What did ancient humans eat?

Unearthed from the graves of children, ceramic baby bottles from thousands of years ago would look perfectly at home in nurseries today. Some have little feet, and one bottle's spout juts from a ceramic critter's bottom like a tail. These itty-bitty Bronze and Iron Age vessels smack of whimsy. But they, like many other everyday items used for feeding and food preparation, are providing scientists an unprecedented taste of how people ate long ago.

An examination of fatty molecules called lipids, for example, tucked into the pores of three ceramic bottles from Bavaria suggests that mothers living between 1200 BCE and 450 BCE were weaning or supplementing their kids' diets with animal milk, Julie Dunne and her colleagues reported in 2019.

Dunne, a biomolecular archaeologist at the University of Bristol in England, speculates that the bottles' creators may have been inspired to amuse their children. "They make us laugh today," she says. More importantly, studying them "gives you such a close connection to the past."

There aren't many ways to study the feeding of infants in ancient times, Dunne says. Ancient bones have yielded insights about when infants were weaned, but "we know very little about how mothers brought up their babies." The same is true of the eating lives of the ancients in general — much of the evidence has been indirect.

Newer scientific techniques, added to a more inclusive view of the importance of everyday activities in archaeology, are leading to a clearer picture of what was on the prehistoric menu. Gathered from bottles, fragments of ceramic pots and even relics from Bronze Age grave sites, microbes and remnants of molecules offer a bevy of new clues about ancient cuisine.

"Archaeology is just like everything else," Dunne says. "Women tend to get kind of left on the sidelines." Traditionally, scholars have been more excited by the lives of kings and conquering warriors than those of mothers.

That's one reason that "boring" archaeological items related to cuisine and cooking have been somewhat neglected, anthropological archaeologist Sarah Graff writes in the 2020 *Annual Review of Anthropology*. Artifacts from the realm of food prep often belong to the domains of those who lack societal power: women, servants and slaves.

"A lot of early archaeology was about finding things that are beautiful and museum-worthy," says Graff, of Arizona State University in Tempe. Bits of broken vessels or mundane-looking items from excavations were sometimes tossed aside with the dirt that wasn't being analyzed, she says. Earlier archaeologists “didn’t really think that things that had to do with domestic labor would have anything to do with politics or economics or even religion.”

Researchers are now finding more of those connections, Graff writes, and powerful analytical techniques are helping scientists mine ancient vessels to learn about the foods once prepared in them — from steaming stews to fermented beverages and cheese.

Grease that sticks around

Earthenware pots were a game changer, Dunne says, and people invented them multiple times in different places. Ceramic vessels helped change what people ate — they could boil meat for stews, for example, or cook tubers long enough to destroy toxins.

Scraps of pottery often litter archaeological sites. Akin to today’s ubiquitous plastic, earthenware is “the nonbiodegradable polymer of the ancient world,” says biogeochemist Richard Evershed, Dunne’s colleague at Bristol and a pioneer of analyzing organic residues left on ancient vessels. Evershed and colleagues have exploited the tendency of fats to cling to pottery fragments to snoop on what people were stewing long ago.

Boiling meat releases globules of melted fat that easily seep into the walls of pots, Evershed says. He made his first identification of fats, or lipids, from foods in ancient pottery around 30 years ago, in medieval shards from a site in England. The chemical fingerprints suggested the leaf wax of cabbage, which was likely stewed with meats, Dunne notes.

In other work from the same site, the scientists identified a large number of pots dating from 950 to 1450 with signatures of dairy fat, probably from making cheese, Dunne says. No fat was detected on others, unearthed near a bygone bakehouse, and those pots are thought to have been used for baking bread. Tucking into stews, cheese, butter and bread, “the medieval peasant wasn’t doing too badly,” Dunne says.

Lipid residues couldn’t be analyzed before the 1950s and the advent of gas chromatography, a method to detangle molecular mixtures. Coupling that technique with mass spectrometry, which helps identify molecules based on their mass, allowed researchers to detect and identify ages-old food remains. In the 1970s, researchers first applied this tag-team approach to archaeological artifacts.

