THE IMPACT OF USING 3D FOOD PRINTERS ON THE FOOD & BEVERAGE INDUSTRY POST-COVID-19

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This research aims to identify changes in consumers' eating and drinking habits following the COVID-19 pandemic, propose solutions to the negative impacts arising from fear of viral infection in the food and beverage sector, and address global food issues. The interview method was employed within the framework of qualitative research techniques. Data were collected through face-to-face interviews with 19 participants. The data were analyzed using content and descriptive analysis methods. It was found that consumers' eating and drinking behaviours have shifted post-COVID-19 pandemic. 3D food printers, offering benefits such as hygienic, contactless production; reduced waste and costs; efficient timing; and competitive advantage, could help address certain food challenges and aid in reviving the food and beverage industry by boosting demand. If society becomes sufficiently informed about the advantages of 3D printers, their adoption rates could increase, leading to broader implementation. Businesses should actively promote 3D printing technology through diverse marketing channels. This would help convince consumers that meals prepared with this technology are very healthy. Identifying the specific changes in people's eating and drinking habits after the pandemic is crucial. This study is among the few in the literature to explore the potential of 3D printers to address the challenges faced in the food and beverage industry and to tackle global food problems.

Keywords: 3D Food Printer; Food and Beverage Industry; Covid-19; Eating Habits.

O IMPACTO DO USO DE IMPRESSORAS 3D DE ALIMENTOS NA INDÚSTRIA DE ALIMENTOS E BEBIDAS APÓS A COVID-19

Resumo

Esta pesquisa tem como objetivo revelar as mudanças nos hábitos alimentares e de consumo de bebidas dos consumidores após a pandemia de Covid-19 e oferecer soluções para as adversidades enfrentadas em razão do medo de contaminação por vírus na indústria de alimentos e bebidas, bem como dos problemas alimentares globais. A técnica de entrevista foi utilizada no contexto dos métodos qualitativos de pesquisa. Os dados foram obtidos por meio de entrevistas presenciais com 19 participantes. As informações coletadas foram analisadas por meio de métodos de análise de conteúdo e de análise descritiva. Constatou-se que os hábitos alimentares e de consumo de bebidas dos consumidores mudaram após a pandemia de Covid-19. As impressoras de alimentos 3D, por oferecerem vantagens como produção higiênica e sem contato, redução de desperdícios e custos, economia de tempo e vantagem competitiva, podem representar uma solução para alguns problemas alimentares e contribuir para a revitalização da indústria de alimentos e bebidas por meio do aumento da demanda. Caso a sociedade seja suficientemente informada sobre os benefícios dessas impressoras, suas taxas de uso poderão aumentar e sua difusão se tornará mais ampla. As empresas devem promover a tecnologia de impressão 3D por meio de diferentes canais de marketing. Dessa forma, é necessário convencer os consumidores de que as refeições são preparadas de forma muito saudável com essa tecnologia. O estudo é relevante por revelar as mudanças nos hábitos alimentares das pessoas após a pandemia. Trata-se de uma das raras pesquisas na literatura que abordam o uso de impressoras 3D como solução para os desafios enfrentados pela indústria de alimentos e bebidas e para os problemas alimentares globais.

Palavras-chave: impressora de alimentos 3D; indústria de alimentos e bebidas; Covid-19; hábitos alimentares.

EL IMPACTO DEL USO DE IMPRESORAS 3D DE ALIMENTOS EN LA INDUSTRIA ALIMENTARIA Y DE BEBIDAS DESPUÉS DE LA COVID-19

Resumen

Esta investigación tiene como objetivo revelar los cambios en los hábitos de alimentación y consumo de bebidas de los consumidores tras la pandemia de Covid-19 y proponer soluciones a las dificultades surgidas debido al temor al contagio del virus en la industria de alimentos y bebidas, así como a los problemas alimentarios globales. La técnica de entrevista se empleó en el marco de los métodos cualitativos de investigación. Los datos se obtuvieron mediante entrevistas presenciales a 19 participantes. Los datos recopilados se analizaron mediante métodos de análisis de contenido y descriptivo. Se reveló que los hábitos alimentarios de los consumidores cambiaron tras la pandemia de Covid-19. Las impresoras de alimentos 3D, gracias a ventajas como la producción higiénica y sin contacto, la reducción de desperdicios y costos, la optimización del tiempo y la ventaja competitiva, pueden ser una solución a ciertos problemas alimentarios y contribuir a la reactivación de la industria de alimentos y bebidas mediante el aumento de la demanda. Si la sociedad está debidamente informada sobre los beneficios de estas impresoras, su uso puede incrementarse y extenderse. Las empresas deben promover la tecnología de impresión 3D mediante diversos canales de marketing. De este modo, es necesario convencer a los consumidores de que las comidas preparadas con esta tecnología son muy saludables. El estudio es relevante por revelar los cambios en los hábitos alimentarios de las personas tras la pandemia. Se trata de uno de los pocos estudios en la literatura que abordan el uso de impresoras 3D como solución a los desafíos de la industria alimentaria y a los problemas alimentarios globales.

Palabras clave: Impresora de Alimentos 3D; Industria de Alimentos y Bebidas; Covid-19; Hábitos Alimentarios.

HOW TO CITE: Kömür, T., Mesci, M., & Türkmen Akbulut, B. (2026). The Impact of Using 3D Food Printers on the Food & Beverage Industry Post-COVID-19. *Anais Brasileiros de Estudos Turísticos, v. 16,* n. 1 (Edição Regular), 1 – 12, Jan./ Dez. Retrieved from: https://periodicos.ufjf.br/index.php/abet/article/view/41865
DOI: https://doi.org/10.5281/zenodo.15270100

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1 INTRODUCTION

COVID-19 was first identified by the World Health Organization on December 31, 2019, following reports of pneumonia cases in Wuhan, Hubei province, China. The COVID-19 pandemic was recognized globally and escalated, severely impacting nearly all countries (Chowdhury et al., 2020, p. 1). A person at the seafood and animal market exhibited symptoms such as fever, cough, and shortness of breath, and it was indicated that the new coronavirus, SARS-CoV-2, originated from research (Velavan & Meyer, 2020, p. 278; Fauci et al., 2020). Since then, the virus has spread worldwide, infecting 244.644.699 people and causing 4,966,466 deaths as of October 28, 2021 (TCDDO, 2021). In Turkey, it has infected 7.601.000 people and resulted in the death of 67.225 individuals (Ministry of Health, 2021).

