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3D PRINTING TECHNOLOGY

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Abstract:

Three-dimensional (3D) printing is an additive manufacturing technique that prints small layers of material and then fuses them together to form a physical product from a digital design.
Using bespoke scans, some companies, like those that make cars, aeroplanes, and hearing aids, use 3D printing to construct prototypes and mass produce their products. Using additive manufacturing, three-dimensional (3D) printing turns a computer design into a tangible product. Thin layers of liquid or powdered plastic, metal, or cement are applied, and the layers are fused together to complete the process.

The manufacturing logistics and inventory management sectors could be severely disrupted by 3D printing technology, even though it is now too sluggish to be used in mass production.

Comprehending Three-D Printing

The productivity of production has already increased since the introduction of 3D printing technology. If it can be effectively implemented into mass production processes, it has the potential to significantly disrupt the manufacturing, logistics, and inventory management sectors in the long run.

At the moment, 3D printing isn't fast enough for mass production. On the other hand, the lead time for developing part and device prototypes and the necessary tooling has been shortened thanks to technology

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I. INTRODUCTION

Three-dimensional (3D) printing is an additive manufacturing which creates an object by depositing or adhering materials in consecutive layers.

Rapid prototyping, which includes methods for fast fabricating models and prototypes, is a subset of additive manufacturing, although it is now being seen as a scalable manufacturing process2. Over the past 30 years3, the usage of 3D printing and other additive manufacturing methods in engineering through biomedical applications has been progressively increasing (Leena Kumari Prasad & Hugh Smyth (2016)).

All professionals working in the food manufacturing industry must stay current with emerging trends, best practises, and tools in order to do their jobs well. Individualization has been identified as the key factor forcing the disruption of conventional food production and delivery methods. Food printing in three dimensions (3DFP) is frequently mentioned as a potential substitute to create personalization and charm a wide range of clients. However, it should be kept in mind that each group will demand a different level of personalization. Most significantly, the 3DFP research is not intended to alter how food is consumed.It is advised to print doughs, vegetable or meat purees, and confectionery when using extrusion-based 3D printing technology, for example, as the printable food should have a consistency similar to paste. Foods like sugar and chocolate that are powdered can be utilised in 3DFP.Therefore, the motivation to master 3DFP depends on identifying the best application, which in turn depends on the characteristics of food materials. (Author - an introduction to the principles... Etc)

A new technique that has received a lot of attention recently is 3D printing. This article focuses on the most recent advances in using 3D printing technology to improve membrane module design. Recent developments in 3D printing technology have enabled breakthroughs in the production of unique In the near future, membrane module components are anticipated. The development of 3D printing techniques in terms of resolution, materials, and speed should guarantee the highly efficient production of diverse membrane module components.(Authors accepted manuscript -journal of memabrane science)

The design of membrane modules could be revolutionised by 3D printing technology, which could also result in a decrease in the amount of energy and chemicals used in waste water and seawater desalination plants therapy facility.

II. 3D PRINTING TECHNOLOGY

Additive Manufacturing (AM) commonly known as 3D printing technology is the construction of a three-dimensional (3D) object design from a computer-aided design (CAD model or a digital 3D model using a printable material. The American Society of Testing and Materials (ASTM) group has classified AM processes into seven categories (ASTM-international, 2015), ie., (1) Powder bed fusion (2) Directed energy deposition (3) Material extrusion (4) Binder jetting (5) Material jetting (6) Sheet lamination and (7) Vat photopolymerization. These classifications were only applicable in non-food material construction.

The process of creating three-dimensional (3D) objects from computer-aided design (CAD) models or digital 3D models using additive manufacturing, also known as 3D printing, Printable content. The American Society of Testing and Materials (ASTM) group has categorised additive manufacturing (AM) processes into seven groups, including powder bed fusion, directed energy deposition, material extrusion, binding jetting, material jetting, sheet lamination, and vat photopolymerization (ASTM-international, 2015). These classifications were only applicable in non-food material construction.

¡)Binder jetting

With the addition of a thin layer (overlapping) of food powder to create a 3D shape, a powdered material is repeatedly bound using a drop-on-demand liquid binder in a method called "binder jetting" (Godoi et al., 2016). In this process, the liquid is essential because it serves as a binder for the powdered substance. This technology is only applied to powder-based materials, and the ChefJet 3D printer follows this approach (3D System, 2013; iReviews, 2014). According to Sher and Tuto (2015), powdered materials like sugar can be bound with flavour liquids and colours. It is possible to create distinctive, intricate, and flavorful confectionary goods with this technique. A complicated design used to require more time to create (iReviews, 2014)