These techniques have become still more sensitive and can now directly detect mere traces of chemicals. Recently, Evershed and colleagues reported the use of radiocarbon dating to find the age of leftover lipids in artifacts from as long as about 7,300 years ago. Previously, archaeologists couldn’t use radiocarbon dating on cooking residues, and had to infer their age by dating other evidence from the site, such as bones.

Such information also reassures researchers that the material they're analyzing is actually ancient and isn't just contamination. "If you're dealing with something that's been buried in the ground for thousands of years," you have to think about that possibility, Evershed says. Molecules that look like they came from food could be from the soil surrounding an artifact or may have been introduced by unwitting excavators who handled pottery without gloves or stored it improperly. Evershed recalls a shard stored in a cheese box, not ideal for an item being analyzed for food remains.

Roadkill and corn mush

Along with analyzing ancient leftovers, Evershed and his collaborators tackled the challenge of disentangling environmental contamination from food signatures. Decades ago, Evershed's team cooked up cabbage leaves, for example, to see how its waxes infiltrated replica pots, giving them a comparison for the real specimens. The researchers also marinated pieces of pottery in flasks of compost to see how microbes may alter fats from milk or olive oil.

To better understand how past cooking relates to modern data, others also have dived into such experimental archaeology. Starting in 2014, researchers cooked various recipes in store-bought unglazed ceramic pots every week. Over the course of a year, they used the same pot to cook the same recipe 50 times, then switched to a new recipe for the last one to four meals. The simple dishes included just one or two ingredients, such as corn or wheat mush or meat from a roadkill deer (apparently, no one tasted them).

Though the grub was unappetizing, "reconstructing a humble meal that was cooked into a pot can potentially unlock a lot of information about people's experiences in the past," says Melanie Miller, an archaeologist at the University of Otago in New Zealand who was part of the cooking experiment. After a year, the pots' thin patina layers held signs of all the recipes but were tilted toward the last meals to hit the pan. But the lipids within the pores of the pots built up over many simmerings and didn't show much evidence of the latest cooking event, her team reported in 2020 in *Scientific Reports*.

