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3D Food Printing- Scope and Limitations

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SUMMARY

The future of 3D printing will be developed in the upcoming years. No doubt, food printing can have many advantages, but whether the market is ready for such a big change and the technology will grow fast enough that is the questions. Can the 3D printed food replace traditional meals? Certainly not today, but it may already be an interesting alternative to traditional meals, as well as an edible decoration limited only by our imagination, difficult or impossible to prepare in other ways. The rest is up to the technology development, lower prices of printers, extent of the food components palette useful for printing, as well as development and availability of recipes. An important aspect in the promotion of 3D printed food may be the ecological and health aspects. Also, it seems to be the right solution to meet the needs of today's consumers, who increasingly have too little time to prepare meals on their own, especially in small or single-person households. In the future, ready, healthy meal, tailored to their individual needs, will be waiting when coming home. It will be prepared by a previously programmed device thanks to 3D printing technology, or even the printers will be programmed remotely via mobile phone, from office or on the way home. Furthermore, no food will be wasted; a portion will be one, fresh and prepared especially for us, at a time when the need arises.

INTRODUCTION

There is an increasing market need for customized food products, most of which are currently designed and made by specially trained artisans. The cost for such a limited number of pieces is relatively high. Three-dimensional (3D) food printing, also known as Food Layered Manufacture can be one of potential alternatives to bridge this gap. It aims to produce 3D custom-designed food objects in a layer-by-layer manner, without object-specific tooling, molding, or human intervention. Thus, this technology can increase production efficiency and reduce manufacturing cost for customized food products fabrication. A three-dimensional (3D) printing, called additive manufacturing (AM), established since 1980s, have been developed and applied in variety applications for many industries. AM crates model by adding material layer by layer from a computerized 3D solid model. An advantage of AM is to construct a complexity model without mould and die, fixtures, cutting tools and coolants. The application of construction AM model have been wildly used in many fields of industry such as automotive, architecture, medical and fashion design. Including, food manufacturing also applies this technology to fabricate food design.

However, a sustainable nutrition and food security are the global agenda and key themes, which are considered during, apply 3D food printing. There are several techniques to construct 3D food printing that are extrusion-based printing, selective laser sintering, fused deposition modelling, binder jetting and inkjet printing. The most commonly used 3-D printing process (~46 percent) is a material extrusion technique called fused deposition modelling (FDM). FDM technology was invented after the other two most popular technologies, stereolithography (SLA) and selective laser sintering (SLS), FDM is typically the most inexpensive of the three by a large margin, which leads to the popularity of the process. 3-D printer can convert only dry and shelf stable ingredients. They cannot deal with wet protein rich ingredients and dairy products because of the risk of spoilage. Designing methods for integrating data about the individuals, and establishing algorithmic representations of traditional recipes. These algorithms would need to map the dishes (crispiness, tenderness, flakiness etc.) to the process parameters of the recipe. Research and industry will also need to develop more stable print materials. Added precision in the crafting of food shapes and the ability to replicate full 3D designs will allow for new presentations of food. Higher throughput and larger reservoir food printers will be needed for mass production. 3D printing is an innovation that promises to revolutionize food formulation and manufacturing processes. Preparing foods with customized sensory attributes from different ingredients and additives has always been a need. The competency that additive manufacturing offers has

been among the key reasons for its success in food processing applications. In this work, an up-to-date review on insight into the properties of printing material supplies and its effect on printing processes is presented. A detailed note on the globalization of customized printed foods, personalized nutrition, and applications in food packaging to highlight the range of applications of 3D printing in the food industry is also given. Importantly, key challenges in 3D food printing, emphasizing the need for future research in this field are elaborated.

Advantages of 3D Food Printing:

Among the advantages of 3D food printing, the following may be mentioned:

- Ease of transportation even to the most remote corners of the world or into space (NASA),
- New opportunities to create dishes, their artistic design - creating culinary works of art,
- The ability to design your own food – being a food designer,
- Economical and efficient technique of mass personalization.
- Food personalization,
- Meal composition adapted to individual diet,
- The use of new components, which are not used or are not popular among consumers,
- Ease and simplicity of preparation of meals,
- Both aesthetic and functional customization can be achieved at the same time,
- Novel food textures,
- Longer shelf life.

