Design Recommendations for Novel Food Experiencing Artifacts and Interactions

by

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KOÇ ÜNİVERSİTESİ

Design Recommendations for Novel Food Experiencing Artifacts and Interactions

Koç University

Graduate School of Social Sciences and Humanities

This is to certify that I have examined this copy of a doctoral dissertation by

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and have found that it is complete and satisfactory in all respects, and that any and all revisions required by the final examining committee have been made.

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25.09.2024

To my family

How to read this dissertation

This thesis is in the Collection of Papers format, with five publications (two published, one accepted, two in submission). These publications are referred to in the relevant chapters and are added to the manuscript.

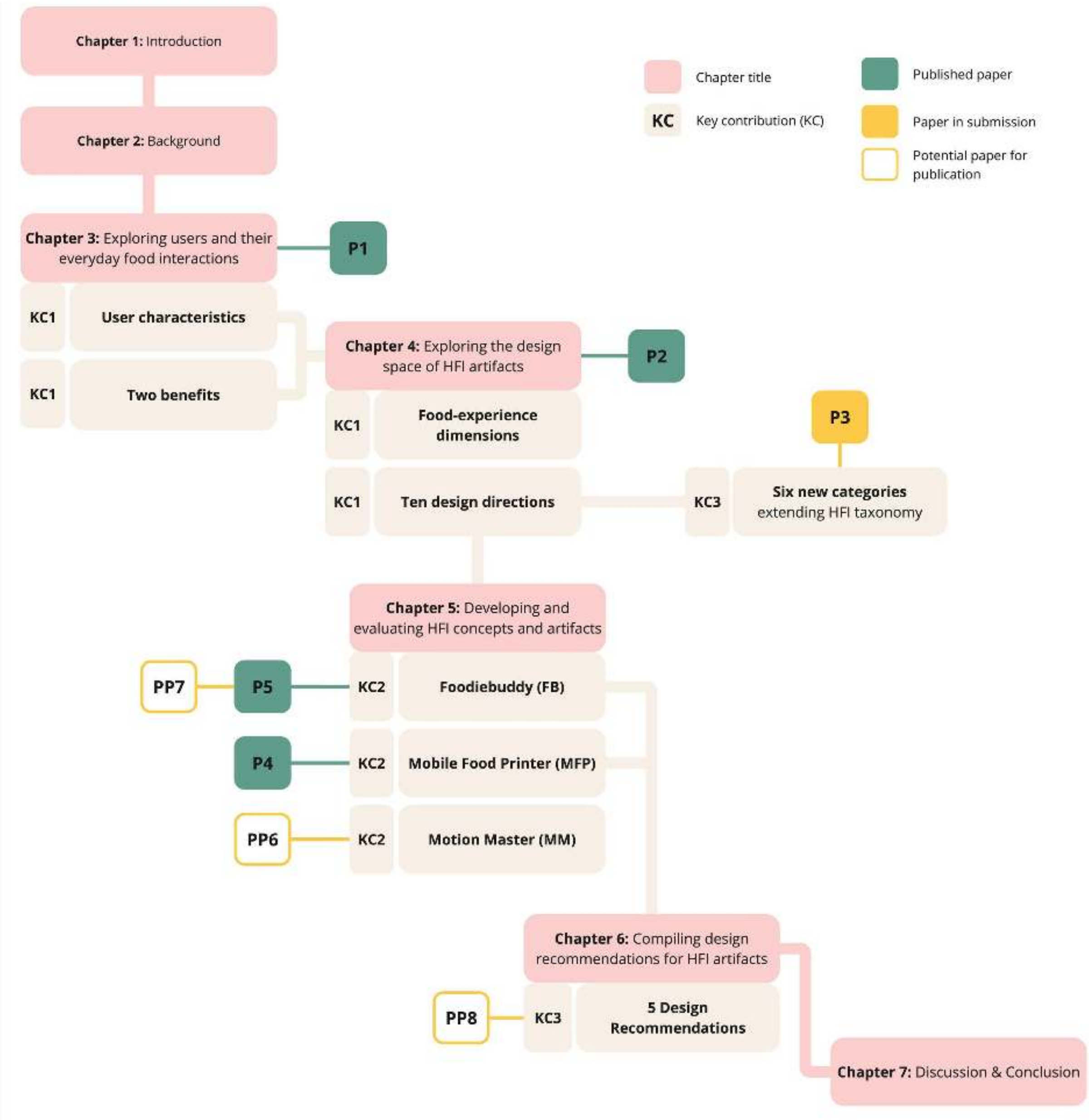

Figure 1: Dissertation outline.

ABSTRACT

Design Recommendations for Novel Food Experiencing

Artifacts and Interactions

Doctor of Philosophy in Design, Technology and Society

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This thesis presents doctoral research into exploring *design recommendations for novel food-experiencing devices and interactions.* Despite multiple studies that unravel the potentials in the unique and multifaceted nature of human-food relations, technology design studies mostly lean into techno-solutionist devices. This approach is reductive and eliminates the social, personal, cultural and traditional methods of food making, limiting the extent to which the device designs might address. In this trajectory, we delved into designing devices considering the multidimensional values weaved into everyday food interactions. This study addresses the following research question: *"What insights can we gain for design research and practice through designing human-food interactions that support everyday food experiences?"* With this study, we aim to reach *Design recommendations (KC3)* that will guide future HFI innovations through designing *food-experiencing artifacts (KC2*) based on *user insights (KC1).* We adopt Research Through Design (RtD) methodology and use design inquiry to build research objects that reframe the research as it progresses. The design knowledge collected manifests itself in the form of three conceptual prototypes namely "Mobile Food Printer", "Foodiebuddy" and "Motion Master". In the end, this inquiry resulted in five design recommendations each addressing a different topic in HFI artifact designs: *(1) limits and boundaries of taste, (2) bodily food-experience activities, (3) sharing activities around food, (4) spatial elements that complete food experience and (5) the utility and pleasure tradeoff.* The design recommendations spark inspiration for future design researchers by showing how to work with different stakeholders in discovering new aspects of a context. They also shed light on design practice and demonstrate how to incorporate users into the design process.