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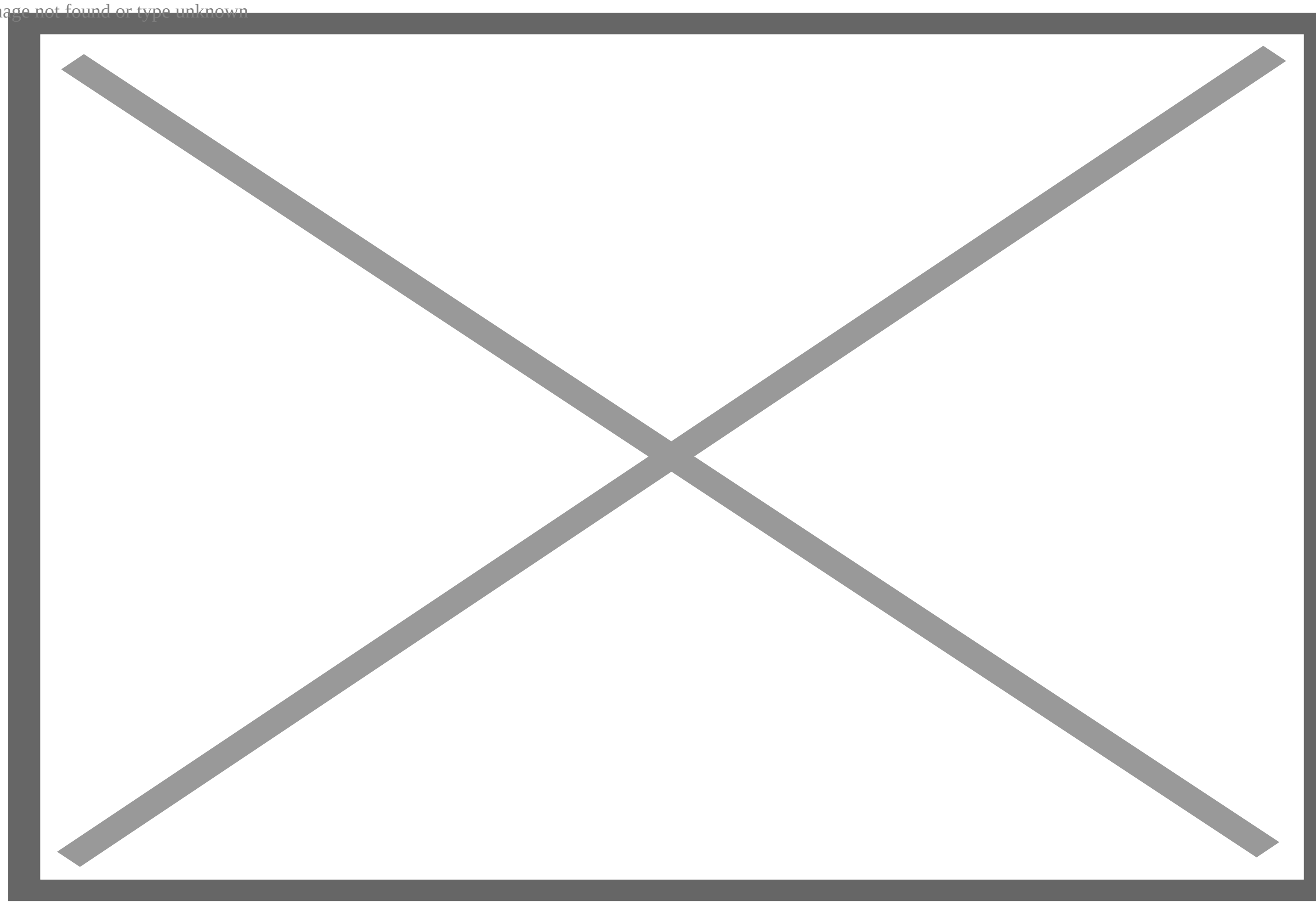

In a yearlong cooking experiment, a research team cooked up bland meals of roadkill or mush in ceramic pots. (None of the dishes were eaten but some were burnt, as shown here.) By studying the chemical fingerprints and carbon isotopes of residues left on the pot, the scientists have shed light on how such vessels reflect the history of meals cooked within them. Credit: Dr. Christine Hastorf

The group’s work aimed to reveal how ancient meals can be preserved and what components would be lost to time. One of the project’s leaders, Christine Hastorf of the University of California, Berkeley, helped to pioneer this field of study in the 1980s, Miller says, by studying how the chemistry of charred, preserved bits hints at ancient food practices. “We definitely need more of this type of work,” she says, to unveil the possibilities and limitations of techniques that sample molecules from ancient cooking.

While Miller isn't sure anyone from this team would be keen to repeat the process, there's more to learn, and she can imagine variations on the theme with more ingredients or seasonings that inch towards mimicking more realistic meals. Once the researchers finished cooking, they broke and buried the pots in Hastorf's backyard. Some shards spent six months in the ground. Others were buried for one year or five years. The team has dug up the last pieces of the pottery with aim of looking to see what the lipid mixes look like now.

The power of proteins

Though the catalog of work on lipids is "really excellent," information from lipids is "much fuzzier than the level of resolution you can get with proteins," says Matthew Collins, an archaeological scientist at the University of Copenhagen and the University of Cambridge. Just as with lipids, progress in analyzing ancient proteins "all comes down to technology," he says. Proteins have also reaped the benefits of progress in mass spectrometry, allowing scientists to pry clues from surprising places.

In 2014, researchers reported milk proteins preserved in the dental tartar of roughly 5,000-year-old teeth. "It's plaque, which becomes hard," just like the buildup on teeth that dental hygienists scrape away, says Jessica Hendy, an archaeological scientist at the University of York in England. The mineral material survives on skeletons and may preserve a record of some of the foods that a person ate.