In addition to threatening human health and lives, the Covid-19 pandemic has significantly impacted the tourism and food and beverage sectors, which are key parts of the global economy (Okat et al., 2020, p. 202). Governments introduced quarantine measures in the first quarter of 2020. With restaurants closing or operating at reduced capacity and switching to takeout services, the food and beverage industry faced challenges from perceived risks, loss of confidence, and fear of virus infection among consumers (Kim & Lee, 2020, p. 67). The virus can be transmitted through food via contact with food workers who are carriers. COVID-19 has changed how people around the world think and act (Yost & Cheng, 2021, p. 1).

This research is important for revealing changes in people's eating and drinking habits after the pandemic, and the results will be influenced by the integration of 3D food printers into our lives to address challenges faced by the food and beverage industry, in line with the information gathered. It is one of the few studies in the literature on the use of 3D printers to address food industry and global food issues.

2 LITERATURE REVIEW

2.1 The Effect of the COVID-19 Pandemic on the Food and Beverage Industry and Eating Habits

By its nature, the tourism sector is among the first to be impacted by global crises. (Vaishar and Šťastná, 2020, p. 1). According to the final 2020 report from the World Tourism Organization, published in January 2021, international tourist arrivals fell by approximately 74% compared with 2019 (UNWTO, 2021). Since the first quarter of 2020, the Covid-19 pandemic has expanded its influence on the international arena and has led to negative social and economic changes worldwide (Göral & Yurtlu, 2021, p. 67).

Various measures implemented in many countries since the beginning of the COVID-19 pandemic have led to a significant economic downturn, including in the food and beverage industry (Teachout & Zipfel, 2020, p. 3). COVID-19 has spread to all continents, affecting the food and beverage industry in almost every region. Faced with reduced demand due to restaurant closures and slowing exports, many food processors have inevitably shifted their efforts to find suppliers for retail channels amid border measures in some countries (Hailu, 2020, p. 3).

Such supply chain disruptions have threatened food stocks and diminished trust in restaurants due to health concerns stemming from the pandemic. The fear of viral contamination from food has quickly shifted consumer preferences, leading to a decline in food and beverage consumption outside the home (Deloitte, 2020). Currently, people's eating habits have begun to evolve.

Eating habits, which are "the habitual decisions of individuals or a group of people about what foods they eat," were also influenced by COVID-19 (Preedy & Watson, 2010). Diet and eating habits play an important role in the physical and mental development of children and adolescents (O'Neil et al, 2014; Storz, 2020).

Since the start of the pandemic, increased time at home and prolonged restaurant closures have led consumers to cook more at home (Zwanka & Buff, 2021, p. 63). According to the researchers, consumers tend to verify whether food and beverage businesses adhere to pandemic protocols, use safe production materials, and prepare food properly (Zwanka & Buff, 2021, p. 65).

At the beginning of the pandemic, Americans' food expenditure dropped by 12.6% compared to the previous four years. There was a 33.7% decrease in spending on meals away from home and a 6.9% rise in spending on meals at home. Many people used delivery services for fast food during the pandemic, which affected the nutritional content of their meals (Dhakal, 2022).

Sgroi and Modica (2022) concluded that 15 participants ate out at least once a week before the pandemic, while the other 5 participants ate out at least twice a week. In the same study, it was found that after the pandemic, people went to restaurants less frequently (once every two weeks). This result suggests that restrictions have changed lifestyles.

However, it was also found that the respondents had at least a past connection to agriculture and, hence, to peasant production (Sgroi, 2022). These respondents preferred to stay at home and consume produce grown in the field and then prepared in the kitchen, as Kirk and Rifkin (2020) also found in their study.

2.2 3D Food Printer Usage Techniques

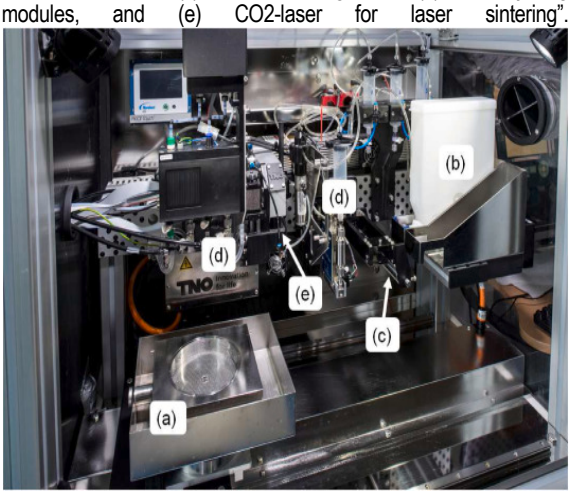
In this section, a few types of 3D printers will be examined and their features explained.

2.2.1 Selective Laser Sintering (SLS)

SLS technology, proposed by Carl Deckard in 1984, was based on a neodymium-doped yttrium aluminum garnet (Nd: YAG) laser with 100 W of power (Awad et al., 2020, p. 1). The system consists of a movable build platform (a) on which the powder is deposited from the powder dispenser (b). Then the powder is levelled using a counter-rotating roller (c) with a 25 mm diameter. The mechanism platform is then moved to one of the binder sputtering modules (d) for Selective Laser Sintering, or to a CO2 laser (e) with a 0.5 mm beam diameter and 12 W peak power. After lowering the mechanism platform, this cycle is repeated until the intended 3D object is obtained (Jonkers vd., 2022, p. 2).

Also, SLS is quicker than alternative practices since, without any printer bed movement, laser or hot air is applied directly to the powder. Post-curing is not necessary for this method, and a little support structure is enough (Mantihal et al., 2020, p. 2).

Figure 1. "TNO powder bed printer: (a) moving build platform, (b) powder dispenser, (c) counter-rotating roller, (d) binder jetting modules, and (e) CO2-laser for laser sintering".