Keywords: Food-experiencing artifacts; Design for food interactions

ÖZETÇE

Yeni Yiyecek Teknolojileri ve Etkileşimleri için Tasarım Önerileri

Yağmur Kocaman

Tasarım, Teknoloji ve Toplum, Doktora

Eylül 25, 2024

Bu tezde, yeni gıda deneyimleme cihazları ve etkileşimleri tasarlanması için tasarım önerileri keşfetmeye yönelik doktora araştırmasıdır. Bu alanda insan-gıda ilişkilerinin benzersiz ve çok yönlü doğasını ortaya koyan çokça çalışma olmasına rağmen, teknoloji tasarımları bu bilgileri ihmal etmekte ve tekno-çözümcü yaklaşımla cihazlar tasarlamaktadır. Bu yaklaşım indirgeyicidir ve gıda etkileşimlerinin bireysel, sosyal, kültürel ve geleneksel yöntemleri ile olan ilişkiyi zayıflatarak cihaz tasarımlarının kapsamını sınırlamaktadır. Bu çerçevede biz de gıda ile etkileşimin çok yönlü değerlerinin cihaz tasarımlarına dönüştürülmesine odaklandık. Söz konusu çalışma, *insan-gıda etkileşimleri tasarımı yoluyla gündelik gıda etkileşimlerini destekleyen nasıl bilgiler elde edebiliriz?* sorusuna cevap aramaktadır. Bu çalışmayla, (KC1) kullanıcı içgörüleri ve (KC2) yeme deneyimi cihazları tasarımlarından temel alan tasarım önerileri (KC3) elde etmeyi hedeflemektedir. Tasarım yoluyla araştırma metodunu izlediğimiz bu araştırmada ürettiğimiz objeleri, araştırma sorumuzu sürekli olarak dönüşüme uğratan birer araştırma nesnesi olarak ele aldık. Kullanıcı verisine dayalı olarak tasarladığımız "Mobile Food Printer" ve "Foodiebuddy" konsept prototiplerini kullanıcılara sunarak elde ettiğimiz içgörüler bu çalışmanın ana kemiğini oluşturmaktadır. Araştırmanın sonunda beş tasarım önerisi çıkmıştır: *(1) tat sınırları ve limitleri, (2) fiziksel yeme deneyimi aktiviteleri, (3) yemek paylaşma aktiviteleri, (4) yeme deneyimini tamamlayan çevresel faktörler ve (5) fayda-zevk dengesi.* Elde ettiğimiz bu öneriler, gelecek araştırmacılara bir tasarım objelerinin farklı bağlamlarda ortaya çıkarabileceği bilgileri gösterme konusunda ışık tutmuştur. Aynı zamanda tasarım pratisyenlerine de kullanıcı verisini nasıl tasarım sürecinde kullanabileceklerinin bir örneğini göstermiş olduk.

Anahtar kelimeler: Dijital gıda deneyimleme cihazları; Yiyecek etkileşimleri tasarımı

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At the core of this journey, I had the privilege of working with my thesis committee members, Fatoş Gökşen, Marianna Obrist, Aykut Coşkun, and Ahmet Börütecene. This work has improved greatly thanks to your guidance and enriching critiques. Fatoş hocam, thank you for insightful discussions on grounding design research, which expanded my perspective and helped me communicate my findings to a broader scientific audience. Marianna, I am grateful for your belief in my work and your constructive, nurturing approach to fostering my growth as a researcher. Ahmet, your kindness and openness to dialogue are unparalleled—thank you for your approachable and optimistic outlook on my research. Aykut hocam, your spot is reserved with me. Your contribution to my work, both formally and informally, has immensely helped me grow as a researcher. Your guidance and support have been a pillar of strength for me, especially towards the end.

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ABBREVIATIONS

3DFP	3D Food Printer
HCI	Human-Computer Interaction
HFI	Human Food Interaction
RtD	Research through Design

GLOSSARY OF TERMS

User Insights: Indicates knowledge collected from users.

Design Insights: Indicates knowledge collected from designers.

Human-Food Interactions: A sub-field of Human-Computer Interaction (HCI) umbrella. The research scope spans investigating interactions between humans and food materials and aims to build technologies to improve life in many ways. Despite being a relatively new field of study, it is highly populated, and recent research maps the current state of the field that forms a taxonomy [3, 22].

Design implications: Design knowledge obtained by using explorative design methods (e.g., ideation workshops) that yield multiple unfinished design concepts. In this thesis, design implications are presented as an annotated portfolio of designer sketches [34, 58], which do not offer definitive designs but suggest patterns and themes for future ideation, hence, is a form of intermediate-level knowledge [58].

Design considerations: Designer's take on designing artifacts by interpreting user data. Also includes design knowledge resulting from the interpretation and criticism of the designer's ideas by the user. May consist of information about design decisions, materials, dimensions, or conceptual tendencies.

Design recommendations: Design knowledge obtained by presenting data from both the user and the designer on a systematic basis (e.g., list, table) supported by examples.

Chapter 1

INTRODUCTION

This dissertation aims to provide design recommendations discovered through designing food-experiencing artifacts that support everyday food interactions. Building novel platforms to endorse new ways of experiencing food has been gaining traction in the field of Human-Food Interaction. However, the design knowledge in this field is still vastly underexplored. Despite the numerous technologies materialized within the scope of this field, further work is needed to develop design knowledge systematically. Based on this motivation, this thesis focuses on forming an intermediate level of design knowledge that is formulated by closely working with users and designers.