When archaeologists working at Çatalhöyük, a site in modern-day Turkey, approached Hendy's team to examine pottery excavated there, Hendy realized that the whitish scale coating the shards may have trapped protein traces like the tooth tartar had. From 10 samples of the mineral-rich scale, the team identified a number of proteins from animals and plants. "It was just an amazing resource for understanding what those early farmers processed in their pots," Hendy says.

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Ceramic pots unearthed from this site in what was once the city of Çatalhöyük, located in modern-day Turkey, yielded food proteins preserved in a thin layer of mineral residue called scale. Studies show tha the city dwellers ate a variety of meats, dairy, grains and other plants. Credit: Jason Quinlan

The shards yielded traces of proteins found in barley, wheat and peas, along with several animal meats and milks. While animal bones from Çatalhöyük suggested sheep and goats lived in this proto-city, the proteins show how people consumed them. People were using the milk of these animals, and they were mixing it with these other food sources, Hendy says. “That level of detail, I found really, really exciting.”

The Çatalhöyük pots provide a first example, but there’s great potential to scour scale samples from other sites, says Collins, who was also part of the research team. Scale may also reveal differences in how items are cooked, he says, with different modifications to proteins when food is boiled versus when they simply dry onto a vessel. “We think that by characterizing the proteins we can say something about their life history as a foodstuff.”

Food tech history

Scientists have already pulled such information from prehistoric proteins. In a Bronze Age cemetery of the Xiaohe people in Xinjiang, China, archaeologists found mummies wearing necklaces strung with clumps of an organic material. An analysis of the proteins in those clumps revealed they were cheese, some of cow's milk and others made with a mixture of milks. Because the lumps contained far more casein proteins than whey, scientists think that the cheese may have been pressed to separate the solids from the liquids, says Anna Shevchenko, a biochemist at the Max Planck Institute of Molecular Cell Biology and Genetics in Dresden, Germany. The liquid would have carried off the soluble whey proteins.

By looking more deeply into the proteins from the roughly 3,500-year-old cheeses, Shevchenko and her colleagues found insights into the ancient cheese-making process. Cheese can be made by rennet, a substance found in the stomach of ruminants that curdles milk, or by the addition of acid. When cheese is made with rennet, enzymes make cuts between the building blocks, called amino acids, that link up to form a protein. The team found no such cuts, suggesting that the cheese was made by acid, which can be produced by certain bacteria and plants.

Shevchenko got a lucky strike when other proteins found in the cheese matched a database entry from a bacterium used to make a fermented dairy drink called kefir, suggesting that those microbes transformed the milk into cheese.

Nobody had imagined that people were using this kind of fermentation technique so long ago, Shevchenko says. Modifications of the proteins that occurred over time assured her that the mummy's cheese was indeed ancient.

