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Next Generation Food Approaches:3D Printed Food Items Benefits And Challenges

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Abstract

Three-dimensional food printing is a new technique that has potential uses in personalized nutrition, texture alteration, and sophisticated food design.Extrusion is the most commonly utilized process, especially for cereal derivatives and chocolate.This technology provides prospects for nutritional content customization, addressing unique dietary demands, and potentially resolving malnutrition disorders. However, obstacles remain, including as microbiological contamination, customer acceptance, and regulatory issues. Additional research is needed to determine the impact on nutrient density, bioavailability, and overall diet quality. Despite these obstacles, 3D food printing offers prospects for novel business methods and enhanced sustainability in the food supply.Future improvements could include merging 3D printing with cooking procedures and the introduction of 4D printing.3D food printing is a novel technology with potential applications in individualized nutrition, sustainability, and creative food design. It enables the development of sophisticated geometric structures as well as customized foods based on individual nutritional requirements, textures, and flavors.Extrusion, inkjet, binder jetting, and selective sintering are some of the processes used in this technology.While 3D food printing has advantages in terms of customization and waste reduction, it has obstacles such as assuring nutritional quality, food safety, and consumer acceptance.Furthermore, there is still room for improvement in terms of production scale and printing resolution.Despite these challenges, 3D food printing has the potential to transform food innovation and manufacturing, addressing concerns such as malnutrition and sustainability in the food sector. In this review, the benefits and potential challenges of 3-D printed food items were thoroughly examined.

Key Words: *3D printing,food systems, consumer,industry, novel approaches*

Yeni Nesil Gıda Yaklaşımları: 3D Baskılı Gıda Ürünlerinin Faydaları ve Zorlukları

Özet

Üç boyutlu gıda baskısı, kişiselleştirilmiş beslenme, doku değişikliği ve gelişmiş gıda tasarımında potansiyel kullanımları olan yeni bir tekniktir. Ekstrüzyon, özellikle tahıl türevleri ve çikolata için en yaygın kullanılan işlemdir. benzersiz beslenme talepleri ve potansiyel olarak yetersiz beslenme bozukluklarının çözümü. Ancak mikrobiyolojik kontaminasyon, müşteri kabulü ve mevzuat sorunları gibi engeller devam etmektedir. Besin yoğunluğu, biyoyararlanım ve genel diyet kalitesi üzerindeki etkiyi belirlemek için ek araştırmalara ihtiyaç vardır. Bu engellere rağmen, 3 boyutlu gıda baskısı, yeni iş yöntemleri ve gıda tedariğinde gelişmiş sürdürülebilirlik için umutlar sunuyor. Gelecekteki iyileştirmeler, 3 boyutlu baskının pişirme prosedürleriyle birleştirilmesi ve 4 boyutlu baskının tanıtılmasını içerebilir. 3 boyutlu gıda baskısı, bireyselleştirilmiş gıda endüstrisinde potansiyel uygulamalara sahip yeni bir teknolojidir. beslenme, sürdürülebilirlik ve yaratıcı gıda tasarımı. Bireysel beslenme gereksinimlerine, dokulara ve tatlara dayalı özelleştirilmiş gıdaların yanı sıra karmaşık geometrik yapıların da geliştirilmesine olanak tanır. Ekstrüzyon, mürekkep püskürtme, bağlayıcı püskürtme ve seçici sinterleme bu teknolojide kullanılan işlemlerden bazılarıdır. 3D gıda baskısının avantajları vardır. kişiselleştirme ve atıkların azaltılması açısından beslenme kalitesinin sağlanması, gıda güvenliği ve tüketici kabulü gibi engellere sahiptir. Üstelik üretim ölçeği ve baskı çözünürlüğü açısından hala iyileştirmeye yer vardır. Bu zorluklara rağmen 3D gıda baskısı, Gıda sektöründeki yetersiz beslenme ve sürdürülebilirlik gibi endişeleri ele alarak gıda inovasyonunu ve üretimini dönüştürme potansiyeli. Bu incelemede, 3 boyutlu baskılı gıda maddelerinin faydaları ve olası zorlukları kapsamlı bir şekilde incelenmiştir.