The following sections of this chapter outline the research rationale, continued by the research questions and key contributions. The chapter concludes with an overview of the research approach and the research methodology.

Research Rationale

Food is a multifaceted notion that forms the source of all life and brings individuals together in making and sharing activities. It is experienced every day with nearly no exception and is integral to many contexts, from home to work and social life. The earliest kitchen tools were aimed at minimizing the effort spent on food-related tasks. Manual tools such as the popular hand-powered egg beater were adopted for manipulating ingredients by putting less energy into the task [77]. Electricity entered homes in the early 20th century and efficiently continued to minimize the human power required for food-related tasks. Hand-powered machines were quickly replaced with electric-powered versions (e.g., electric cookers, kettles, toasters, dishwashers) [30]. Today, even after the developments of digital technologies, many kitchen technologies still mainly focus on improving the functionality of food-related activities (eating, sourcing, disposing, preparing) [3]. This is evident in the example devices on the market today, which mainly provide affordances such as easing cooking tasks and reducing the steps required for achieving a more nutritious diet [6, 17, 68].

Scholars critique this design approach as reductive and techno-solutionist, as it deprives cooking skills of improving and 'alienates' food [54]. As a consequence of diminishing tacit knowledge, food interactions end up being detached from secondary meanings [26, 31, 66]. These meanings are attributed to personal, social, cultural, and traditional values and are essential to defining one's relationship with food [3]. The secondary meanings of food have been more valued in the twentieth century, and this attention formed the basis of fascination for food [31]. Food is no longer consumed for survival, but it can take new forms to create memorable experiences. In response, HFI research innovated numerous ways to introduce new foods and food interactions to enhance everyday life [9]. Some system designs focus on making personalized foods [38], and others focus on kindling social interactions by leveraging playful [4, 21] or intimate social interactions [36].

These projects offer a fresh look into designing artifacts and clearly demonstrate the potential impact of addressing food's secondary meanings to enhance everyday life. This thesis aligns with these research endeavors, advocating a departure from the techno-solutionist approach yet acknowledge the benefits of advanced technological developments. The aim is to align the technology design with the secondary meanings of food and improve their potential positive impact on everyday life.

Designing *food-experiencing artifacts* involves unique considerations due to the intimate and multisensory nature of food. Food is experienced by body not only as nourishment but also through all the senses—smell, sight, taste, touch, and sound [82]. This multisensory engagement distinguishes *food-experiencing artifacts* from other technological artifacts, offering an opportunity to redefine human relationships with food, their social circles, and the surrounding environment. We argue that extracting values from the current settings in everyday life and embedding them into the design of food-experiencing artifacts would reveal *new ways of interacting with food.*

This outlook into device design presses on the importance food neophobia and food technology neophobia. These terms reflect one's general aversion of new foods and foods produced by new technologies [19]. As social psychologists put it, there is decreasing food neophobia in today's societies, and the perception of new foods is changing [31]. It is also possible to reduce food technology neophobia by developing clear communication strategies [15]. Despite being a common concept among food scientists, there is a lack of systematic design knowledge that provide guidance for how to design food-experiencing artifacts and tackle the novelties encountered in food interactions.

From this perspective, this thesis delves into designing devices and producing design knowledge considering the values extracted from everyday food interactions. To address this gap, we adopt Research Through Design (RtD). This method focuses on designing artifacts and using them to open discussions with relevant stakeholders [70, 86]. This process may reveal technical opportunities, create new situations or practices for design researchers, or reveal design patterns [70]. Under this motivation, we aim to develop design knowledge in the form of design recommendations for food-experiencing artifacts and interactions that support everyday experiences.

Research Question and Key Contributions

Under the foretold rationale, this research aims to reach design recommendations through developing new food artifacts and interactions that support everyday food experiences by following the Research Through Design (RtD) approach. With the lens of the employed methodology, we reflected on and reformulated the research question at each stage of the research until it reached its final form: *"What insights can we gain for design research and practice through designing human-food interactions that support everyday food experiences?"*

To deconstruct and explore the components of this question in steps, we formulated sub-research questions along the way. The sub-research questions helped guide each stage of research and are disclosed in the related chapters. With this inquiry, we expect to reach the following key contributions: *Design recommendations (KC3)* that will guide future HFI innovations through designing *food-experiencing artifacts (KC2*) based on *user insights (KC1).* The key contributions are the main outcomes that provide insights into the main research question and are formulated to inform HFI research and practice.

(KC1) User Insights

User insights are the type of knowledge we aim to gather through explorative user surveys and interviews. They explain users' relations with food, tools, people, and information but do not reflect direct design knowledge. In the first two stages of this research, we conducted desktop research for user insights into novel food technologies. Our initial focus was on 3D Food Printing (3DFP) technology as it is timely because of its early developmental stage and potential. Inspired by the technology adoption studies in 3DFP literature, we implemented a relevant scale to our inquiry and identified users based on their Food Technology Neophobia [15, 38]. In the earliest stages of our user inquiry, we implemented the findings from relevant research and collected data from the local context to increase the reliability of our results [19]. In addition to quantitatively describing users, we elaborated user insights with qualitative inquiries that deepened our understanding. Adding to the insights collected with surveys, we collected in-depth data through semi-structured interviews as food's cultured nature urged us to explore possibilities in situ [26]. To achieve this key contribution, we dedicated the first step of our research (**Chapter 4 – Step 1**).