¡¡)Selective laser sintering/hot air sintering

Sintering is a technique used to create 3D objects quickly and efficiently using powder-based materials (Sun et al., 2015a). The 3D model in SLS and hot air sintering (HAS) is created using 3D software and the An infrared laser will be pointed at a scanner, reflecting a laser beam onto the powdered material on the printer bed to sinter it into a solid structure (Godoi et al., 2016). By scanning in a cross-section motion derived by the 3D digital description contained by the 3D software, the laser functions as a heat source selectively fusing powdered material.The powder bed is lowered by one layer of thickness to create a 3-dimensional object as a fresh powdered layer is added on top of the initial layer of cross-section. The sintering procedure is continued until the 3D item is finished. According to Diaz et al. (2014), SLS can be used to build many layers with various food substrates in each layer. For direct metal laser sintering, for example, the SLS machine may employ a single-component powder (Mellor et al., 2014). The laser only melts the particle's exterior surface in single-component powder SLS machines, a process known as surface melting. To produce a three-dimensional object, the process will fuse the solid, unmelted cores to one another and the layer that came before (Periard et al., 2007).

¡¡¡)Extrusion method

According to Chokshi and Zia (2004), extrusion technology is typically used to a molten material utilising a temperature control or semi-solid viscous system. To print chocolate, melting extrusion has been used to create a 3D structure, 28 to 40 °C temperature range (Chen and Mackley, 2006). The extrusion technique for food substrates is shown in

Fig. 3. Depending on the material type, heat is delivered to a substance (through a heating block or syringe) and the right temperature is maintained to manage its viscosity so that it can flow freely through the nozzle (Tadmor and Klein, 1970). According to Chokshi and Zia (2004), HME was extensively used in the production of rubber and plastics. Food extrusion for semiliquid materials like pre-tempered chocolate and food puree has also used the HME principle. This idea has been applied to 3DFP using the Choc Creator (ChocEdge, 2013), Foodini (Molitch-Hou, 2014), and Porimy 3D printers (Porimy, 2014).

Given that the majority of fresh foods may be liquefied and mixed, extrusion is the best way for using them in food products (Godoi et al., 2016; Hao et al., 2010). Fruit and vegetable (Severini et al., 2018), dough (Yang et al., 2018), pectin-based food formula (Vancauwenberghe et al., 2018), meat (Dick et al., 2019), and gel-based material (Wang et al., 2018; Yang et al., 2018a) are a few examples of food materials that have been successfully printed using this technique.. However, using auger extrusion and food additives, powdered pre-tempered chocolate might be produced in three dimensions (Porimy, 2014). Although the extrusion approach creates a structure layer by layer, it may be difficult to produce a food product with a well-defined, self-supported 3D shape. This is due to the fact that not many foods have the ability to rapidly harden upon extrusion. Therefore, a modification is necessary to promote printability, flowability, and solidification (such as a food additive or hydrocolloid).

Application of food additives in 3 d printing

As they are essential to improving food printability, food additives are currently the subject of extensive research in 3D food printing (Dankar et al., 2018; Mantihal et al., 2019a). Making an item with three dimensions using a For a material to have superior resolution, it must have the right viscosity for its layers to support one another (Godoi et al., 2016; Periard et al., 2007). To increase the viscosity and printability of the substance, food grade additives could be used. Hydrocolloids such proteins, starches, and sugars, as well as carbs and carbohydrates, could be employed to improve printability (Cohen et al., 2009). Transglutaminase in meat and agar in vegetables are two examples of food additives that can be used to enhance the rheological qualities of printed items (Lipton et al., 2010).

Printable food materials

The intricate structure of food influences its flowability and printability. Glass transition temperatures (Tg), gelling, melting, and rheological characteristics are crucial factors in the manufacture of a 3D printed object that looks good and is sturdy (Zhang et al., 2018; Liu et al., 2017; Godoi et al., 2016). Therefore, in order to build 3DP structures, it is essential to completely comprehend the qualities of the material and the technologies pertinent to it. It is crucial to build on this and discover additional viable substrates and additives for 3DFP. The next sections go over the characteristics of chocolate, sugar, gel, and dough's printability as examples.

¡)Sugar

Granulated or powdered sugar can be employed in the SLA, HAS, and binder jetting processes of 3D food printing (Godoi et al., 2016). This is because heat or moisture at the surface can melt or solubilize sugar, causing it to fuse. in close proximity (Knecht, 1990). Additionally, depending on its purity and moisture level, crystalline sucrose melts or decomposes at temperatures between 160 and 186 degrees Celsius. Therefore, factors like powder density and compressibility must be taken into account since they have an impact on how easily powder flows through the vessel when a heat source, such as a laser or hot air, is supplied to the powder bed (Berretta et al., 2013). According to Shirazi et al. (2016), the interface between the powder and binder utilised in 3D printing might be affected by chemical reactions or adhesion forces. For instance, the fundamental factors in binder jetting printing are powder flowability and wettability in sugar since it is crucial to create a thin film. When sugar powder is applied to the printer bed, a layer forms (Godoi et al., 2016). When a liquid binder has a limited flowability, the powder may not be sufficiently coated, and when it has a high flowability, the powder bed becomes unstable. The amount of binder absorbed as well as the volume of binder spread into the powder bed will impact the resolution and mechanical characteristics of the printed output, therefore particle wettability is crucial.