Disadvantages of 3D Food Printing:

- Post Processing
- Large Volumes
- Part Structure
- Limited Materials.
- Restricted Build Size
- Reduction in Manufacturing
- Design Inaccuracies
- Copyright Issues
- 3D Food printing Technology is Expensive
- 3D Food printers Aren't that User-friendly
- 3D Food printers are Slow

Scope of 3D Food Printing:

Customization & Personalization: Enables the creation of foods tailored to individual dietary needs, such as low-sugar, high-protein, or vitamin-enriched meals. Useful for medical nutrition and dietary restrictions.

Food Waste Reduction: Can use alternative ingredients like food byproducts or insect proteins to create sustainable food sources. Helps repurpose surplus food into edible products with longer shelf life.

Innovative Culinary Experiences: Allows chefs and food designers to create intricate and artistic food presentations. Offers new textures and flavors that are not possible with traditional cooking methods.

Automation & Efficiency: Reduces manual labor in food preparation, making processes more efficient. Could be integrated with smart kitchen technology for automated meal production.

Space & Disaster Applications: Potentially useful in space missions where traditional food storage and preparation are impractical. Could provide emergency food solutions in disaster-affected regions.

Limitations of 3D Food Printing:

Limited Ingredient Compatibility: Not all food ingredients can be 3D printed; it mainly works with paste-like substances such as chocolate, dough, or purees. Difficulty in printing fresh fruits, vegetables, and complex food structures.

Slow Production Speed: Printing food takes significantly longer than traditional cooking methods, making it inefficient for large-scale production.

High Cost & Accessibility: 3D food printers are expensive and not widely available for household use. Cost of food-grade printing materials and maintenance is also high.

Nutritional and Safety Concerns: Potential loss of nutrients during the printing and post-processing stages. Ensuring food safety and hygiene during automated food preparation is a challenge.

Consumer Acceptance & Regulatory Challenges: People may be hesitant to adopt 3D-printed food due to concerns about taste, texture, and naturalness. Regulatory approvals and food safety standards for printed foods are still evolving.

