously studied microbiome, and opening the setup to the acid whey and its own rich assortment of bacteria (such as common gut microbiota from the Lactobacillus family), caproic acid, caprylic acid, and other minor products could be continually extracted over a period of several months.

The next challenge will be to see what happens when the twin bioreactor system is boosted to pilot plant capacity. "There is much more that can be done to optimize the extraction process and to scale up in an economical way," says Angenent. "We can also learn more about the nature of the microbiomes and the biology involved and start investigating whether this technology can be translated to other waste streams."

More information: *Joule*, Xu et al.: "Temperature-phased bioconversion of Greek-yogurt waste into medium-chain carboxylic acid oil via lactic acid without external electron donor addition"
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