Food Research Institute
UNIVERSITY OF WISCONSIN–MADISON

FRESH Seminar: "Dinners by Design: The Emerging Field of 3D-Printed Food"

Benjamin Cox, Assistant Engineer of Medical Devices
UW–Madison Morgridge Institute for Research
March 24, 2015

MADISON, Wis. (FRI) – The ability to "print" three-dimensional objects is still relatively new, with the first patent in the field issued in 1986 for a stereolithography apparatus. The high cost of 3D-printing equipment until recently has limited its use to the manufacturing industry, where it is commonly used for "rapid prototyping." As key patents expire, this technology is expanding rapidly into new areas, including the food industry. The application of 3D printing to food was highlighted by Benjamin Cox of the Morgridge Institute for Research at UW–Madison at a recent FRESH seminar.

3D printing is, at its most basic, a way of creating an object layer by layer. In contrast to the milling of a machine part where unnecessary material is removed during manufacture ("subtractive" manufacturing), 3D printing is an additive process. The terms "additive manufacturing" and "rapid prototyping" are roughly synonymous with "3D printing." 3D printing will not replace standard manufacturing methods due to its defined material requirements and relatively high cost for mass production of objects. However, it can play an important complementary role by allowing rapid production of new parts and prototypes. 3D printing could also play a similar niche role within the food industry.

Four main 3D printing technologies have evolved:

1. **Fused deposition modeling (FDM)** is essentially an extrusion process where each layer is created with an extruded filament. A key advantage of FDM is the flexibility of using virtually any material that can be melted as a substrate. FDM also generates durable parts, but its products suffer from poor surface finish and relatively low resolution.

2. **Stereolithography** is a resin-based printing method in which objects are created by curing the resin in each layer with UV light. This method can provide a superior surface finish with high resolution. However, stereolithography requires specialized resins that are toxic in their uncured forms, and the finished parts are brittle.

3. **Selective laser sintering** uses a laser to melt powder layer by layer to create an object. Very durable metal and plastic parts can be made using this process, which is the method behind the manufacture of titanium hip replacements. However, selective laser sintering is expensive, and the powders are often difficult to work with.

4. **Laminated object manufacturing** uses inkjet-based printing technology in which each layer of an object is created by gluing powder together. The use of colored glue allows objects to be made in any color (or multiple colors), so very artistic products can result. However, objects made from this method are fragile, and the powders can be difficult with which to work.

The Morgridge Institute "Fab" (Fabrication) Lab has a stereolithography system (3D System's Viper Si, capable making parts with 150-micron resolution) as well as an FDM system (Statasys's Dimension Elite). Among the many 3D-printing products that Ben has developed is a chamber that allows live imaging of fruit fly larvae and a collagen-stretching device used in cancer research.

Although the Morgridge Institute's Fab Lab currently is not working with food, plenty of other groups are exploring 3D-printing food applications. 3D printing of food may sound novel and technically sophisticated, but as Ben explained, most 3D-printing food applications involve extrusion, which is not really new. Many foods — such as pasta, sausage, cake icing, ice cream, and even ketchup — are extruded.

For 3D printing of food, FDM technology is usually used. Food is extruded in layers and stacked one on top of the other. A number of 3D printers have been developed with food-based applications in mind:

- **The Frostruder (MakerBot)** was an early (~2006) open-source printer originally intended for use with frosting and chocolate.
- More recently, the **Choc Creator 2.0 (Choc Edge)** was introduced in the UK, allowing 2D and 3D chocolate shapes to be created easily.
- A Kickstarter campaign was launched by a London group (3D Ventures) to fund development of a confectionary printer called **"Candy."**
- Natural Machines is developing a 3D food printer called the **"Foodini,"** which will allow consumers to build pasta, chicken nuggets, pizza, and many other food products.

While some of the applications being proposed for 3D-printed foods may seem gimmicky, there are very practical applications being explored as well. Peter Thiel of PayPal fame has funded a Missouri startup company called Modern Meadow to combine tissue engineering with 3D printing to create "bioprinted" meat. The company hopes such an approach can improve sustainability and reduce the costs of meat production. NASA has granted a Phase 1 SBIR grant to a Texas company (Material Research Consultancy) to investigate 3D food printing as a way to generate on-demand food for astronauts in space. Shelf-stable nutrient powders could be hydrated and mixed in different ways to generate a variety of foods, minimizing food-packaging waste and improving availability of high quality food for long missions. 3D

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printing also is being explored to make visually appealing foods that have a soft texture, making them easier to chew for the elderly and the infirm.

Increased availability and lower cost of 3D printing has increased momentum for novel applications of the technology. The fact that many conventional foods are already extruded or layered makes 3D printing of food a logical application, with both practical and fanciful new food products expected in the future.

About the Food Research Institute

The Food Research Institute (FRI), a part of the College of Agricultural and Life Sciences at the University of Wisconsin–Madison, operates its own laboratories and administers its own research and service programs. The mission of FRI is to catalyze multidisciplinary and collaborative research on microbial foodborne pathogens and toxins and to provide training, outreach and service to enhance the safety of the food supply. To fulfill this mission, FRI conducts fundamental and applied research, provides accurate and useful information and expertise, delivers quality education and training, and provides leadership in identifying and resolving food safety issues to meet community, government, and industry needs.

For more information, please contact Lindsey Jahn, associate outreach specialist for FRI, at ljahn2@wisc.edu or 608-263-4229.