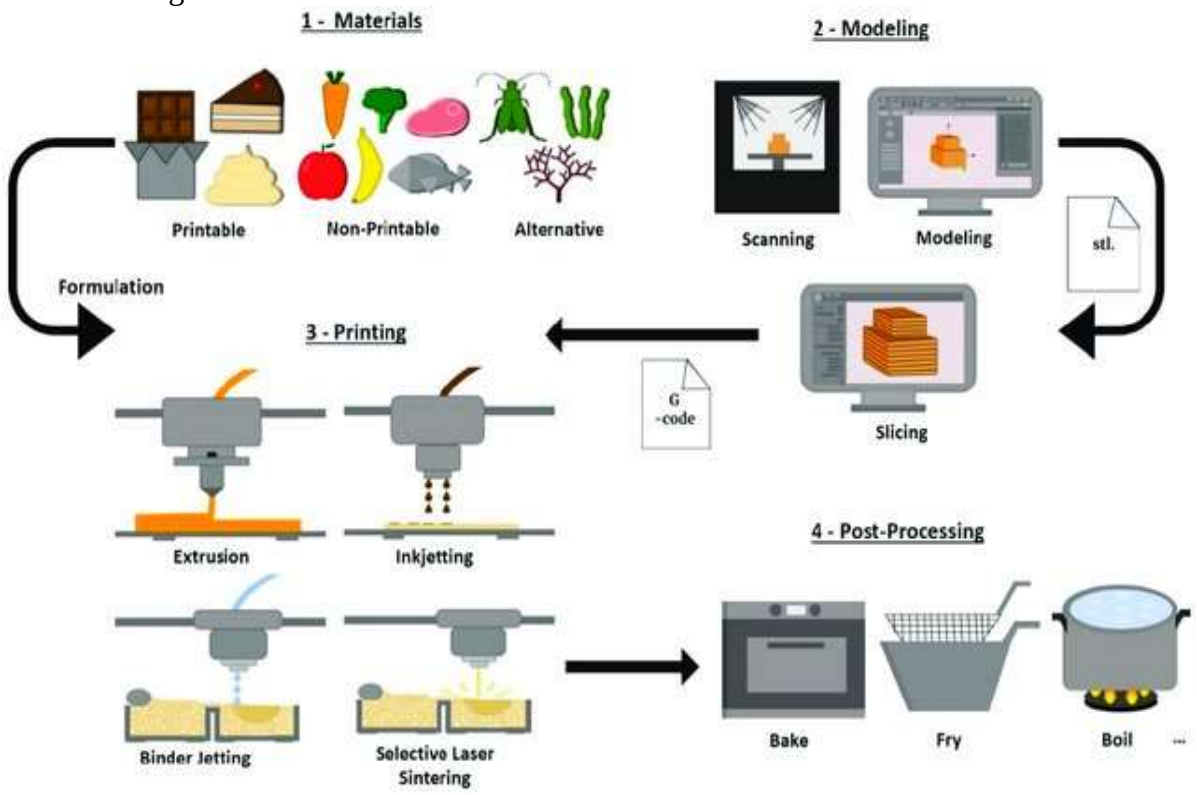

Fig.01: 3D Food Printing Process

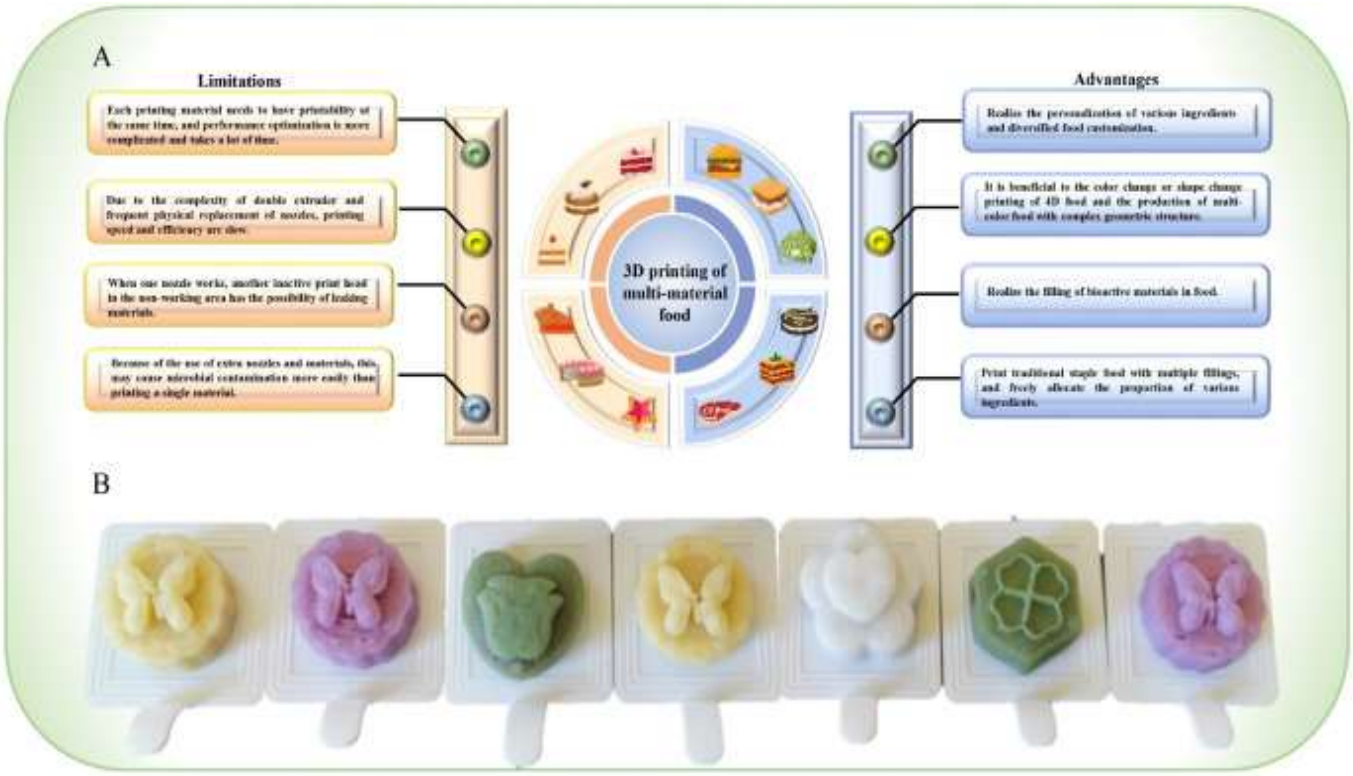

Fig.02: Limitations and Advantages of 3D Food Printing of multi-material food

CONCLUSION

3D food printing holds immense potential in personalized nutrition, sustainability, and culinary innovation. However, technological and practical challenges must be addressed for it to become a mainstream food production method. Further advancements in ingredient compatibility, printing speed, and cost-effectiveness are essential for wider adoption in both commercial and household settings.

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