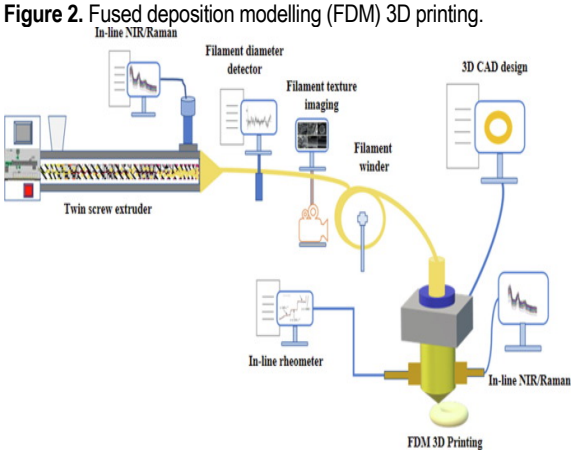


Source: Jonkers et al., 2022.

2.2.2 Fused Deposition Modelling (FDM)

Crucial procedure parameters of 3D printing are specific to equipment, process and material. Equipment-specific parameters include nozzle measurements and the number of feeder heads. The nozzle temperature, mechanism platform temperature, refill intensity, print speed, and layer height constitute process-specific parameters. Material-specific parameters involve filament automatus features and surface morphology (Bandari et al., 2021, p. 56).

Figure 2. Fused deposition modelling (FDM) 3D printing.

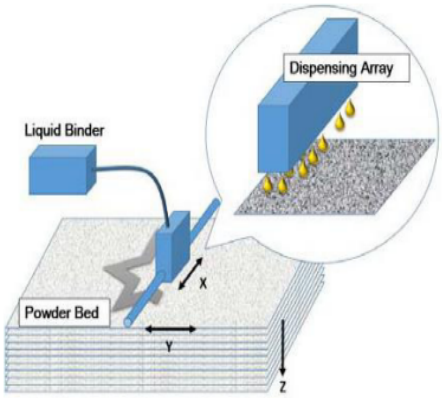


Source: Bandari et al., 2021, p. 56.

2.2.3 Binder spray (powder bonding) technology

Binder jet printing, also known as inkjet 3D printing (3DP), was first introduced by Sachs, Haggerty, Cima, and Williams (1994). Meanwhile, the powdery materials were deposited layer by layer, and the binder was selectively sprayed onto each material layer. There are specific regions based on the data file for the generated object. The connector connects the current segment to the fused segment before and the fused segment after. Unfused powder always supports the fused parts during the fabrication process, enabling the production of complex structures. Finally, unbound powder is removed and recycled for later use (Liu et al., 2017, p. 90).

Figure 3. Powder Bed Binder Jetting.

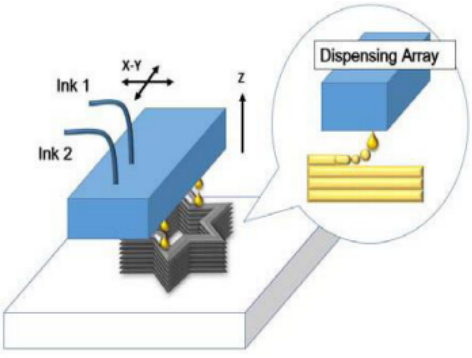


Source: Sun et al., 2015, p. 315.

2.2.4 Ink-Jet Printing

Generally, low-viscosity materials are used in printers that employ inkjet printing technology. Therefore, it is frequently used to print two-dimensional images. When it comes to printing precision and accuracy, compatibility between the ink and the substrate surface, ink viscosity and rheological properties, and temperature and printing speed are important factors for successful printing. This technology is not utilized in complex food printing processes (Liu et al., 2017).

Figure 4. Inkjet Printing.



Source: (Sun et al., 2015).

2.3 Use of 3D Food Printers After the Covid-19 Pandemic

Having examined the history of cooking, we have observed significant events and radical changes over the centuries. In this context, influenced by artistic activities,

traditions, technological advancements, and more, the food and beverage industry has continuously evolved (Aksoy & Üner, 2016, p. 3). Today, with population growth, sustainable food and beverage policies are becoming increasingly crucial. According to the United Nations' 2017 estimates, the world population will reach 9,8 billion by 2050. Therefore, producing 70% more food will be necessary to meet the basic dietary needs of the increasing global population.

Since COVID-19 is a very new disease, there is no precise data on direct transmission. However, it may be spread by clinging to food surfaces (Sağdıç et al., 2020, p. 929). Digital technologies that make our daily lives easier have also been used in the food and beverage sector (Yang et al., 2017: p. 3147). Additive layer manufacturing, also called 3D printing, is a rapid prototyping technology that integrates materials, computer science, computational control, precision transmission, and direct writing systems (Yang et al., 2018, p. 68).

3D printers are widely used in architecture, construction, automotive, medicine, labour, food processing, education, geographic information systems, and scientific research across various fields (Lee, 2021). Since the first 3D printer emerged in the 1980s, 3D printing technology has been studied for applications in food production processes due to its significant potential to create complex geometric shapes that offer economic and environmental benefits and satisfy consumer needs (Kim et al., 2018, p. 32).

3D food printing technology was first developed by Hod Lipson at Cornell University in 2006 (Malone & Lipson, 2007). Food printers consist of a three-axis XYZ table (Cartesian coordinate system), dosing/sintering devices, and a user interface (Aldanmaz & Sever, 2017, p. 2). Three-dimensional (3D) printing, also known as additive manufacturing, increasingly attracts interest due to its unmatched ability to produce complex geometric shapes, enabling serial production while offering economic and environmental benefits (Kim et al., 2018, p. 28). Recent developments have led to rapid progress in the field of 3D printing (Izdebska & Żołek-Tryznowska, 2017).

3D food printing technology is expected to become a new trend in the post-COVID-19 era. Its ability to offer personalized printing and produce food without human contact is seen as a key reason for its popularity (Lee, 2021). The pandemic is encouraging many industries to adopt "contactless" options (Lau, 2020, p. 501). It is anticipated that the sector will grow more active, providing personalized services while reducing individual contact due to social distancing during COVID-19 (Dankar, 2018).