¡¡)**Gelatine**

Gelatine is a protein that develops when the collagen fibrous structure is irreversibly broken down, either by alkaline or acidic treatment (Nocera et al., 2015). Gelatine is one of the potential substrates for 3D printing since it has a distinctive "melt-in-the-mouth" texture that offers a noticeable mouthfeel sensation (Diaz et al., 2015; Nocera et al., 2015). Warm water is used to dissolve air-dried gelatin, and the hydrated gelatine particles immediately coil together. The collagen triple helix shape is reversed during the gelation process when a brief stretch of polypeptide chains forms at junction zones (Burey et al., 2008). Since gelatine is a Newtonian substrate that is accepted when it is stretched by a charge group in a diluted solution, viscosity is a crucial factor in gelatine extrusion.

Gelatine is added to food ingredients to increase viscosity and printability. Using a combination of several ingredients, Cohen et al. (2009) printed food flavours using the Fab@Home 3D food printer. gelatine content varying from 0.5% to 4% w/w. The fact that a hard superstructure was generated as the gelatine concentration increased revealed that food material was printable. Yang et al. (2018) decided to build a gel-based product with a lemon flavour using the extrusion method. Some of the 3D printed lemon juice gel.

Dough

When combined with water, dough has viscoelastic qualities and is a type of carbohydrate macronutrient generated from wheat flour (Hoseney and Rogers, 1990). When a gluten is present, viscoelasticity occurs. Because protein and water may interact, the protein in gluten will swell when exposed to water. Additionally, since doughs may hold onto gas, the rate of gas diffusion in the dough mixture will be slowed. A gluten protein can interact with both hydrogen and hydrophobic bonds due to its large molecular size and low charge density (Hoseney and Rogers, 1990). Wheat flour dough's propensity to build up during post-processing steps like baking and frying is due to its viscoelastic nature.Dough made from wheat flour has the potential to build up during post-processing steps like baking and frying thanks to its viscoelastic nature. Dough is a potential contender because of its characteristic for 3DP. The goal of 3DFP is to create shapes without the need for several steps, which enables the creation of a single complicated design without the use of a separate mould (Lipton et al., 2015). The capacity to maintain this shape while baking, frying, or other cooking processes is crucial. Two solutions were proposed by Lipton et al. (2010) to address the problem of form instability: recipe management and the addition of food additives. As a binding agent in the creation of edible powder during the printing process, additives like hydrocoloids increase the flow and migration of a liquid spray onto a powder

Chocolate

These qualities describe chocolate. Because it contains cocoa butter, chocolate is a thermosensitive substance. Additionally, by properly tempering, a more stable crystal is produced. It can be obtained and this produces chocolate with a better quality such as a glossy appearance, a snap and a desirable texture (Afoakwa et al., 2007; Afoakwa et al., 2008; Afoakwa et al., 2009; Beckett, 1995; Chen and Mackley, 2006; Chocolate Alchemy, 2008; Cidell and Alberts, 2006; Kinta and Hartel, 2010; Talbot, 1994). Due to its intricate structure, chocolate considerably changes in character even with slight temperature changes. For instance, chocolate is semi-solid at room temperature, but when the temperature hits body temperature (37 °C), it becomes liquid.For instance, chocolate is semi-solid at room temperature but becomes principally fluid and has a low yield stress of 10–20 when it reaches body temperature (37 °C). (Chen and Mackley, 2006) Pa. Other composites are also present in chocolate, such as soy lecithin, which serves as an emulsifier and improves the coating of hydrophilic sugar particles and hydrophobic fat molecules.

Conclusion

The potential of this application for food is being studied and replicated by numerous food technologists as a result of the technological improvement of 3DP in food creation. This technology is thought to would have a significant impact on food production because 3DFP can tailor products to each customers' demands and preferences. A sophisticated meal design can also be prepared because every step will be totally automated and supported by 3D model software. The use of 3DFP technology in the restaurant, bakery, or cafe sectors of the hospitality industry, specifically with regard to printing customised desserts, decorating cakes with 3D-printed chocolate, and printing pizza dough in a variety of shapes, could support the development of this technology. The major finding is that using 3D printing technology to design membrane module components has enormous potential. When choosing a 3D printer to fabricate membrane module components, resolution and material considerations are crucial. This cross-curricular.Over the past ten years, the field has shown slow but consistent growth. Here, we give a few illustrations of opportunities and potential future developments. First, 3D printers' ability to print in several materials has not yet been effectively utilised.

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