(KC2) Food experiencing artifacts

To approach developing design recommendations for future HFI innovations, we started our initial inquiry focusing on a recent technology (i.e., 3D Food Printing (3DFP)). In the earliest steps (e.g., collecting user insights through surveys and interviews) we collected data on prospective uses of 3DFP. However, after we started developing ideas with designers based on user insights, we discovered that the naming limits thinking about potential concepts and, thus the obtained results. This point pivoted our research focus from 3DFP to *food-experiencing artifacts* in a more general sense. For an in-depth study of technologies that mediate human-food interactions, we reframed our scope towards the theory of affordances [40]. Based on our understanding of what 3DFP devices *offer* and *provide* the animal, we reach the conclusion that they are *technologies that allow food interactions in any context*. For this reason, we switched our adopted terminology to *food-experiencing artifacts.* This framing helped us in the ideation process while developing three concept demonstrations (i.e., prototypes) in varying fidelities. To explain, naming our objects of inquiry as *food-experiencing artifacts* instead of a particular technology (e.g., 3DFP) allowed us to draw on the knowledge base of technologies from external domains beyond food (e.g., games, personal mobile gadgets) (Figure 2).

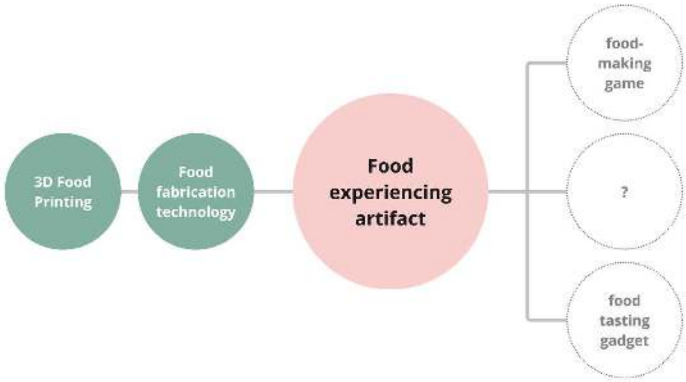


Figure 2: Changes in the naming of artifacts throughout the Ph.D. journey

From this lens, this thesis aims to produce *food-experiencing artifacts* that primarily considers user insights and design insights and builds on the knowledge base available in the HFI literature and the peripheral technology domains.

The *food-experiencing artifacts* we generated in this thesis are treated as design probes that initiate discussions for possible food futures [20]. In Mattelmaki's definition, design probes are a means of collecting self-reported data regarding users' personal context and perceptions [60]. Design probes mainly focus users' attention on the context and keep a log of various aspects of their everyday life (e.g., social, aesthetic, and cultural environment, needs, feelings, values, and attitudes). We present design probes that initiate users to experiment, express, and reflect on their experience on their food experiences and reveal context-based user and design insights [60].

(KC3) Design recommendations for food-experiencing artifacts

Producing design recommendations is an essential step for developing design guidelines in the future and reaching them is the primary goal of this thesis. Design recommendations are essential for the food and kitchen appliances industries, and human-food interaction (HFI) research is needed to pave the way for new food-experiencing artifacts and interactions. In this thesis, we aim to reach design recommendations that build a foundation for designing new devices that operate in any context where food is either sourced, stored, produced, cooked, eaten, or disposed of [3]. In our understanding, design recommendations are suggestions for future designs that are rooted in the examples from studies with users and designers.

The design recommendations are generative intermediate level knowledge presented in a systematized (e.g., list or table) format that categorizes suggested solutions and design decisions targeted at specific issues for the design. In that sense, they demonstrate broader implications in various other fields by making design proposals for personal, architectural, structural, social, remote interactions, or material experimentations.

We also provide a strong concept for conceptualizing the design recommendations further and discuss the overarching theme that ties together the initial research aims and the outcomes [47]. Strong concepts are pieces of generative knowledge, that are solution-oriented yet reside on an abstraction level in-between instances and theory [47]. Both the strong concept and the design recommendations represent specific applicable design knowledge with no claim of universality and represent intermediary level knowledge that serves generative purposes [47].

Aim and Scope

To address the foretold rationale and research questions, the main aim in this research is to develop design recommendations for human food interaction (HFI) innovations through designing food-experiencing artifacts and interactions. As indicated above, *Research Through Design (RtD)* will be utilized as our primary approach to reach this aim [86].

One of the definitions to be made in the earlier define & discover phases of RtD research is the concept of user. Research on the theory of adoption suggests that the earlier adopters of a technology could vary greatly based on the contextual variables. This is especially accurate for food technologies as food differs from other materials due to its natural and intimate relationship with the human body. Studying food is especially complex because of its varying crucial roles in everyday life. The roles of food range from but are not limited to being a mediator for social occasions or being a determinant for mental and physical health. For this reason, we chose to reach users in the domestic context in the initial phases, as they are one of the most widely used user bases and are more accessible as study participants. As the research proceeded and the contexts were specified with conceptual prototypes, we reframed our target base and reached users specific to the target context. (For the user studies of Foodiebuddy, we reached travelers, and for Mobile Food Printer, we reached novice chefs).

Another element we determined in this research was the body of knowledge that is rooted in everyday life (i.e., food experiences and practices). Although it is beyond the scope of this research to map all the practices that occur in everyday food interactions, our findings from the interviews with kitchen users in the earlier phases showed that daily food routines are subjected to constant change depending on various factors. In other words, food practices, routines, and habits are affected by the changes in the context (e.g., occasion, social setting). For this reason, what we refer to as everyday food experience has continuously changed as the research proceeded.

Research Approach

We stress that the above contributions expand the current approach taken for designing artifacts and interactions, which currently focuses on solving problems by offering mainly automation (i.e., techno-solutionism [65, 66]). A sole focus on automation may not be sufficient for addressing all user-related issues and opportunities in future food experiences. As an alternative to this approach, our research follows the iterative nature of RtD and cumulates knowledge throughout the research. From this perspective, this research starts with collecting *user insights* as the first step of the inquiry (Figure 3).