3D food printing technology is an energy-saving technology that enables environmentally friendly, high-quality, reasonably priced food production and allows for customized food according to individual preferences and needs (Lili et al., 2018). In addition, they enable the development of healthy foods with proper nourishment automatically organized by personal medical data (Lili et al., 2018). Today, 3D printers produce various foods by using cream, cheese, sugar, fluid chocolate, pasta dough and pasta (Sun et al., 2015, p. 310).

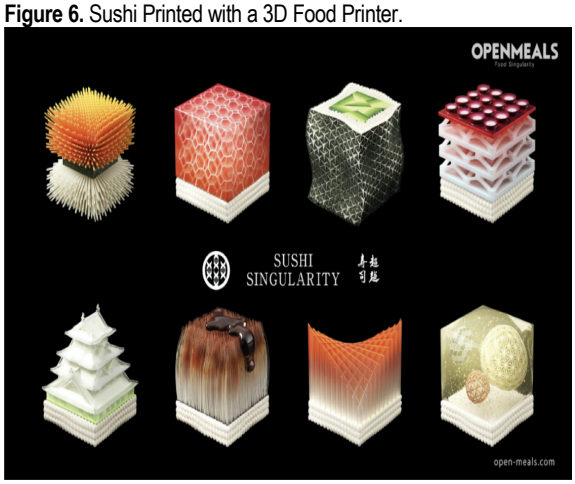
FoodInk, the world's first 3D food printer restaurant, opened in London in 2016. The restaurant makes dishes such as hummus, chocolate mousse, pea puree, cake, and pizza dough using a 3D food printer manufactured by the Dutch company byFlow (Lyncnh, 2016).

Figure 5. First Pizza Made with a 3D Food Printer.

Source: Lyncnh, 2016.

Smart sushi restaurant "Sushi Singularity Tokyo", opened in Tokyo in 2020, has started preparing meals according to the nutritional needs of its customers. That company plans to upgrade its 3D technology to enable the printing of all types of food, addressing many of the problems of the global food system, such as food insecurity and biodiversity loss (Ho, 2019).

Figure 6. Sushi Printed with a 3D Food Printer.



Source: (www.greenqueen.com, 2021).

Japanese design studio "Open Meals" states that personalized food production will have a significant place in the food industry of the future. Moreover, there will be individual food identities for every person, tailored to their health identity, thanks to DNA, urine, and stool tests (greenqueen).

With the rise in global changes in eating and drinking habits, the use and benefits of 3D food printers have gained attention (Pitayachaval et al., 2018). 3D food printing can create different shapes and textures that are complex and time-consuming to make by hand. This printing method is preferred by those who want to produce food with various designs and decorations in a healthier (hygienic) way (Singh & Raghav, 2018). Additionally, it is believed that 3D food

printers will be used to prepare healthy meals for consumers requiring special nutrition programs (Sun et al., 2015).

3 METHODOLOGY

This research aims to identify changes in consumers' eating and drinking habits following the Covid-19 pandemic and to propose solutions to address the negative impacts of the fear of virus transmission on the food and beverage industry and global food challenges. Face-to-face and telephone interviews (with participants who could not be interviewed in person due to pandemic restrictions) were conducted to gather participants' perceptions of 3D food printers. This study is significant for revealing post-pandemic changes in individuals' dietary habits and the potential outcomes of integrating 3D food printers into our lives to address issues in the food and beverage sector.

3.1 Population and Sample

The population consists of people living in Düzce, who are accustomed to eating out and are knowledgeable about the tourism sector. The data were collected through face-to-face interviews conducted in January and February 2022 with 19 participants, of whom more than half were academicians in tourism and food science. Since these academicians are experts in this subject, an attempt was first made to contact and interview them.

This research is qualitative and involves easily applicable situation sampling. It is an all-purpose method which is used. This method is rapid and easy because it prefers an easily accessible situation. Since it was not possible to reach and interview every desired person, convenience sampling was used.

3.2 Data Collection Process of the Research

In the study, face-to-face and telephone interviews (with people who could not be interviewed face-to-face due to pandemic conditions) were conducted with 19 participants, and notes were taken using a semi-structured interview format. The average interview duration is 30 minutes. The participants were asked six open-ended comment questions.

Questions as how, what did you mean, and why were asked to reach the desired answers on condition that they do not wander from the subject. The interview form was prepared based on the central theme “Measuring the perceptions of the participants towards 3d food printers and whether these printers can be a solution to the problems of the food and beverage industry.”

A literature review was conducted to prepare the interview form, and model studies were found. The questions in the interview form were selected from a pool of questions developed based on the literature and authored by Cömert & Yeşilyurt (2021), Derossi et al. (2021), and Filimonau et al. (2021). The interview form prepared for content validity was evaluated by five academicians, all experts in their fields (3 Professors and 2 Associate Professors), on inclusiveness, intelligibility, and alignment with the research purpose.

Necessary adjustments were made to the interview form, taking into account the experts' criticisms and suggestions regarding the theoretical statements. After the suitability of the interview form was confirmed, the implementation phase began. To ensure data collection during the application phase, each participant was asked whether they were familiar with the 3D food printer. If they do not have the necessary information, it has been provided.

3.3 Analysis of Research Data

Notes taken during the interviews were turned into written documents. Codes like P1, P2 and P19 have been used for participants interviewed. If data sufficiency is reached during data collection and no new information is obtained from the answers to the questions, it indicates that saturation has been achieved in the research (Morse, 1995, p. 147). Since the answers to the questions were repeated after a specific point and no new information was obtained, the research was confined to 19 people.

Some descriptive statistics, such as gender, position, age, and graduation status, have been ranked for the people. The questions in the interview form have been organized into six themes. After this arrangement, content and descriptive analyses have been conducted using the data. The data are summarized and interpreted under previously testified titles (such as themes) (Coşkun et al., 2015, p. 324).

To ensure the study's validity, it is intended to increase external validity by providing detailed information on data collection and analysis. After the participants' interviews were transcribed, the interview notes of the 5 participants were randomly selected by another expert. The sound recordings related to the written documents were compared, and the analysis of the written documents was verified.

The researcher coded the cases consistently across time during the analysis of the reports, thus ensuring time-dependent reliability. In addition, a faculty member was asked to code the research data, and the coding rate for the cases in the study by different researchers was approximately 91%; the cases that were coded differently were coded by two researchers together.