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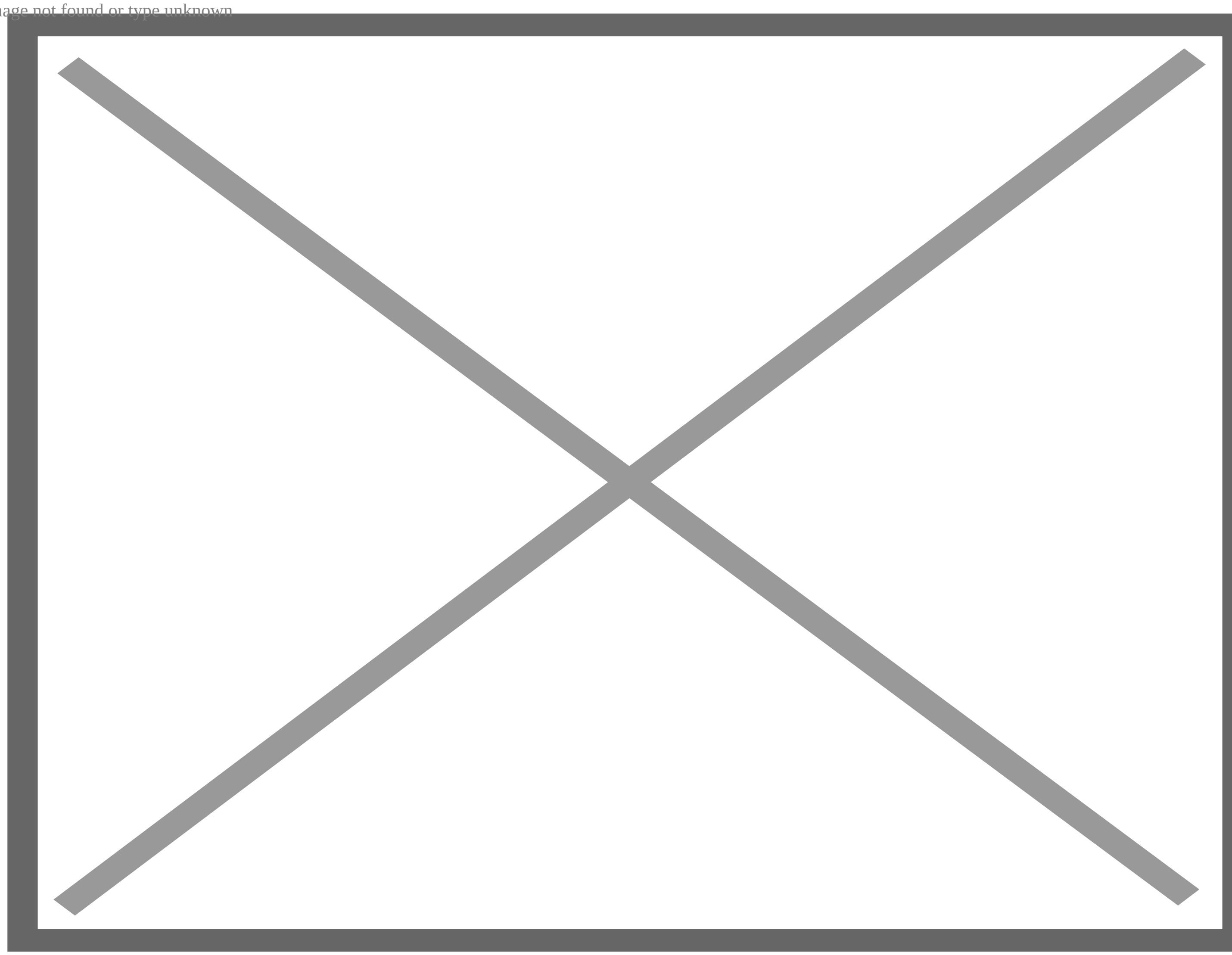

Fragments of what was once cheese decorate the neck of a female mummy discovered at a burial site in Xinjiang, western China. Analysis of the proteins in the roughly 4,000-year-old clumps showed they were made of kefir-type cheese fermented by Lactobacillus kefiranofaciens bacteria. Credit: Y. Liu/Y. Yang

Collins and his colleagues, too, are trying to put such modifications to work. Over time, the amino acids that make up proteins become damaged. Patterns in that damage can be used to date the proteins and rule out modern contamination, he says. This sort of dating is needed because “one of the saddest things … is that one of the most common proteins in any biochemistry lab is milk,” says Collins, who calls himself the “granddaddy” of this area, having worked with ancient proteins for 30 years. Milk proteins are used as carrier proteins for many lab techniques, he says, which means the potential for contamination of a sample is never far away. That can undercut findings, as has happened with researchers claiming to identify remnants of animal milk from ancient times.

Of course, any one protein (nor proteins alone) doesn't capture the full picture of what people ate long ago. Plus, some proteins survive the ages more easily than others, further distorting the picture. It's unclear why, for example, but milk proteins seem to be preferentially preserved. "Clearly, there's some kind of bias," Hendy says, either in the detection techniques or how milk, but not other foods, get trapped in plaque.