Anahtar Kelimeler: *3D baskı,gıda sistemleri,tüketici,endüstri,yeni yaklaşımlar*

Introduction

Recent advancements in 3D printing have transformed many industries, including healthcare and biology. Using patient-specific data, the method allows for the development of complicated biomedical devices, implants, and scaffolds for tissue engineering (Chia and Wu, 2015). Significant advances in printing processes, materials, and post-processing methods have enabled the development of piezoelectric devices, blood vessel-like hydrogel structures, and even live cells (Karakurt & Lin, 2020). In healthcare, bioprinting mixes biomaterials to create biomedical parts, addressing medical crises in locations without advanced technology (Mukhopadhyay & Poojary, 2018). 3D printing's versatility and efficiency have led to its widespread use in areas such as prototype, automobile, aviation, and space exploration. Advanced printing processes such as SLS, DLP, and LOM, as well as the development of composite and nanocomposite materials containing carbon fibers, graphene, and carbon nanotubes, are boosting the capabilities of this technology (Ghongde and Sachdev, 2020). Recent breakthroughs in 3D food printing have demonstrated intriguing uses for generating customized and functional food products. This technique enables personalized nutrition, customized textures, and complex geometries (Diañez et al., 2022; Leontiou et al., 2023). Diañez et al. (2022) report that extrusion-based systems with in situ gelation and mixing capabilities offer improved control over final product qualities. The utilization of functional components and interior structures can influence both the physiological advantages and the physicochemical features of printed foods (Zhao et al., 2020). However, obstacles remain in adjusting food ink compositions and printing conditions for successful results (Zhang et al., 2021). The new concept of 4D food printing adds another level of utility (Zhao et al., 2020).In this review the benefits and challanges were evaluated deeply in comprasion.

Benefits of 3D-printed Foods

Advancements in 3D food printing (3DFP) hold promise for generating personalized, healthy, and sustainable food items (Hamilton et al., 2024; Diañez et al., 2022). This method has the ability to adapt dietary qualities to specific demands (Zhang et al., 2021). Material qualities, printing settings, and food ink printability are all important aspects in determining the success of 3D printed foods. Diañez et al. (2022) are developing innovative technologies, such as in situ gelation and mixing devices, to automate the printing process and improve end product attributes. Hydrogel-based inks have emerged as a viable method for producing 3D printed foods with actual food qualities (Sharma et al., 2023). However, obstacles remain, such as food safety concerns, machine hygiene, and the requirement for standardized reporting of critical physicochemical parameters (Hamilton et al., 2024; Zhang et al., 2021). Overcoming these challenges is critical to the general implementation of 3DFP in the food business. Three-dimensional (3D) food printing is a new technology with several potential applications in the food business. It permits the development of complicated geometric structures, personalized nutrition, and customized textures for specific consumer demands, such as dysphagia patients (Zhu et al., 2023). The technology has economic and environmental benefits, such as waste reduction and the utilization of eco-friendly ingredients (Le-Bail et al., 2020). 3D food printing enables the modification of color, shape, flavor, and nutritional content, addressing concerns such as malnutrition (Singhal et al., 2020). It also has uses in intelligent food packaging, which might help reduce food waste (Leontiou et al., 2023). However, obstacles persist, including worries regarding nutritional quality, food safety, and regulatory issues (Zhu et al., 2023). Current research aims to improve print resolution and create large-scale production systems (Le-Bail et al., 2020). As technology progresses, it may transform food production and consumption habits.

Challanges of 3D-printed foods

3D printed food is a new technology with potential uses in personalized nutrition, food sustainability, and addressing global food supply issues (Tran, 2016; Roslin et al., 2022; Baiano, 2020). However, it confronts a number of challenges, including safety concerns, labelling requirements, and consumer acceptance (Tran, 2016; Baiano, 2020). The technology primarily employs extrusion techniques and a variety of ingredients, including grain derivatives, chocolate, and alternative protein sources (Baiano, 2020). Religious considerations, such as halal certification, also apply to 3D printed food goods (Roslin et al., 2022). Consumer opinions regarding 3D printed food are mixed, with concerns about its "unnatural" nature and the redefining of what constitutes food (Lupton and Turner, 2016). Legal frameworks may have to classify 3D printed foods as "novel foods" (Baiano, 2020). Despite the limitations, 3D food printing provides prospects for new business strategies and increased food supply chain sustainability (Baiano, 2020). 3D food printing has the potential to improve individualized nutrition and texture modification, especially for dysphagic patients (Zhu et al., 2023; Lorenz et al., 2022). Carbohydrate-based inks are widely used to generate desirable textures and can be supplemented with prebiotics and probiotics (Singh et al., 2022). However, the technique presents problems in terms of nutritional quality, food safety, and regulatory issues (Zhu et al., 2023). The ultra-processed nature of 3D-printed foods may have a negative influence on digestion and gut flora, however methods such as adding hydrocolloids and probiotics can help alleviate these impacts (Lorenz et al., 2022). Safety and labeling issues are key concerns, particularly in terms of food poisoning hazards and long-term consumption impacts (Tran 2016).

Conclusion

In this review, benefits and challanges of 3D-printed foods were evaluated.While 3D food printing holds promise for enhancing texture-modified diets and developing appealing foods for certain populations, additional study is needed to address potential health hazards and assure proper regulation.The important comments given from this review, the highlihts could be beneficary for not only academicans but also industry and public.