The same coding of a phenomenon by two researchers is expressed as observational reliability. Thus, observational reliability was also ensured. Internal validity in qualitative research is to convey a phenomenon as it is, with direct quotations, if possible, in an unbiased manner (Yıldırım & Şimşek, 2011, p. 257). To increase the research's internal validity, direct quotations from participants' comments were used.

4 RESULTS ANALYSIS

During the interview, participants voluntarily shared their ideas, suggestions, and comments in response to open-ended questions, either face-to-face or by phone. The purpose of the first part of the form was to collect demographic information. To analyze participants' demographic qualifications, a frequency distribution was used. As indicated in Table 1, the majority (63,15 %) are male participants.

It is seen that a significant portion of the interviewees (78,94 %) are between the ages of 30 and 40, and a significant portion (89,47 %) is postgraduate. More than half

of the interviewees participating in the research (52,63 %) are academicians who are experts in the tourism field. In the second part of the form, the participants were asked six questions. In light of the interviews, the prepared version of the answers is as follows.

Table 1. Profiles of Participants.

Code	Occupation	Age	Gender	Education status
P1	Academician	36	Male	Postgraduate
P2	Academician	35	Female	Postgraduate
P3	Academician	51	Male	Postgraduate
P4	Academician	32	Male	Postgraduate
P5	Academician	39	Female	Postgraduate
P6	Academician	40	Female	Postgraduate
P7	Academician	35	Male	Postgraduate
P8	Academician	26	Female	Postgraduate
P9	Academician	36	Female	Postgraduate
P10	Academician	38	Male	Postgraduate
P11	Food Engineer	35	Female	Postgraduate
P12	Civil servant	36	Male	Postgraduate
P13	Civil servant	39	Male	Postgraduate
P14	Civil servant	35	Male	Postgraduate
P15	Civil servant	38	Male	Postgraduate
P16	Civil servant	36	Male	Undergraduate
P17	Tourism sector personnel	25	Male	Undergraduate
P18	Tourism sector personnel	25	Female	Postgraduate
P19	Tourism sector personnel	33	Male	Postgraduate

Source: own elaboration.

4.1 Evaluations of the Participants on Research Questions on the 3D Food Printers

The codes and themes that emerged from the detailed analysis of the answers during the research are presented in this section.

Table 2. Participant Opinions Regarding Eating and Drinking Habits Outside Home.

Theme 1 – Eating and Drinking Habits Outside Home (36)	
Sub Themes	**Codes**
1.1. Eating and drinking habits have not changed	**Habits have changed (32)** ✓ Eating out habit has decreased (11) ✓ Preferring hygienic places (7) ✓ Stay away from crowds (6) ✓ Cooking own food (3) ✓ Package service habit (4) ✓ Eating more fat with stress
1.2. Eating and drinking habits have not changed	**Habits have not changed (4)** ✓ Working of everybody at home ✓ Needs socialization ✓ Habit does not change easily ✓ Food chat habit

Source: own elaboration.

In Table 2, 88% (32) of the codings are in the sub-theme that eating-drinking habits have changed. In this sub-theme, expressions include reducing the habit of eating and drinking outside, preferring hygienic places, avoiding crowds, and cooking your own food. 12% (4) of the codings are under the sub-theme of eating-drinking habits not changing. In this sub-theme, the reasons are the husband and wife's working schedules, difficulty in changing habits, and the need for socialization.

The statements of the participants regarding eating and drinking habits outside the home are as follows:

P11: Before COVID-19, we spent a lot of time outside and ate out once a week. We had to give up our habit of eating out due to the risk of infection with the disease after the pandemic and the restrictions that came with it. After a while, even though pandemic conditions eased and restaurants reopened, we could not continue eating outside as we did before.

P13: With COVID-19, our eating and drinking habits have changed significantly. Because the kitchen is where people care most about being healthy and want it to be clean, we tried not to bring in food from the outside to avoid bringing in disease. We started to clean everything we bought from outside in more detail. We started doing everything, from bread to vegetables, on our own. We grow vegetables on the balcony and terrace. We have reduced contact with the outside as much as possible, like everyone else.

P19: After the pandemic, I have started to apply a more meticulous approach to cafes and restaurants related to the eating and drinking sector. The cleanliness of food and beverage businesses is more important than ever. Both the presentation of the products and the cleanliness of the personnel have become important to me. I try not to spend too much time in places I have been and to avoid crowded environments.

Table 3. Participant Opinions Regarding the Use of 3D Food Printers.

Theme 2 – The Use of 3D Food Printers (27)	
Sub Themes	**Codes**
2.1. A 3D printer can be the solution	**A 3D printer can be a solution (19)** ✓ Contactless service (payment, service) (9) ✓ Explaining the benefits of the 3D printer (4) ✓ Dissemination of use (2) ✓ Health protection ✓ Delivery service to the address ✓ Food savings ✓ Product variety
2.2. 3D printer can't be the solution	**3D printer can't be a solution (8)** ✓ Contact in the service, payment (3) ✓ Additional cost required (2) ✓ Not giving up on the tradition ✓ Preferring natural products ✓ Not enough variety of products

Source: own elaboration.

In Table 3, 70% (19) of the codings are in the sub-theme *3d printer can be a solution*. In this sub-theme, it is stated that, to use 3D printers in the food and beverage industry, the health benefits, such as contactless service, should be explained to consumers. 30% (8) of the codings are in sub-theme 3: the 3D printer cannot be a solution. In this sub-theme, expressions such as 'contact in the service,' 'additional cost required,' and 'not giving up on the tradition' are cited as reasons for this situation.

P2: Although it is possible to prepare food contactlessly with 3D printing, the risk of infection does not only come from the food itself. A fully contactless system is not achievable. Even if food is prepared using 3D technology, contact remains necessary in the service area, and it is unavoidable in payment and other areas. With 3D printing, only food preparation can be contactless, but it is not a complete solution. Additionally, it is not very practical for businesses to switch to this system, which would introduce new costs, especially when they are already struggling to cover their expenses during this difficult period. Furthermore, the fact that it is made solely with 3D technology does not provide clear reasons to prefer it.

