An overview on 3D printing of foods

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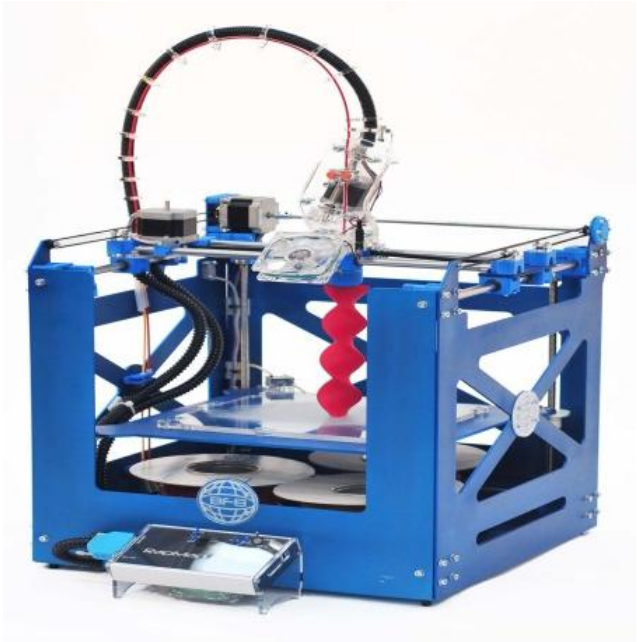
The 3D printing is a process of taking a digital 3D model and turning that digital file into a physical object. 3D printer was invented by a man named Chuck Hull back in 1986 he came up with the idea in 1983 when he was using UV light to harden tabletop coatings. He coined the term "stereolithography" in his Patent entitled "Apparatus for Production of Three-Dimensional Objects by Stereolithography". He defined stereolithography as a method and apparatus for making solid objects by successively "printing" thin layers of the ultraviolet curable material one on top of the other. His invention concentrated solely on a fabrication process called Stereolithography (SLA). later on numerous other 3D printing technologies have been developed, such as Fused Deposition Modeling (FDM)/Fused Filament Fabrication (FFF), Selective Laser Sintering (SLS), PolyJetting and others, all of which rely on layer-by-layer fabrication and are based on a computer code fed to the printer.

How 3D printer works

The 3D design of food which meets the unique demand of special consumer categories,

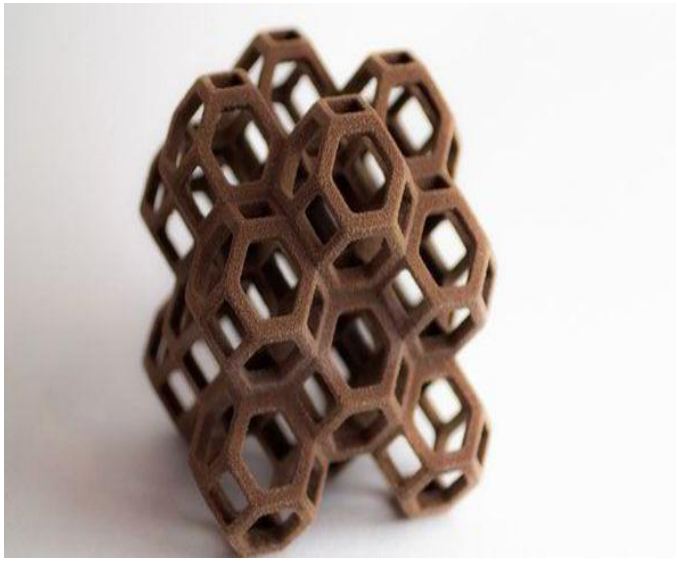


such as, elderly, children and athletes are once designed in computer or simply downloaded, must be converted into some computer language/codes so that 3D printer can read it. The 3D design model is converted into G-code, which is a numerical control programming language used mainly for computer aided manufacturing. It is a language which tells a machine how to move. Without G-code there would be no way for the computer to communicate where to deposit, cure or sinter a material during the fabrication process. There are some programs which convert the 3D model files into G-code. Once the G-code is created it can be sent to the 3D printer, providing a blueprint as to what its next several thousand moves will consist of. These steps all add up to the complete fabrication of a physical object.

Application of 3D printing

Once the 3D printing was commercialized, many manufacturers started producing their end use components or their entire product via additive manufacturing as a way to reduce costs, save time,

and produce better products. It is used in aerospace industry, medicine, food industry and art. Many aircraft manufacturers and aeronautic agencies such as NASA and the ESA, are relying upon 3D printing in order to produce complex geometries and reduce the overall weight of their aircraft and



hence save the fuel. Companies like Boeing and Airbus are using 3D printing to reduce the weight of their aircraft, allowing them to cut fuel costs for each flight. At Organovo, they design and create functional human tissues using 3D bio-printing technology. They do so by using a process similar to an FDM desktop 3D printer where they use hydrogels infused with living cells. 3D printing has a great potential to fabricate complex geometries, elaborated textures and tailored nutritional contents. For this reason, 3D technology is driving major innovations in food industry. The printing of 3D food relies on three key factors: (1) printability, (2) applicability and (3) post-processing.

3D printing of food

Additive manufacturing was used to develop 3D objects based on the materials such as ceramics, metals and polymers. For printing 3D objects layer by layer, ultra violet curable polymers (photosensitive) were used. However Additive Manufacturing (AM) technology using photo-sensitive materials is not suitable to design food. In the food sector, the application of 3D printing techniques was firstly reported by researchers from Cornell University who introduced the Fab@Home Model 1 which operates on extrusion process and is capable of producing forms using liquid food materials. In subsequent years many studies were carried out in an effort to adapt AM technology to the design 3Dimensional foods. However, this technology also represents some challenges as it is not easily applied to the complex food materials with a wide variation in physico-chemical properties.

The 3D food printing techniques can be classified based on the material supply: liquid, powder and culture of cells. The deposition of liquid-based materials can be performed via extrusion and inkjet processes. Powder-based structures are printed by deposition followed by application of a heat source (laser or hot air) or particle binder. The cell culture deposition (bioprinting), as this technique is applied to print meat analogue.

Conclusion

Although AM technologies have received a lot of attention in the field of food engineering, there are still many barriers to overcome for AM technology to be incorporated in place of traditional manufacturing fabrication processes. Ideally, the end-properties related to the mechanical stability of 3D printed food should match with those in conventional manufacturing processes. And, in terms of texture design and nutritional optimization, AM technology would potentially defeat traditional fabrication methods. If any challenges are to be faced by AM technology, in the field of food engineering is attributed to process productivity and product innovation and functionality.