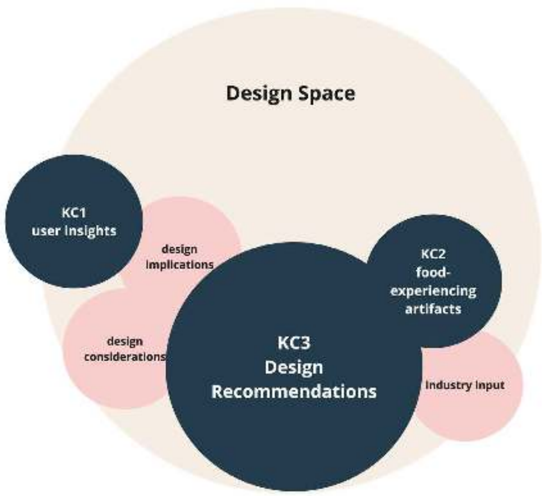


Figure 3: A snapshot of the research approach and Key Contributions (KC).

The *user insights* contribute to illustrating initial *design implications* and are transformed into *design considerations* through in-the-wild research inquiries with artifacts. Using the obtained knowledge as a grounding, we formulate design recommendations for future HFI artifacts and interactions. However, we believe the potential impact of this research does not end with *design recommendations* since this research is conducted in the scope of an industrial Ph.D.

In general, the design recommendations help navigate the potential use cases in contexts related to the HFI field. Moreover, they may also provide meaningful inputs to meet industry needs directly or indirectly. This motivation has the potential to hold two concurrent explorations, which will form the basis for the final steps of this research. By analyzing the design ideas collected along the way, we aim to formulate a *design space*. We finally focus on building a technical knowledge base to translate these findings into industry-related outputs. These two explorations would contribute to building a broader design ecosystem, including but not limited to our case-specific findings.

Research Methodology

As indicated above in the aim section, *Research Through Design (RtD)* will be utilized as our primary approach to reach the aim described above [70, 86]. Although there is not a single definition of RtD, we refer to the research approach structured by Zimmerman and Forlizzi [70]. Based on their description, RtD essentially involves an iterative process that emphasizes empathy with the user. The artifacts used in the RtD approach act as vehicles representing what «ought to be» in their eyes [86]. During the RtD process, the research problem is reframed as needed following the new research curiosities that emerge in the meantime. Figure 1 overviews our journey of conducting this research, which was designed by adopting the RtD methodology. We followed a research approach that started with collecting user insights, arriving at design concepts and speculations, building three conceptual prototypes, deploying two, and reaching design considerations.

Define & Discover

Overall, this research starts by exploring how ‘individuals’ interact with their kitchens and food. The first steps were designed to serve this explorative purpose. We identified potential users of the initial case (i.e., 3DFP) since these users are expected to provide in-depth insights into this emerging technology [38]. First, we conducted a study to gauge the characteristics of the interested users. The results provided six user characteristics (Paper 1 – User Exploration). Along with the user characteristics, this study resulted in two potential benefits of 3DFP for improving everyday food experiences (Paper 1 - User Exploration). After identifying interested users, the next step aimed to develop a deeper understanding of these users' everyday food interactions. Thus, we interviewed interested users (N=19) to obtain initial user insights. Three design themes emerged from analyzing the user insights we derived from the interviews: (1) search for better foods, (2) many agents of kitchen, and

(3) joy of bodily activities (Paper 2 – Design implications).

Synthesize & Construct

The research proceeded by transferring the user-derived knowledge (i.e., user insights) into tangible design ideas. Based on the RtD approach, these tangible ideas serve an explorative purpose to uncover future potentials and reveal key patterns that future research and practice may build upon [34]. By working with interaction and kitchen appliance designers (N=25), we transformed the user insights into ten design implications. The designers melted the user insights for ideation while developing concepts. (Paper 2 – Design implications) This collection of ideas generated by designers also induced another analysis that contributes to extending the design space of food-experiencing artifacts by suggesting six new categories for HFI taxonomy. (Paper 3 – HFI Design Space Extension).

After developing several design instances and implications, the following steps focus on developing conceptual prototypes. Through user evaluation, we also report the discussions and dialogues triggered by these artifacts. Through a final compilation and reflection on the outcomes so far, we aim to reach design recommendations for designing food-experiencing artifacts and interactions that help improve users' lives.

Refine & Reflect

We prioritized the most relevant design implications based on user insights and developed conceptual prototypes and scenarios (Mobile Food Printer, Motion Master, and Foodiebuddy). In the following steps, we used the conceptual prototypes embodying the collected knowledge and explored user evaluations (Paper 4 – MFP in restaurants, Paper 5 – FB in travel and Appendix 1).

This research finalizes by exploring the broader impact and the extensibility of the proposed design recommendations. Concurrent with the prototype development, we explored the technical feasibility of Foodiebuddy and discussed the technical potential for building this as a product based on industry knowledge.

List of Publications

Publications within the thesis scope

Paper 1 – Full research article in journal

Kocaman, Y., Ermiş Mert, A., & Özcan, O. (2022). ***Exploring Users Interested in 3D Food Printing and Their Attitudes: Case of the employees of a kitchen appliance company.*** International Journal of Human–Computer Interaction. https://doi.org/10.1080/10447318.2022.2104835

Paper 2 – Full research paper – conference proceedings

Kocaman, Y., Gözde Kocaman, D., and Özcan, O. (2024***) Discovering design implications for future food experiencing artifacts***, in Gray, C., Ciliotta Chehade, E., Hekkert, P., Forlano, L., Ciuccarelli, P., Lloyd, P. (eds.), *DRS2024: Boston*, 23–28 June, Boston, USA. https://doi.org/10.21606/drs.2024.420

Paper 3 - (In submission)

Kocaman, Y., & Özcan, O. (2025) ***Extending the Human-Food Interaction Taxonomy through Design Speculations.*** – ACM Computer Supported Cooperative Work (CSCW).