P8: It can definitely increase, especially now when the use of contactless credit cards has risen significantly. Food and beverage businesses can accept payments through the online platform they develop and deliver directly to the provided address, without any contact with the consumer. For example, the project carried out by the X brand can be reviewed, and its integration into food and beverage businesses can be confirmed.

P18: It can definitely increase. Millions of people have to eat out because of work and private life. These individuals will likely prefer consumer products made with 3D printers over traditional foods during the pandemic. For example, a 3D-printed hamburger. Since it is a contactless production process, it can be chosen with confidence and quickly meet the person's needs.

Table 4. Participant Opinions Regarding Preferring 3D Food Printers After the Pandemic.

Theme 3 - Preferring 3D Food Printers After the Pandemic (21)	
Sub Themes	**Codes**
3.1. I prefer after the pandemic	I prefer after the pandemic (16) ✓ Hygienic and contactless (5) ✓ If becomes widespread (3) ✓ Benefit to pandemic (2) ✓ Different designs (adult, child) (2) ✓ Cost-effectiveness (2) ✓ Enrichment of nutritional value ✓ Taste standardization
3.2. I don't prefer after the pandemic	I don't prefer after the pandemic (5) ✓ Traditional priority (3) ✓ Believing in hand taste ✓ Everyone has different tastes

Source: own elaboration.

In Table 4, 76% (16) of the codings are in the sub-theme I prefer after the pandemic. In this sub-theme, there are expressions of spreading the 3D printer, being hygienic and contactless, and creating different designs. 24% (5) of the codings are in the sub-theme I do not prefer after the pandemic. In this sub-theme, expressions include 'this tradition is a priority' and 'hand taste is important'.

P6: I *always prefer a product that allows me to achieve the design I want. Eating 3D cube hamburgers or spherical pizza, especially pastry and fast-food items, could be enjoyable.*

P9: Hygiene is very important to me. Actually, I pay close attention to how clean service providers and the business environment are. I prefer higher standards of hygiene. These printers will also influence the perceived quality of food and beverages. Because when I return to a place where I like the food, not being able to taste it the same way makes me unhappy. That's why I choose businesses that provide this service.

P14: Yes, I do prefer. I would have tasted and tried innovations I had not experienced before in terms of shape and taste. Presenting the composition of nutritious items in different ways may also attract children's attention.

Table 5. Participant Opinions Regarding the Effect of 3D Printers on Traditional Food Culture

Theme 4 – Affection of Traditional Food Culture (24)	
Sub Themes	**Codes**
4.1. It affects food culture	**It affects food culture (14)** ✓ Constantly changing culture (6) ✓ Good taste ratio (3) ✓ Contribution to traditional culture (2) ✓ Rapid adoption of innovation (2) ✓ Simplifying local dishes
4.2. It doesn't affect food culture	**It doesn't affect food culture (10)** ✓ Taste is important, not shape (5) ✓ Creating only a niche market (3) ✓ Not all food prepared (2)

Source: own elaboration.

In Table 5, 58% (14) of the codings are in the sub-theme 'it affects the food culture'. In this sub-theme, expressions indicate that the culture is constantly changing, that the taste ratio is good, and that it contributes to traditional culture. 42% (10) of the codings are in the sub-theme that does not affect the food culture. In this sub-theme, some expressions emphasize that taste is more important than shape and that it creates a niche market that appeals only to specific segments.

P7: Yes, it will change, but it cannot taste the same when traditional dishes are prepared with 3D food printers (contactless service). Because in our society, there is a hidden secret called "hand taste". No machine device can have that similar flavour. For example, there is a meat grinder, but the most delicious kebabs are made with ground meat.

P10: This is already one of the most basic, most powerful, and prominent features of 3D printers. 3D printers make it easy to produce complex geometric shapes that cannot be produced using standard production processes. This will not adversely affect the traditional food culture.

On the contrary, cooks, experts, dietitians, and artists interested in food will benefit from this. The production of the most basic dishes (juicy dishes, meat and vegetable dishes, types of bread, etc.) that reflect Turkish culture in a fast and wasteless way, and the design of new forms and shapes, may help introduce our Turkish dishes to the world.

P13: It will cause change because the years have shown that. Every innovation that comes in opens the door to change. Revealing some traditional aspects that are difficult to prepare with human features will be possible with 3D printers, as this will be valuable. I think that by preserving the traditional food culture, unnoticed new aspects will emerge with 3D printers. With this technology, ingredient ratios, which play an important role in taste, can be better

adjusted, and flavour and other properties will be more stable.

Table 6. Participant Opinions Regarding Advantages and Disadvantages of 3D Printers

Theme 5 – Advantages and Disadvantages of 3D Printers (54)	
Sub Themes	**Codes**
5.1. Advantages	Advantages (30) ✓ Hygienic/contactless production (14) ✓ Waste and cost reduction (5) ✓ Timing and competitive advantage (4) ✓ Increase in product sales (4) ✓ Visual design (2) ✓ technology-oriented development
5.2. Disadvantages	Disadvantages (24) ✓ High cost (7) ✓ Reducing employment (5) ✓ Reaction of the traditional (5) ✓ Lack of flavor (3) ✓ Infection risk in a closed environment ✓ Less food variety ✓ Inability of watching the production ✓ Loss of intimacy

Source: own elaboration.

In Table 6, 55% (30) of the codings are in the advantages sub-theme. In this sub-theme; there are expressions such as hygienic and contactless production, preventing waste and cost, providing time and competitive advantage. 45% (24) of the codings are in the Disadvantages sub-theme. In this sub-theme, high cost, reduced employment, and traditional reaction expressions are included.

P2: As an advantage, it can increase the preferability of businesses, provide prestige and sell more products in the short term with good advertising. However, in order to make this permanent, businesses must find alternative components and diversify their services. The disadvantage would definitely be the cost. In addition, employment in production will be negatively affected, and unemployment will increase.

