EXPERT PANEL:

How fermentation is powering the future of food

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From bread and beer to cutting-edge pharmaceuticals, fermentation has long transformed simple ingredients into something greater. Today, it's powering a new wave of food and pharma innovation — one that's not only sustainable and scalable, but also transparent and trustworthy. To explore how fermentation is shaping the future of food and nutrition, we sat down with some of Cargill's experts: Dr. Erin Marasco, Ph.D., senior director of global biology; Dr. Maria McClintock, Ph.D., lead innovation project manager; Dr. Anton Woo, Ph.D., senior director for food innovation; and Nathan Knutson, R&D director for beverages.

Q. Why is fermentation such a trusted tool in food production?

ERIN: We've been consuming foods made through fermentation since ancient times. Bread, yogurt, beer, kombucha... they're all products of fermentation. And it's not just food and drink. Pharmaceuticals like penicillin, insulin and GLP-1s are made through fermentation, and we rarely give them a second thought.

ANTON: And why should we? Fermentation is a simple, natural process. It's just microbes taking carbon – often in the form of sugars – and nitrogen and converting them into useful products.

Q. How has fermentation evolved into a high-tech innovation?

MARIA: Citric acid is a good starting point. Once scientists discovered that a common fungus could produce it, production shifted from fruits to fermentation. A century later, microbes remain at the center of citric acid production.

ERIN: Beyond food, fermentation revolutionized pharmaceuticals, too. Advances in fermentation technology during World War II made penicillin widely accessible. Then came insulin. Before 1982, we extracted it from the pancreases of cows and pigs. It was expensive, inconsistent and required tens of thousands of animals to produce a single kilogram.

ANTON: Using microbes to produce human insulin was a major advance. It was safer, more consistent, and resulted in a far more reliable and cost-effective supply.

Q. What makes fermentation such a valuable tool today?

ERIN: Our growing knowledge of biology means that we can now guide the fermentation process. While citric acid is made by a naturally occurring fungus, scientists played a bigger role in directing microbes to produce human insulin.

MARIA: It's about accuracy. We identify the genes responsible for the compound, insert them into microbes like yeast, and let fermentation do the rest.

ANTON: That control also supports consistent labeling. The final ingredient is chemically identical to what's found in nature — and we can verify that through rigorous analysis.

ERIN: It's an incredibly efficient system, unaffected by weather, pests or seasons. Because we use fermentation vats, not crop fields or farm animals, we're not geographically constrained. All of this helps lower supply chain risk and control costs.

ANTON: There are environmental advantages, too. Fermentation often uses far less water and land, and produces much lower greenhouse gas emissions compared to traditional agriculture.

NATHAN: Best of all, these advantages scale: if you can make 1,000 pounds of an ingredient through fermentation, you can just as readily make 10,000 pounds — or even 1,000,000 — using the same process.

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Q. Can you share examples where fermentation improved ingredient accessibility?

MARIA: We already mentioned insulin. In the food world, the cheese-making enzyme rennet is a good model. While rennet was historically sourced from calf stomachs, we've used fermentation to produce it for the last 30 years. Nearly all the cheese manufactured today uses fermentation-derived rennet.

ERIN: It's the most efficient and sustainable way to create a product that tastes like the best part of the stevia leaf, too. Of the 70 to 80 compounds in the stevia leaf, some taste great and some don't. We only want the best ones. Instead of investing significant energy into purifying leaf extracts — or relying on bioconversion processes that still depend on plant inputs — fermentation allows us to produce only the desired molecules... cleanly, efficiently and independently of agricultural constraints. This results in fewer inputs, lower environmental impact, greater control over quality and meaningful cost savings.

NATHAN: Human milk oligosaccharides (HMO), which are vital to infant development, are another great example. Once found only in human breast milk, they can now be produced at commercial scale though fermentation. That's a breakthrough in infant nutrition.

Q. What does "nature-identical" mean and why does it matter?

ANTON: It means that the compound produced via fermentation is chemically identical to the one found in nature. Whether it's produced by a microbe or extracted directly from a plant or animal, the molecules in the final product are the same.

MARIA: Many times, the exact-same genes are used to make the molecule as are in the plant or animal. We're not inventing something new; we're optimizing nature's process for better yields, concentration and purity.

ERIN: Think of it like following a LEGO® manual. Whether I build it, or a robot builds it, if we follow the same instructions, the final product is identical.

Q. But how do you know it's the same?

ANTON: That's part of my job. At the molecular level, a compound's identity is defined by its chemical structure. We can use analytical techniques, such as chromatography, mass spectroscopy and nuclear magnetic resonance (NMR) to identify this structure and show if compounds produced by different methods are identical.

ERIN: Take vanillin. It can be extracted from a vanilla bean, synthesized chemically or produced by a microbe via fermentation. In each case, the resulting molecules all have the same chemical composition.

NATHAN: Beyond molecular analysis, there are additional evaluations to affirm safety and performance. In the U.S., new ingredients and traditional ingredients produced by new processes must complete rigorous testing, including safety and metabolic studies. We also verify that they perform just like their conventional counterparts in formulations.

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Q. What excites you most about fermentation's future?

NATHAN: We hear about the challenges facing our food system every day. Unpredictable weather. A growing global population. Geopolitical instability. Fermentation complements traditional agriculture, allowing us to build more resilient supply chains, lower our environmental impact and produce more affordable food ingredients.

MARIA: That's why I started in fermentation. It's a more responsible way to produce the food, fibers and pharmaceuticals we need... in a way that is better for people and the planet.

ERIN: That's going to be increasingly important in the years ahead. If we rely only on crops, we may lose access to ingredients like vanillin and saffron. With fermentation, we can continue to enjoy them in our diets; they'll just be made in a different way.

NATHAN: Imagine a future where products like eggs are produced through fermentation, unaffected by avian influenza. It won't replace chickens, but it could prevent the supply disruptions we've seen in recent years.

ERIN: Fermentation has always been part of our diets. Now it's poised to feed our future with targeted solutions, scalability and sustainability. It offers a reliable, more efficient way to deliver nature-identical ingredients — without the variability and limitations of traditional agriculture. For manufacturers, that means a more secure, consistent supply. Backed by trusted science and proven performance, fermentation helps brands innovate with confidence. That's a future we can all support.

Learn more about Cargill ingredient innovation at cargill.com.

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