Referencess

Baiano, A. (2022). 3D printed foods: A comprehensive review on technologies, nutritional value, safety, consumer attitude, regulatory framework, and economic and sustainability issues. *Food Reviews International, 38(5)*, 986-1016. https://doi.org/10.1080/87559129.2020.1762091

Chia, H. N., & Wu, B. M. (2015). Recent advances in 3D printing of biomaterials. *Journal of biological engineering*, *9*, 1-14. https://doi.org/10.1186/s13036-015-0001-4

Diañez, I., Martínez, I., Franco, J. M., Brito-de la Fuente, E., & Gallegos, C. (2022). Advances in 3D printing of food and nutritional products. *Advances in food and nutrition research*, *100*, 173-210. https://doi.org/10.1016/bs.afnr.2021.12.003

Ghongde, N., & Sachdev, A.P. (2020). D Printing and advance material technology.

Hamilton, A. N., Mirmahdi, R. S., Ubeyitogullari, A., Romana, C. K., Baum, J. I., & Gibson, K. E. (2024). From bytes to bites: Advancing the food industry with three-dimensional food printing. *Comprehensive Reviews in Food Science and Food Safety*, *23*(1), e13293.
https://doi.org/10.1111/1541-4337.13293

Karakurt, I., & Lin, L. (2020). 3D printing technologies: techniques, materials, and post-processing. *Current Opinion in Chemical Engineering*, *28*, 134-143. https://doi.org/10.1016/j.coche.2020.04.001

Le-Bail, A., Maniglia, B. C., & Le-Bail, P. (2020). 3D printing of foods: recent developments, future perspectives and challenges. *Current opinion in food science*.

Leontiou, A., Georgopoulos, S., Karabagias, V. K., Kehayias, G., Karakassides, A., Salmas, C. E., & Giannakas, A. E. (2023). Three-dimensional printing applications in food industry. *Nanomanufacturing*, 3(1), 91-112. https://doi.org/10.3390/nanomanufacturing3010006

Lorenz, T., Iskandar, M. M., Baeghbali, V., Ngadi, M. O., & Kubow, S. (2022). 3D food printing applications related to dysphagia: A narrative review. *Foods*, *11*(12), 1789. https://doi.org/10.3390/foods11121789

Mukhopadhyay, S., & Poojary, R. (2018, February). A review on 3D printing: Advancement in healthcare technology. In *2018 Advances in Science and Engineering Technology International Conferences (ASET)* (pp. 1-5). IEEE. doi: 10.1109/ICASET.2018.8376890.

Roslin, U. H., Razali, M. F. A., Ghazali, M. I. M., & Baharuddin, A. S. (2022). Three-dimensional (3D) printed food products from halal forensic perspective: A preliminary review. *Malaysian Journal of Syariah and Law*, *10(1)*, 54-62. DOI: https://doi.org/10.33102/mjsl.vol10no1.382

Sharma, R., Nath, P. C., Hazarika, T. K., Ojha, A., Nayak, P. K., & Sridhar, K. (2024). Recent advances in 3D printing properties of natural food gels: Application of innovative food additives. *Food Chemistry*, *432*, 137196. https://doi.org/10.1016/j.foodchem.2023.137196

Singh, J., Kaur, J., Rasane, P., & Kaur, S. (2022). 3D printed foods-carbs from the lab for better health. *Current Opinion in Clinical Nutrition & Metabolic Care*, *25*(4), 271-276. *DOI:* 10.1097/MCO.0000000000000837

Singhal, S., Rasane, P., Kaur, S., Garba, U., Bankar, A., Singh, J., & Gupta, N. (2020). 3D food printing: paving way towards novel foods. *Anais da Academia Brasileira de Ciências, 92(3),* e20180737. 10.1590/0001-3765202020180737

Tran, J. L. (2016). 3D-printed food. *Minn. JL Sci. & Tech.*, *17*, 855.

Zhang, J. Y., Pandya, J. K., McClements, D. J., Lu, J., & Kinchla, A. J. (2022). Advancements in 3D food printing: A comprehensive overview of properties and opportunities. *Critical Reviews in Food Science and Nutrition*, *62*(17), 4752-4768.https://doi.org/10.1080/10408398.2021.1878103

Zhao, L., Zhang, M., Chitrakar, B., & Adhikari, B. (2021). Recent advances in functional 3D printing of foods: A review of functions of ingredients and internal structures. *Critical reviews in food science and nutrition*, *61*(21), 3489-3503. https://doi.org/10.1080/10408398.2020.1799327

Zhu, W., Iskandar, M. M., Baeghbali, V., & Kubow, S. (2023). Three-Dimensional printing of foods: A critical review of the present state in healthcare applications, and potential risks and benefits. *Foods*, *12*(17), 3287.https://doi.org/10.3390/foods12173287