P10: Advantages: it can help businesses overcome financial difficulties; flatten the demand curve; untouched food preparation can reduce people's perceived risk of the virus; the ability to produce and deliver to customers' locations if 3D printers are portable; fast delivery; personalized product availability; zero waste. Disadvantages: people's lack of knowledge about 3d printers, people see food production from 3D printers as unhealthy, 3d printers are still not suitable for every business in terms of cost and size, the possibility of producing products more expensive than other products

P18: One of the most important advantages is absolutely contactless production. In addition, saving time and space is also an important factor. However, due to this advanced technology, the need for personnel in the workplace may decrease, leading to unemployment. In addition, the cost issue is important because 3D printers can be expensive.

In Table 7, 63% of the codes (14) are in the sub-theme that can solve food problems. In this sub-theme, there are statements that it prevents biodiversity and that it contributes to the production process. 37% (8) of the codings are in the sub-theme that cannot solve food problems. In this sub-theme, technological expressions reduce the required trust in Government policy, increasing the use of food colouring and obliging humanity to include companies.

Table 7. Participant Opinions Regarding 3D Printers as a Solution to the Food Problems.

Theme 6 – Solution of the Food Problems (22)	
Sub Themes	**Codes**
6.1. It can solve food problems	It can solve food problems (14) ✓ Sustainable and safe food (9) ✓ Prevention of biodiversity loss (3) ✓ Contribution to the production process (2)
6.2. It can't solve food problems	It can't solve food problems (8) ✓ Technology reduces trust (2) ✓ Government policy required ✓ Increasing use of food coloring ✓ First, fair food distribution is necessary ✓ Only in developed countries ✓ Obliging humanity to companies ✓ Organic product is required

Source: own elaboration.

P2: I do not agree with that. The more technology gets into your business, the more insecurity will increase. The use of products such as food dyes will increase, and perhaps so will health problems. My thinking in this way may also be related to my being unconventional and open to innovation, or to my lack of knowledge of the 3D system. I have less confidence in food production this way.

P6: Sustainable food is one of the most important solutions sought today. In particular, the widespread use of a technology product that can make significant contributions to raw material savings will be an important development in this regard. The issue of food insecurity, on the other hand, will be resolved on its own with the continuation of the process.

P8: It will be a solution to the sensitivity and insecurity towards food, especially after the pandemic and the question marks in people's minds. Although we cannot say for sure whether sustainability can be achieved, we can note that it is possible, depending on the course of the pandemic.

5 FINAL CONSIDERATIONS

With the emergence of the virus in China, the Chinese Government closed food and beverage businesses, and as the virus spread, all other countries followed suit (Sürme, 2020: p. 23). With the measures taken after the COVID-19 pandemic, the social distancing obligation has negatively affected the tourism and food and beverage sector (McKinsey & Company, 2020). Country administrations and tourism businesses are developing various methods to help the tourism sector emerge from the pandemic with the least damage (Sürme, 2020, p. 86).

After this worldwide pandemic, it has been observed that consumer behaviour has changed, and they are more careful about what they eat and drink. Additionally, it has been observed that consumers are more cautious about eating outside the home due to concerns about viral infection (Sürme, 2020: p. 24). According to research on the future of

the food and beverage industry after the Covid-19 pandemic, hygiene is expected to return to the forefront as interest in healthy foods grows (Bucak & Yiğit, 2020, p. 7).

In this context, both food and beverage businesses and consumers have begun to benefit more from technology. While it is still too early to know precisely what the food and beverage industry will look like once the COVID-19 lockdowns are over, it is thought that the use of technology to manage this pandemic will continue in various forms (Zeng et al., 2020, p. 725). 3D food printers can be of interest and reliable in this regard. It is seen that the studies on 3D food printers continue, and the potential for progress is high. It is expected that the use of products printed with these new technologies will increase in the food and beverage industry (Candoğan & Bulut, 2021, p. 162).

This research aims to reveal changes in consumers' eating and drinking habits after the COVID-19 pandemic and to offer solutions to the negative impacts arising from the fear of virus infection in the food and beverage industry. With technological advances, the food and beverage industry has seen significant changes. Given the importance of contactless contact during the Covid-19 pandemic, it is thought that printing food with a 3D food printer without touching will be a solution to the problems faced in the sector.

In this context, secondary data that will serve as the background for the field research were obtained through a literature review. The primary data for this research were obtained through face-to-face interviews with 19 participants, of whom more than half were academics in the field of tourism. The obtained data were analyzed with content and descriptive analysis methods.

According to the results, it was revealed that most of the participants (88%) changed their eating and drinking habits. People who ate outside the home before prefer places they believe are hygienic for meal preparation (kitchens), and they are afraid of crowded tables during the pandemic.

Food and beverage businesses that experienced a decrease in preference rates during the period can increase them by using 3D food printers (contactless service). To achieve this, businesses must first develop their marketing activities within the framework of the “Attitude development” concept in sociology. This concept means that people mostly avoid what they do not know and change their habits if they are sure.

Habits (including buying) can be changed through planned efforts to change people's attitudes. Within the scope of the research, a result supporting this concept has been reached. A majority of participants (70%) stated that these printers would be a solution to the demand problem in the food and beverage industry if their benefits were adequately explained and communicated.

For this reason, if society is sufficiently informed about the benefits of 3D printers, their usage rates can be increased and their prevalence achieved day by day. Since COVID-19 is a disease transmitted from person to person, the fewer contacts there are in this chain, the less it will spread. Knowing this, people, of course, prefer a use where there are healthier 3D printers and no human contact.

At this point, businesses should promote this technology using different marketing channels. In this way, it is necessary to convince the consumers that the meals are prepared very healthily with this technology. Likewise, Long and Khoi (2020) found that there is a direct relationship between the risk perception of consumers and the tendency to stockpile in their study in Vietnam during the COVID-19 pandemic.

It has been determined that there is a significant increase in the rate of eating at home, with consumers preferring to have food prepared more hygienically rather than eating outdoors due to the fear of infection (Long & Khoi, 2020).

A significant portion of the participants (76%) stated that they would prefer 3D food printers even after the pandemic. This result suggests that if such a printer were to become widespread in the sector, there would likely be strong demand. The pandemic showed us what a healthy environment should look like, how much contactless service is needed, and that contactless could be a solution to the demand problem faced by the food and beverage industry. In addition to this benefit to the sector, it is of great importance to increase the use of healthy technologies with less human contact and a low infection rate to avoid pandemics like this and future spread.