Paper 4 - (Accepted - In publication)

Kocaman, Y., Bulut, T. U., & Özcan, O. ***Mobile Food Printing in Professional Kitchens: A design inquiry of potential applications.*** (2024) International Journal of Food Design (EFOOD'24 Proceedings & IJFD Special Issue)

Paper 5 – Extended Abstract (Accepted – In publication)

Kocaman, Y., & Özcan, O. (2025) ***Pick your Foodiebuddy: Travelers' Reflection on a Personal Taste Exploration Gadget.*** International Conference on Tangible, Embedded, and Embodied Interaction (TEI '25). https://doi.org/10.1145/3689050.3706010

Publications outside the thesis scope as research training

Paper 6

İ. Ozan Yıldırım, E. Keskin, Y. Kocaman, M. Kuşcu and O. Özcan, ***From Concept to Implementation: Streamlining Sensor and Actuator Selection for Collaborative Design and Engineering of Interactive Systems***, in *IEEE Sensors Journal*, vol. 24, no. 8, pp. 13259-13278, 15 April15, 2024, https://doi.org/10.1109/JSEN.2024.3373059

Chapter 2

BACKGROUND

Food in Everyday Life

Kitchen, cooking, and food have received much attention from food science research, cultural studies, and technology-oriented research. The existing body of literature in this field spans from ethnographic studies to technological implementations. These studies demonstrate the depth of accounts that relate to food interactions and confirm that it is a wicked problem space [16]. By reviewing the relevant literature, we formed an initial basis to this thesis for understanding the nature of food-experiences.

The multifaceted nature of everyday food interactions

Considering the number of tools, tasks, ingredients, and skills that are part of cooking, we believe cooking at home is a multifaceted notion. Similarly, the cooking tasks also vary, such as frying, boiling, cutting, freezing, and many others. Some of the tools that facilitate the cooking process are measuring cups, pots, pans, knives, stoves, and fridges. Moreover, individuals' responses to the same foods greatly differ in many cases, especially when trying new foods [31]. Food experiences can be considered as a combination of practice, the senses, and memory [81]. Each of these components of food fabrication can be a potential path for future queries on smart kitchen research. Recent research develops a taxonomy by compiling the focus, agency, and domains of recently published work in HFI [3]. Being an initial taxonomy that maps the field, this study confirms the vast landscape of potentials embedded in the multifaceted nature of designing for this context.

Although listing all the user types, social settings, kitchen tools, methods, or recipes that are part of everyday food interactions is beyond the scope of this thesis, we acknowledge the significance of stressing its complex nature.

User types and roles in the domestic kitchen

Adding to the multifaceted nature of everyday food interactions, the user's agency is also a vital component of the everyday kitchen. The kitchen is a space where individuals come together to collaborate or share cooking chores [32]. In terms of user profiles, the domestic kitchen is a gendered and social space as well as a functional workspace [7, 81]. In households where cooking is not shared among members, women perceive the kitchen as a *workspace*, while in households where cooking responsibility is shared, it is not [7]. Moreover, previous research asserts that users do not want future technologies that endanger their roles in the household [18].

Defining the labor processes and skills in the domestic kitchen should be approached differently than those in the professional kitchens. In fact, the kitchen is a multifaceted notion with multiple different possible scenarios. Some concerns of the domestic cooking skills that differentiate it from professional settings can be fitting cooking between other household activities and preparing food to suit a range of tastes and dietary requirements for the household members.

Food-experiencing technologies and their potential impacts on daily life

Since the beginning of time, humankind has been developing tools to support their cooking activities. The first tools that helped cooking were mostly stoneware tools that focused on minimizing the effort to pulverize the hard substances into paste or powder (e.g., mortar and pestle, hand-operated mixers, and whiskers) [78].

After the electricity entered homes, the hand-powered machines were replaced by electric-powered versions. For instance, the first electric mixer was found by Rufus M. Eastman in 1885 [78]. The foundation of electricity could be considered a milestone for kitchen tool development. Today, newly designed kitchen appliances offer a seamless experience with smart appliances that reduce the cooking effort with increased functionality and automation. For instance, Oliver [6] and Cooking Pal [17] are two smart kitchen robots that foster consistent cooking with minimal effort.

As electrical devices evolve and become more widely used, reducing the effort put into manipulating ingredients has no longer been challenging. However, the use of these devices was sometimes so cumbersome that ergonomics emerged as a new problem to be solved. At the same time, the entrance of electrical appliances into homes has led to the emergence of new needs in the home [30, 32]. For instance, designing aesthetic-looking kitchens and devices has become a measure of determining consumers' choices. All these potential problems (i.e., minimizing effort, ergonomics, and aesthetics) have accumulated, forming criteria that should be considered in designing devices. They suggest a more convenient cooking experience even for those who look for quick and easy cooking solutions. 3D Food Printing (3DFP) devices such as the Foodini [68] computerize cooking and bring healthier, personalized meals 'one-click away'. With this characteristic, 3DFP technology is promoted as an extravagant solution that 'magically' eliminates tedious tasks [26]. In this sense, these devices are perceived as able to produce food without the need for human effort.

With the development of digital technologies, the possibilities have increased considerably. Technologies that enter homes can track personal data and offer personalized meals. Today's technologies can encourage users to eat healthier and have the potential to augment, extend, and otherwise challenge the ways we engage with food in everyday life [32].

For instance, it is now possible to cultivate food at home using vertical farming systems such as HECTAR, specifically designed for home kitchens [61]. Such interventions enter the home kitchen thanks to technological developments. These advancements are opening a path for re-examining the ways of cooking in the future and designing appliances for a more desirable future.