Still, with all the information they can provide, proteins are a powerful source of knowledge about past diets. "Proteins are everywhere," Collins says, and they can help answer important questions: Which tissues from an organism — for instance, a plant's root or its seed head — were used? How were they processed? The best way to get at this understanding is by studying lipids and proteins, along with other complementary sources of information, such as DNA, he says.

A cold one for the ages

Researchers have been picking through lipids and proteins from ancient pots for decades. But within just the last few years, scientists have started searching for culinary clues in vestiges of a different sort: microbes, which play key roles in creating fermented fare such as beer, wine and cheese.

Happy for an excuse to keep a fridge full of beers in the lab, microbiologist Ronen Hazan of the Hebrew University of Jerusalem investigated a query from his brewer friend: Can yeasts stay alive in a sealed glass bottle left in the dark for two years? Yes, they can.

When Hazan and his colleagues got to thinking about how to brew a beer out of the history books, they recalled the yeast that lived and wondered whether yeasts could survive way longer — for 3,000 years. "And we were probably very drunk at the time," Hazan says, "because we said, 'Yeah, for sure they will do that.'"

Returning to the idea post-inebriation, the scientists asked the Israel Antiquities Authority for pieces of pottery that may have been used for brewing. They received pieces of clay pottery from several sites around Israel: Egyptian vessels from 3100 BC, Philistine ones from 850 BC and Persian ones from 500 BC. Overall, the team isolated and grew six strains of yeast from 21 ancient vessels.

Using modern recipes, the team made beer using the strains they extracted. "It was good," says Aren Maeir, an archaeologist at Bar-Ilan University in Ramat Gan, Israel. "I told everybody, 'Either it's going to be good or we'll all be dead in half a minute.' We survived to tell the story."

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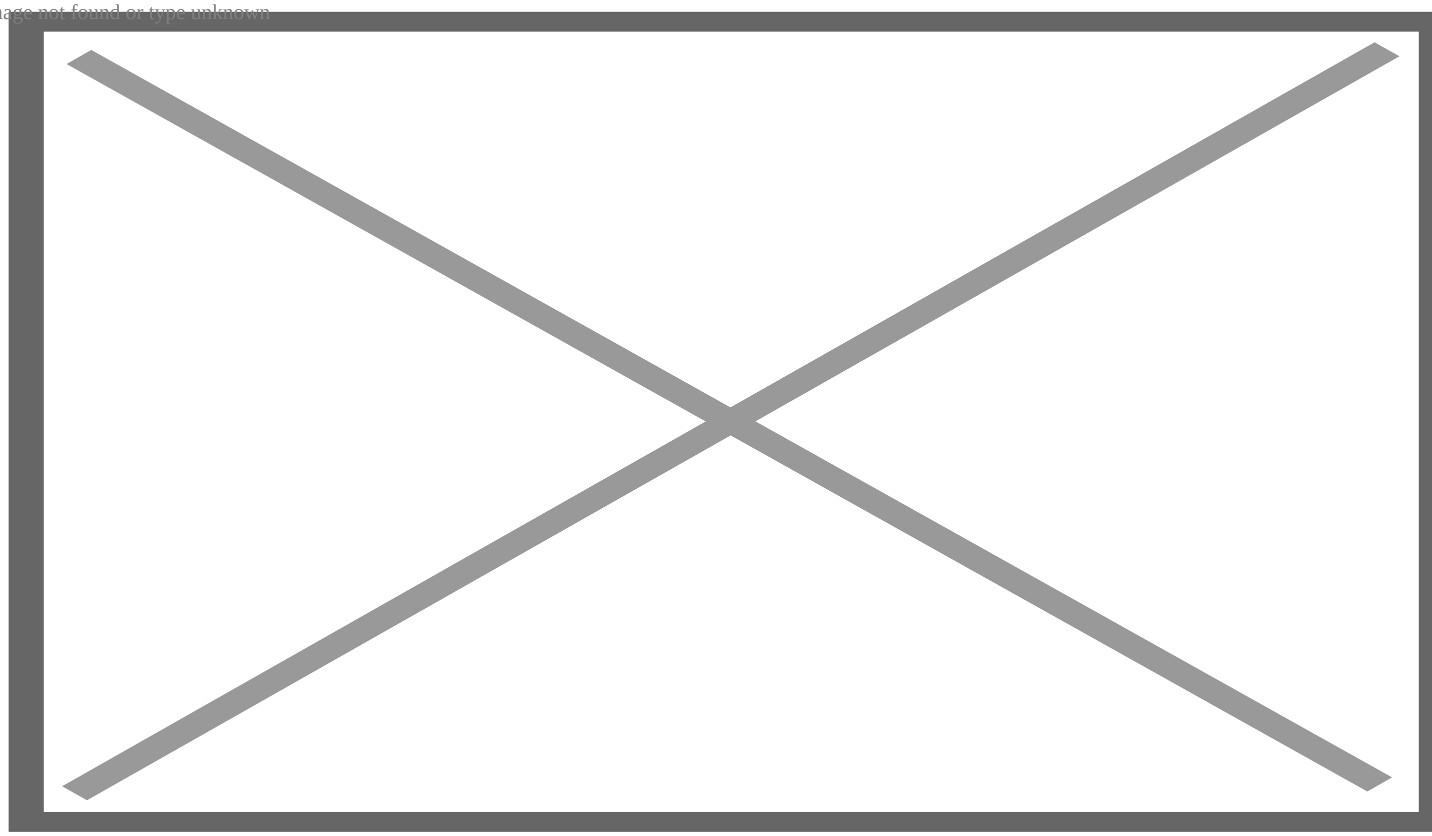

