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*Democracy Dies in Darkness*

## INNOVATIONS

# Man-made cow's milk may soon be a reality



By Tuan C. Nguyen

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Biohackers Ryan Pandya and Perumal Gandhi are working on crafting a plant-based concoction that's nearly identical in makeup to what's found in grocery milk.

To achieve this, they've gone so far as modifying sunflower oil so that it can take on a structural composition similar to milk fats, substituted lactose with galactose, a nearly indistinguishable sugar, and culturing yeast to release casein, a natural animal milk protein. If successful, the process they've developed could someday be used to churn out a wide range of dairy products, such as cheese, butter and yogurt.

The duo, both with bioengineering backgrounds, are the co-founders of Muufri, a San Francisco-based start-up that hopes to fashion the idea of lab-brewed milk as a more humane alternative for consumers. Funded by Singularity University's Synthetic Biology Accelerator program, they've spent the last few months in a lab at University College Cork in Ireland, where they're closing in on a prototype batch that's 100 percent animal-free.

"If you have all the right ingredients, making milk by hand can actually be surprisingly easy," Pandya says. "Part of the reason why we've come this far and to put in the effort to see if it would work is because we're passionate animal lovers at heart."

Ambitions to manufacture milk sans cow has been around for a least a century. In 1912, German scientists, using a mix of vegetables, created a synthetic mixture they claimed had a more nourishing creaminess than what you can get from a cow. [Another notable effort in 1921](#) from an inventor in Boston led to a version made from grounded peanuts, oatmeal and "a pinch of salt." None of these efforts, however, yielded anything comparable in taste and composition that would pass muster with the masses.

Since then, dairy farming in America has ramped up its output to account for as much as \$140 billion annually. But to satiate growing demand, farmers have expanded the use of standardized practices that are known to be particularly resource-intensive. In fact, it takes about 1,000 liters of water to produce one liter of milk, according to data from the non-profit Water Footprint Network.

Thus taking the process of milk production down to where it's simply a matter of chemistry and hacking yeast cultures, Pandya says, could potentially go a long way toward easing the industry's strain on the environment. Besides, he adds, moving the process in-house, where each phase of production can be tightly controlled, would also ensure better sanitation, not to mention the added benefit of a longer shelf life.

"We're basically using biotechnology to make milk without pasteurization and without the risk of contaminants like pesticides, hormones or bacteria that can spoil the milk quickly," Pandya says. "It's quite similar to the process to make medicine and insulin, so it will be super sterile."

But perhaps the biggest advantage of milk that's man-made is that it's highly customizable. Each element, for example, can be processed separated and tweaked to whip up healthier formulations like lactose-free or cholesterol-free milk, without any significant compromises. Currently, the refining process for turning out such variations involves either using Lactaid, an enzyme, to break down lactose or high-speed centrifuging to remove fatty acids. In both instances, the taste is altered and, in the case of non-fat skim milk, minute amounts of cholesterol remain in oxidized form.

Team Muufri's admits, however, that they may have a ways to go before having something that poses a legitimate challenge to traditional milk. Their latest test batch, while comprised mostly of plant-derived fats and sugars, isn't entirely cow-free. The taste, though, Pandya describes as "97 percent" resembling milk. To get to 100 percent, they've taken the approach of feeding the DNA sequence for cow's milk into the yeast's genetic code to make casein, a technique they're hoping to get perfect by early next month. Still, the crucial part is seeing whether they can scale up the system to where it's feasible to make enough of the product for large segments of the population.

"The beauty of this method is that we can use the same DNA since the difference between various kinds of milk, like donkey's milk or goat milk, has mostly to do with ratios of fat, sugars and proteins," Ghandi says. "So the most important thing is to get the flavor as close to exact possible."

At the moment, Ghandi and Pandya are pushing feverishly to have something in select stores in California before 2017. Just ahead though is a return trip to San Francisco on Aug. 19, where they aiming to unveil the world's first glass of genuine milk, made entirely from scratch (or the closest thing to it).