Approaches to Device Design in HFI

Techno-solutionism in Device Design and Potential Drawbacks

Techno-solutionism refers to addressing complex problems with quick fixes using technology [65, 66]. Even though the proposed solutions mostly work, applying technological fixes without thoroughly identifying problems causes side effects that may lead to more significant issues than the initial problem [65]. This approach causes technologies like 3DFP to be perceived by potential users as superficial solutions that delineate them from the common knowledge of food-making [26]. The automation focus in 3D food printing (3DFP) design is linked with techno-solutionism [22, 26]. Moreover, quick solutions to the problems in the domestic kitchen do not trigger any behavior change, and their effects are mostly temporary [26]. For instance, to reduce food waste in the kitchen, foodstuffs that are about to be spoiled can be made reusable with the support of 3DFP. However, this method solves the problem for users rather than encouraging positive behaviors such as portion control or buying as much as one can eat. Therefore, in the absence of the device, the problem may re-occur. On this basis, we formulated our research aims which seeks for generating design knowledge for building context-aware HFI innovations.

A Trend in Multi-Sensory Technologies Research

Because 3DFP designs mostly adopt a tech-oriented approach with only a few exceptional studies focusing on creating novel user experiences, they mostly neglect the potential values that such a novel food fabrication technology could offer for everyday life. The clues for potential values that 3DFP could introduce to everyday life can be comprehended better by looking at recent Human-Food Interaction (HFI) research.

One emerging trend in the HFI domain is the potential of creating multisensory experiences with novel technologies [14, 42, 69, 83]. The increasing interest in multisensory human-food interaction (MHFI) lies beneath the potential to trigger people to eat healthier by augmenting their perception of foods and drinks [83]. For instance, Foodfab explores whether modifying the infill pattern of food could change a person’s perception of satiety [57]. Another study suggests a set of design probe kits for exploring novel multisensory experiences [37].

Playful human-food technologies

Another trend in the HFI field focuses on supporting playful experiences with technological interventions [4, 5]. Altarriba Bertran summarizes the three main approaches in the Playful HFI domain: productivity-focused, de-contextualized, and out-of-the-ordinary. They assert that to enrich mealtime with playful interventions, the foretold approaches should be considered limitations that are challenged. A recent example that could be a beginning for challenging this approach would be Devendorf's proposal for device design [24]. According to this study, humans and fabrication machines are in a collaborative relationship. A new freeform machine emerges from this fabrication relationship, a design that guides but does not manage the user, thus leaving room for surprises. In our opinion, more research that will trigger a rethinking of the relationship with machines is valuable for developing future food fabrication technologies. Lastly, recent HFI research asserts the importance of discovering cultural and local knowledge of food while developing novel food technologies [26].

Recent research uncovers a catalog of playful mealtime experiences by presenting an extensive annotated portfolio of cultural eating practices that were found to have the potential to inspire design ideas [2]. A recent study transforms the potential design directions based on futuristic user typologies into tangible design ideation cards [27]. This playful approach to designing food interactions sparks meaningful discussions and reveals enticing concepts.

Other scholars investigated the playful potentials of technologies by building technical platforms that enable new ways of experiencing foods. A previous study investigated the potential of sharing food while eating and built an augmented social eating system that uses wearable robotic arms attached to diners' bodies for eating and feeding food [62]. Others focused on the potential of crafting computational recipes in the presence of novel technologies and explored shape-shifting [64] or *dancing* foods [21] for fostering gamified eating scenarios.

3D Food Printing Case

3D Food Printing (3DFP) is one of the technologies that is shown to have great potential to introduce new ways of experiencing foods in everyday life [38]. Besides this, we find a review on 3DFP technologies is significant for this thesis because this technology is a pressing matter of interest for the kitchen appliance industry. 3DFP is still in early development but developed enough to point to groundbreaking developments in shaping future food interactions [8]. Despite the potential impact of 3DFP on everyday life, current devices focus mainly on automating tasks that minimize effort and precision. Scholars critique this approach as reductive, for it eliminates the cultural and traditional methods of food making [26]. Such techno-solutionism in cooking deprives cooking skills of improving [66], thus detaching users from traditional food-making methods. 3DFP mainly uses edible materials to fabricate food. The technology uses a similar process to 3D printing. The three main methods of 3DFP can be summarized as 1) Additive Manufacturing or Extrusion-based printing, 2) Laser assist printing, and 3) Inkjet printing [72].

Current Approach in 3D Food Printing Device Designs

Several 3DFP device concepts are either initiated as Kickstarter projects (e.g., Foodini [68], Bocusini [12]) or design concepts (e.g., Moléculaire [50], Food Probe by Philips [28]) However, there is not a commercially available product yet that entered the consumer market [72]. When we compared the product designs of the current examples, we observed that they are designed similarly to 3D printing devices. These devices are almost kitchen copies of 3D printers. So far, device design has been mainly focused on extending the technical capabilities by studying device parameters such as increasing the printing speed to reduce production times print speed [53]). Some examples investigate improving the functionalities that enable multi-material printing [46] and printability of materials-based flow behavior [25].

User Perceptions of 3D Food Printing (3DFP)

Recent studies asserted that for a successful acceptance of 3DFP technology, early communication about the technology is crucial for the user's opinion-forming [15, 56]. Some food attributes such as health benefits, natural content, fun, and creativity were also empirically verified as they shape consumers' attitudes towards the technology (Lee et al., 2021). These attributes were found to be associated with both utilitarian and hedonic values.

The acceptability and edibility of 3D-printed food were also associated with the perception of *naturalness*, *familiarity* with the food, and *similarity* to the type of food people are used to eating [59]. The perception of naturalness depends not just on the sources of the ingredients but also on how the ingredients are processed (i.e., 3D printed). It is reported that users perceive foods that are 3D printed as not “real” or “natural” [59]. In line with these results, in another study, users found 3DFP to have a potential impact in extreme cases, for example, emergency aid contexts, emphasizing that they do not perceive 3DFP as a domestic device [38].

