Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 02, Issue: 01 (JAN-FEB, 2022)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

An Overview of 3D Food Printing Technology: Concepts, Advantages and Challenges

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Digitalizing food using 3-Dimensional (3D) printing is an incipient sector that has a great potential of producing customized food with complex geometries, tailored texture and nutritional content. An individual must consume a meal that contains a specific combination of ingredients and nutritional values. 3D printing is a revolutionary technology that can boost the nutritional value of meals and even alleviate hunger in countries where fresh, affordable ingredients are scarce. 3D printing technology is being adopted by the global food sector to make food production more efficient and sustainable.

3D Printing Concept

3D printing is a method of producing three-dimensional things with great precision and quality finishing in their dimensions. Aviation, automotive, packaging, construction, pharmaceuticals, and food are among the industries where the technology is used. In the food industry, 3D printing is being studied in a variety of areas, including customised food designs, personalised and digitalized nutrition, a streamlined supply chain, and a wider range of food materials. Recently food industry has utilize this technology to manufacture a complicated and intricate part required in the industry. It is foreseeable that 3D food printing (3DP) are possible to produce complex food model with unique internal pattern. A 3D food printing technique is composed of an extrusion-based printing, selective laser sintering and inkjet (liquid binding) printing.

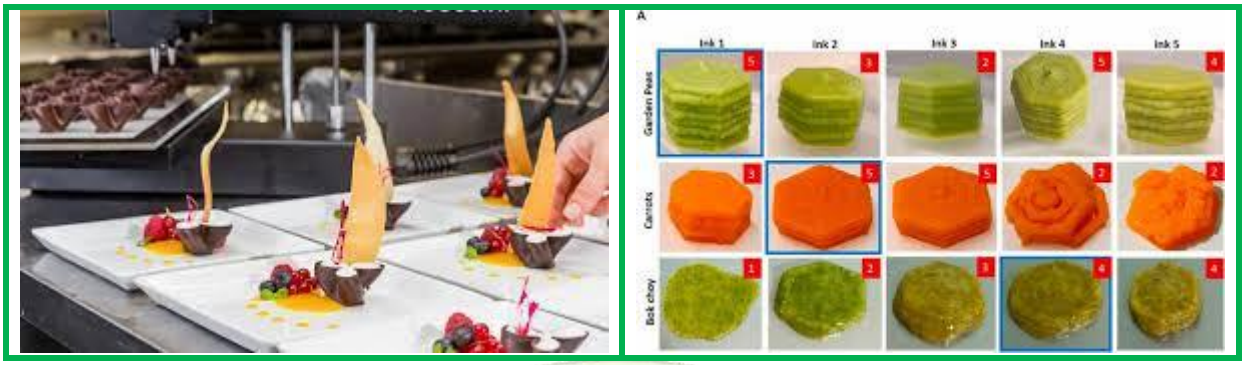
A 3D food printer consists of a food-grade syringe or cartridge that stores material, such as a genuine food item, and deposits precise fractional layers directly onto a plate or other surface in a layer-by-layer additive manner through a food-grade nozzle. Another way is the mold-based method, which involves using 3D printing food machines to mould dough using a hollow container or moulding box. Collaboration between hardware and software is required for 3D printing. Advanced 3D food printers have user-friendly interfaces and pre-loaded recipes and designs that can be accessed via a computer, mobile device, or Internet of Things device.

TABLE 1: 3D Printer Types and Food Materials Manufactured

3D Printer Type	Food Material Type	Raw Material Used
Extrusion Base	Soft foods such as chocolate, cheese, dough, and meat puree	Polymers, hydrogels, and biogels
Inkjet-based	Low viscosity materials like fruit puree and pizza sauce	Liquid/solid phase (ink, fruit concentred, and fruit juice)
Binder Jetting	Powdered materials like sugar, starch, and flour	Sugar and starch mixtures
Selective Laser Sintering	Powdered materials like fat chocolate and sugar	Non-sticky powdered materials without any tendency to agglomerate

Source: Secondary Research and FutureBridge Analysis

Nozzles, tiny materials, lasers, and robotic arms are currently used in 3D food printers. The raw material flows easily from the print cartridge to the printing platform, protecting the platform's solid construction. Substances like starch and proteins, which may create hydrogel structures, can be easily obtained from cheese, chocolate, and humus that can easily flow from the printer cartridge to the platform in a similar mechanism.



Crystallized sugar cake, intricate chocolate designs, ready-to-bake pizzas and pasta, and cracker-like yeast structures with seeds and spores that can sprout over time are among the culinary options popular among 3D printed food consumers.