Extractions from these Philistine beer jugs such as these from 850 BCE produced viable microbes that researchers could grow in the lab, including a strain of S. cerevisiae yeast related to the common yeast used for brewing and baking today. The yeasts, including the Debaryomycetaceae yeast known for producing flavorful beer, collected from some of the jugs were used to recreate the ancient brews. Credit: Tell Es-Safi/Gath Archaeological Project

Four out of six extracted yeasts were able to make alcoholic beverages and produce the aromatic compounds that make them taste good. The yeasts' DNA revealed how they were related to other known brewing microbes. The team reasoned that the yeasts plucked from the vessels were descendants of the yeasts seeded thousands of years ago when the beer was brewed.

But the million-dollar question, Hazan says, was whether these yeasts were from the pots or from their burial environments. The team examined 27 vessels from the same sites that were not used for ancient alcohol but rather for cooking, eating or as lamps. From these they extracted three strains of yeast, including two known to live on olives, which could have provided oil for the lamp in which it was found.

Hazan thinks that coincidence can't explain that the brewing microbes turned up only in vessels used to make alcoholic drinks. At first, the researchers were skeptical about the beer-making yeasts' authenticity, he says, but they're more convinced now — though not 100 percent. "You always have some doubts."

The Israeli team's 2019 endeavor is the first published attempt at using microbes from ancient artifacts to make actual food or beverages. But this line of work could be expanded to other foods made with assistance from microbes, such as cheese, wine and bread. The researchers are now examining a jar full of holes that may have been used for cheese making. Living organisms add a new dimension to the work of re-creating ancient foods, Maeir says. “Usually, you can see the remains, you can feel the remains … but here we’re tasting the remains.”

From scouring the traces of meals consumed long ago to reenacting the methods that made them, these scientists are unveiling aspects of the shared human experience that is cooking. For Miller and her colleagues, this profound connection motivated them to continue cooking their bland meals. Cooking is “one of the most unifying things that humans have across time and space,” she says. Food and food practices embody culture, politics, status, identities, upbringings and more. Though often done without much reflection, food reveals much. “It’s a daily practice … usually representative of all these much larger questions about our place in the world.”

Carolyn Wilke is a freelance science journalist who enjoys cooking and eating as much as she enjoys writing about food. Find her on Twitter @carolynmwilke

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