Thus, the sustainability of the food and beverage industry can be ensured thanks to these more widely used technologies. Similarly, in Richards and Rickard's (2020) study, demand for food sold online has increased because consumers have begun to avoid contact with others due to the risk of infection, and access to sales points has become difficult. For example, while 1.5% of foodstuffs were sold online in Canada before the pandemic, this rate increased to 9% by the third week of March after the pandemic. This shows the importance of technology for the sustainability of the food and beverage industry (Richards & Rickard, 2020).

The concept of culture is a variable influenced by many factors, such as geography, economy, technological developments, wars, and religion. Therefore, changes in food culture are inevitable. More than half of the participants (% 58%) answered positively to the question about the effect of 3D printers on traditional food culture.

In other words, 3D printers may have the potential to be seen and accepted as part of culture. Traditional food culture can be generalized through 3D food printers. Using 3D, the traditional product can become more accessible. For this printer to become more preferable, promotional and public relations activities should be carried out across all segments of society through multiple channels, using a holistic marketing approach.

The 3D food printer has both advantages and disadvantages. While 55% of participants mentioned advantages of 3D printers, such as hygienic and contactless production, reduced waste and costs, timing and competitive advantage, and increased product sales, 45% stated that they have disadvantages, such as reduced employment, resistance from traditional people, and a lack of taste.

As it will be a healthier service to prepare food to the desired time, shape, form, and size using 3D printers, it could increase demand in the food sector. Since it reduces human error, it can make service times more precise and yield fewer defective products. It can reduce personnel costs, which cover the extra expenses of businesses, such as insurance and personnel salaries. In addition to these advantages, it

may be difficult for traditionalists who are not open to innovation to make a choice.

The purchase and maintenance costs of 3D printers can be high, and qualified personnel with hardware knowledge of this new technology may be needed. This may lead to a decrease in employment and an increase in unemployment in the food sector, which is labour-intensive. Likewise, Tomašević et al. (2021) stated that 3D food printers save time and energy, can extend the shelf life and nutritional value of foods, and have advantages such as sustainability and personalized, reproducible food production. In addition, Liu et al. (2017) noted that they have disadvantages, including low production capacity, the inability to cook simultaneously with printing, and high prices.

According to the research, 3D food printers can be a solution to some food problems, which are among the most important issues of today, as well as to reviving the food and beverage industry. The majority of participants (68%) stated that 3D printing will not only revive the food and beverage industry but also solve problems in today's food system. They stated that they would provide benefits such as sustainable, reliable food, prevent biodiversity loss, and contribute to food production.

3D printers can reduce food insecurity by producing clean, healthy food. Since they have programmable, measurable features, they can help prevent waste and biodiversity loss by providing concrete data for predictions and evaluations. Consumers adopt anything they find clean and healthy. Therefore, it can contribute to sustainability. Likewise, Yang et al. (2017) thought that the use of 3D food printers would reduce food and water waste, save energy and time, and thus contribute to sustainable development (Yang et al., 2017).

5.1 Suggestions

Based on the research results, suggestions were made to the industry, consumers, and future researchers in academia.

1.A 3D food printer can be preferred by individuals who prefer the special or perfect design in food. It can be preferred by everyone for presenting different dishes on the plate (especially in molecular gastronomy) and for designing new-generation food products (cakes, chocolates, confectionery, etc.).

2.The dishes and desserts of the traditional food culture do not have a certain standard. With the 3D printer, product presentation can be achieved with consistent visual consistency across the country.

3.By expanding the scope of the research, the subject can be examined in depth by conducting quantitative research for consumers to investigate the applicability of 3D food printing technology to other sectors in the field of tourism.

4.According to the research, the eating and drinking habits of most of the participants (88%) have changed, and hygienic preparation of meals (kitchen) is preferred more than eating outside the home due to being afraid of the virus infection. More in-depth research can be conducted on consumers to reveal what changes have occurred in their eating and drinking habits.

This study has some limitations. Due to the limited scientific research on this subject before, it was conducted in a single region using interviews, a qualitative research method. The data for this research were obtained from 19 participants, most of whom are academicians in the field of tourism, live in Düzce, have a habit of eating out, and have knowledge of the tourism sector.

Therefore, this study is limited to Düzce. The data analyzed is limited to the data collected in January and February 2022. Despite these limitations, this research is among the few studies in the literature on the use of 3D printers to address food industry and global food problems.

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CRediT author statement

Term	Definition	Author 1	A2	A3
Conceptualization	Ideas; formulation or evolution of overarching research goals and aims	x	x	x
Methodology	Development or design of methodology; creation of models	x	x	
Software	Programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components	x		
Validation	Verification, whether as a part of the activity or separate, of the overall replication/ reproducibility of results/experiments and other research outputs	x		
Formal analysis	Application of statistical, mathematical, computational, or other formal techniques to analyze or synthesize study data	x		
Investigation	Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection	x	x	x
Resources	Provision of study materials, reagents, materials, patients, laboratory samples, animals, instrumentation, computing resources, or other analysis tools	x		
Data Curation	Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later reuse	x		
Writing - Original Draft	Preparation, creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation)	x		x
Writing - Review & Editing	Preparation, creation and/or presentation of the published work by those from the original research group, specifically critical review, commentary or revision – including pre-or post-publication stages	x		x
Visualization	Preparation, creation and/or presentation of the published work, specifically visualization/ data presentation	x		
Supervision	Oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team	x	x	
Project administration	Management and coordination responsibility for the research activity planning and execution	x	x	
Funding acquisition	Acquisition of the financial support for the project leading to this publication			

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Processo Editorial / Editorial Process / Proceso Editorial
Editor Chefe / Editor-in-chief / Editor Jefe: PhD Thiago D. Pimentel (UFJF).
Recebido / Received / Recibido: 21.09.2025; Revisado / Revised / Revisado: 02.11.2025; Aprovado / Approved / Aprobado: 19.03.2026; Publicado / Published / Publicado: 15.04.2025.
Artigo ressubmetido / Resubmitted paper/ Artículo reenviado.
Documento revisado às cegas por pares / Double-blind peer review paper / Documento revisado por pares ciegos.