Advantages

Following are the important advantages of 3D printing.

1. At the moment, 3D food printers use nozzles and delicate materials.
2. Allows for meal customization based on preferences, as the 3D printer can calculate the exact amount of vitamins, carbs, and fatty acids based on the input and calculate the appropriate nutrient proportion for a certain age.
3. When it comes to experimenting with different sorts of food dishes, 3D printing saves both time and energy.
4. It also facilitates the attainment of perfection with less work and time.
5. The usage of the food printing technique promotes creativity and innovation.
6. By customizing ingredients, users can create recipes in whole new ways.
7. In addition, 3D printers can change the composition of a product or combine two products to create a unique recipe.
8. 3D printing allows for food reproducibility.
9. Food waste is reduced when the same set of ingredients is used to make a comparable dish multiple time.
10. It also enables for the long-term utilisation of elements like duckweed, grass, insects, and algae, which can be used to create classic recipes.

Challenging Aspect

1. To begin with, food safety is a major concern.
2. The 3D printing technique generates food in a short amount of time, which restricts heating food at specific temperatures or may result in temperature fluctuations, allowing germs to thrive and contaminate the food.
3. As a result, manufacturers must follow specific standard practises and guidelines while preparing food to avoid contamination risks.
4. Food makers are unable to employ all of the ingredients that are used in traditional cooking.
5. Every ingredient has specific storage and cooking criteria, such as an ideal temperature, that must be adhered to.

6. When 3D printing food, all of the ingredients, as well as the main component or dough, cannot be placed in the same container.
7. The utilisation of a 3D printing machine requires the use of skilled staff.
8. Individuals receive appropriate training on how to utilise a 3D printer for food manufacture, resulting in a high-cost investment.
9. The cost of training is increased by the knowledge base and abilities required to run the machine. Furthermore, 3D printers are costly.
10. The manufacturer bears a significant financial burden due to the usage of skilled manpower and machine costs.

Scope of 3D Printing Adoption

Three-dimensional (3D) food printing is the technology of the future, capable of presenting creative, unique and intricate food items in an attractive format. The 3D food printer is potentially a 'print and eat' technology for the future generations. The next few years will see a rise in the use of 3D printing technology in food that will create unique novel textured foods, healthy foods and smooth and easy-to-swallow foods for the elderly. Additionally, the technology will contribute toward preventing food wastage. Some recent examples of 3D food printing given below:

1. While some businesses are still exploring the technology's potential, major corporations such as PepsiCo and Hershey utilize 3D printing on a regular basis.
2. While PepsiCo employs 3D printing to make a plastic prototype of various shaped and coloured potato chips, Hershey's scientists use it to make custom chocolates. Oreo has created cookies with customized creme designs and flavours using 3D printing.
3. Barilla, a pasta maker located in Italy, cooperated with TNO, a Dutch scientific research organisation, to develop a 3D printer capable of manufacturing a variety of different shaped pasta, allowing clients to quickly and easily 3D print their CAD files with various pasta patterns.
4. The Barry Callebaut Group, a Zurich-based global manufacturer of high-quality chocolate and cocoa goods, recently announced the opening of the world's first 3D printing studio to mass-produce personalised 3D printed chocolate.
5. Mona Lisa, the company's global decorative brand, debuted its chocolate masterpieces. Mona Lisa collaborated with Jordi Roca, one of the most innovative pastry chefs, to create 'Flor de Cacao,' a one-of-a-kind 3D chocolate sculpture. It depicts a cocoa bean that blooms into a cacao blossom when it comes into contact with hot chocolate sauce.

Conclusion

This article is to categorize, printability, productivity, properties of printable material and mechanism of 3D food printing techniques, as well as to propose the future direction of this novel technology. In the food industry, 3D printing technology opens up new options such as individualised nutrition, automated cooking, and reduced food waste, among others. In the food sector, 3D printing technology can meet unmet demands in terms of tailored nutrition, food waste, demand, and availability of food. It is a rapidly expanding technology with numerous advantages, including time savings, high efficiency, sustainability, and many others. Nowadays, food production companies focus on technologies or processes that will enable them to make the best use of food materials in order to provide healthy and nutritious food while reducing food waste. Because the world's population is fast growing, there will be an increase in food demand, as well as food waste, resulting in food source scarcity. This circumstance necessitates the deployment of cutting-edge technology, such as 3D printing, that can efficiently utilise food resources with little or no waste.

Prototype printers for food production are accessible all around the world. 3D printing will continue to emerge as an extraordinary technology in the food industry; although, enterprises focusing on product innovation and/or direct-to-consumer strategies will be the most likely to utilise it.

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