



TNO, the Netherlands

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These days, 3D printers are laying down plastics, metals, resins, and other materials in whatever configurations creative people can dream up. But when the next 3D printing revolution comes, you'll be able to eat it.

Engineers and gourmands alike are dabbling with edible substances as raw materials for 3D printing. Among their hoped-for results: previously unachievable food shapes and textures, personalized grub, and varied menus on future long-term voyages to Mars. "There is some very cool stuff going on," says Jeffrey Lipton, CTO of Seraph Robotics and a Ph.D. candidate at Cornell University.

Edible 3D printing emerged several years ago with Cornell's Fab@Home printer, which won a [2007 Popular Mechanics Breakthrough Award](#). The syringe-based machine works like an inkjet printer, depositing layers of viscous liquids to build up an object according to a user's uploaded design. Cornell researchers posted the Fab@Home blueprints online, much to the delight of tinkerers the world over. "People started experimenting, putting in different things like epoxies and silicones," Lipton says. "Then we started seeing what other people did when they went into their kitchens, things like Cheese Whiz, Nutella and frosting . . . You can extrude anything through it." Lipton says wild new shapes and textures for artisanal purposes might serve as some of 3D food printing's first, albeit limited, commercial successes. "You could see food tchotchkes find a little niche. We've pretty much exhausted every known process for inventing new foods."

In fact, foods created by printers have already hit shelves. "A lot of people don't know this, but all the microwave pancakes available in supermarkets in the Netherlands are printed," says Kjeld van Bommel, a researcher at the Dutch Organization for Applied Scientific Research (TNO in Dutch). Van Bommel calls the pancakes "two-and-a-half-D-printing," because they are formed through a single deposition of batter. Other products out there meet the definition of 3D printing, or additive manufacturing. The U.K.'s [Choc Edge](#), for example, sells printers that melt chocolate and pile it up in layers to create custom shapes. This past Valentine's Day, [FabCafe](#) in Japan crafted 3D-printed chocolate faces of customers' significant others. Last summer, Google introduced 3D-printed pasta in its employee cafeteria.

These early examples have all used simple, processed, single-ingredient pastes, powders or purees. No one is yet able to manufacture anything as diverse as, say, a burger with all the fixings. Cobbling together all

the different ingredients and structures, given varying temperature requirements and sterility needs, is truly daunting. "Making one grain of wheat is a hell of a lot more complex than doing anything with wheat flour," van Bommel says. And in many cases, it doesn't yet make economic sense to try. "If a complex structure already exists in nature, like a lettuce leaf, why would you want to print it?" says van Bommel.

So rather than reinventing an organic object, van Bommel says one of the promises of 3D food printing is to create novel consumables with personalized nutritional content. "You can add extra calcium or omega-3 fatty acids, and all done in a patient-specific way," he says. To this end, his group is researching 3D food printing to help nursing home residents who suffer from dysphagia and have trouble chewing and swallowing food. These elderly people typically get their meals in the form of an unappealing milkshake of pureed chicken and broccoli, for example, leading to loss of appetite and malnourishment. Van Bommel has a grant from the European Union to develop 3D-printable soft replacement foods loaded with nutrients.



Printed foods could also use smarter, more sustainable caloric sources, such as algae protein in place of resource-intensive animal meat. "I'd rather that instead of printing a steak from cow protein, you could make it from algae or insects," van Bommel says. In one example, his group added milled mealworm to a

shortbread 3D cookie recipe. "The look [of the worms] put me off, but in the shape of a cookie I'll eat it," van Bommel says. "You eat with your eyes."

But what about the dream of a universal 3D food printer—something like a *Star Trek* replicator that could fabricate whatever you request? This prospect, while theoretically possible, poses immense challenges, van Bommel notes. "Obviously if you're going for universal 3D food printer, you can't have 50 million cartridges lying around for the moment you want to print a tomato," he says. "It sounds simple to say 'we'll have a fat cartridge,' but there are hundreds of kinds of fats." Instead, he envisions a machine with a limited range of inputs. "Maybe three types of proteins, three types of carbs . . . It could happen, but we would need to know a lot about how to make different types of foods from those building blocks."

A major obstacle for all 3D printing, and especially for that of food, is that the printing process is slow, requiring cooling or curing periods, for example, before more material is deposited. "If I can start a steak and it takes three months to print, no one is going to eat it—it needs to work in minutes or hours," Lipton says.

Some researchers are trying to speed up the process to make 3D-printed food more realistic. Van Bommel's TNO has a process that uses a laser-based technique to locally cook the food (the company used it to cook an egg white into the world's smallest fried egg, less than an inch across). TNO recently demonstrated a machine called PrintValley that aims to accelerate the process. PrintValley runs 100 platforms under deposition nozzles consecutively, assembly-line-style, building up 100 objects about a square inch in size in less than 10 minutes, or about 6 seconds per widget. "We developed this to show it doesn't need to take so long to print a 3D object," van Bommel says.

Printing food in 3D isn't quite practical in most places, at least not yet. But there's one place where it could make a major meal-making difference: [in space](#). Michelle Terfansky recently explored this concept in a master's degree project at the University of Southern California. Terfansky heard how astronauts on the International Space Station get bored with the regular weekly meal rotations; travelers on a future journey of many months to Mars will deal with similar cabin fever. Three-dimensional printers could let friends and family on Earth transmit recipes to break the tedium. Storage-space-wise, 3D printers could allow for a wide variety of dishes without having to stockpile pieces of animal carcasses and heaps of vegetables. "It's a very basic way of making people happy and feel at home, whether on the Moon or Mars or an asteroid," Terfansky says. "It's a morale booster."

But there's one more important area—perhaps the most important area—where 3D food printing will need to improve to be a factor in the future of food, and that is taste. Lipton notes that some of the lab-grown, 3D printed meat stand-ins have been dubbed "shmeat," in a crudely obvious portmanteau. To address this issue, TNO is teaming up with a culinary school to devise more gastronomically advanced and delicious offerings. "As long as it looks okay and it's not toxic, we call it 3D printed food," jokes van Bommel. "But the recipes could be optimized a lot further. We're technicians, not cooks."

Read more: [Will 3D Printers Manufacture Your Meals? - Popular Mechanics](#)