Chapter 3

STEP 1: EXPLORING USERS AND THEIR EVERYDAY FOOD INTERACTIONS

This chapter outlines the first research inquiry that we used to explore everyday life in the kitchen. At the beginning of this research, one of the main curiosities that required definition was the target users of food-experiencing technologies and devices. Thus, we first put forth a task to identify a user group that would be interested in using the technologies at the inquiry. Based on an initial literature search, we formed a theoretical basis rooted in the adoption literature [74]. Aiming to contribute user insights for the main research question, this step addresses the following sub-questions: (1) *What are the common user characteristics of individuals interested in using 3DFP in their kitchens?* and (2) *What are the interested users' perceptions and perspectives on using 3DFP at home in reflection on their everyday food experiences?*

To identify the characteristics of interested users, we constructed a user identification survey (Appendix 2) based on the literature on trying new foods prepared with novel technologies [15, 19]. Collecting quantitative data (N=146) from domestic kitchen users and analyzing by descriptive statistics and logistic regressions, we reached six characteristics of users interested in using 3DFP technology in their homes: *1) Cooking every day, 2) Ordering food less than once a month, 3) Eating out at least a couple of times a month, 4), Having a mini oven, a multicooker, or a kettle, 5)Liking to try new foods, 6) Thinking that cooking is a fun* *activity*. (See Paper 1 – User Exploration – Study 1: Identifying domestic users based on their relationship with food in everyday life).

Following the user characteristic identification, we conducted semi-structured in-depth interviews with survey respondents with low-to-mid FTN scores (between 13-60) (N=19) (See Paper 1 – User exploration – Study 2: Exploring the attitudes of interested domestic users). We discussed their food-related habits, routines, and practices in their daily life and also deeply conversed about prospective uses of 3DFP technology in their own homes (Appendix 3).

Overall, we analyzed the interviews [13] and they yielded two potential benefits of 3DFP to everyday domestic food life and three user-related themes (Paper 2 – Design implications - Study 1: Exploring the user perspective) that would help extend the understanding of the multifaceted nature of the food relations in everyday life.

Chapter 4

STEP 2: EXPLORING THE DESIGN SPACE OF HFI ARTIFACTS

Our first two steps of user inquiry revealed several insights that could be transformed into tangible design ideas by designers. In continuation, we worked with interaction designers, kitchen appliance designers, and illustrators to generate tangible design ideas based on user insights. In this step, the sub-research questions formulated to feed the main question are: (1) *HMW alternate concepts to address the everyday food experiences reported by interested users?* and (2) *HMW develop a new food-experiencing artifact to address the everyday food experiences reported by interested users?*

We presented the user insights to interaction and kitchen appliance designers to transform user insights knowledge into tangible design ideas. We worked with designers in four ideation workshops (N=25) and presented them with user insights as ideation materials (Appendix 4). Designers generated a total of 73 product ideas and thematically analyzed the visual catalog of designer sketches and description transcripts (Appendix 8). This analysis revealed ten *design implications* that could inform future HFI innovations. We present the design implications in an annotated portfolio, including designers' sketches and concept descriptions [33, 34, 58]. (Paper 2 – Design implications - Analyzing designers' ideas: Generating design implications).

After developing the design implications, we further demonstrated the practical potential of our findings by developing three complete design concepts and scenarios. To do so, we worked with an illustrator on an ideation session, in which we discussed potential product concepts that mix the design implications based on their relevance to user data (Paper 2 – Design implications - Sketching concepts by combining design implications).

Moreover, the ten design implications formed a basis for speculatively mapping a future design space for HFI innovations. After collecting the 73 ideas from working with designers, we ran a quantitative analysis with the data we collected from the ideation with designers and compared it with the HFI taxonomy. Our initial aim in this analysis was to determine whether designers' ideas were aligned with the common discussions in the literature. However, we did not only find the relevance of our dataset with the literature as a result of this analysis, but we also reached a total of six categories that extend the HFI field speculatively (Paper 3 – HFI design space extension - Results).

Chapter 5

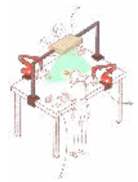
STEP 3: DEVELOPING AND EVALUATING HFI CONCEPTS AND ARTIFACTS

After working with designers and demonstrating the utilization of the design implications by developing concepts, we moved on to prototype the concepts and explore their potentials. The main research question of this step is formulated as follows: *What design considerations can we learn by developing and deploying conceptual prototypes that address the everyday food experiences reported by interested users?* Overall, we present the development processes of three conceptual prototypes: Foodiebuddy (FB), Motion Master (MM), and Mobile Food Printer (MFP).

Clarifying the prototyping plan and prioritization criteria for the ideas

We developed prototypes for each concept we developed in the previous step in varying fidelities [75]. In each design process, we used different mediums and addressed different contexts. We evaluated the feasibility of each concept for prototyping with four experts (1 electrical engineer, one software engineer, and two interaction designers). This meeting lasted one hour. Here, the experts were asked to evaluate each idea in terms of the cost for production (required resources and know-how), prototyping medium, and fidelity. They also provided feedback about how to refine the ideas further to overcome the challenges in the prototyping process. We also compiled the core qualities of each idea in a table (Table 1). From this point on, the prototyping journey for the concepts began, and the projects continued in their own time frames and project requirements. In our analysis, the Tabletop Chef (TC) concept requires a high production cost. For this reason, we simplified the design of this concept into a Mobile Food Printer design and continued prototyping with this version (Paper 4 – MFP in Restaurants – Design and Implementation of MFP Prototype).

Table 1: Core qualities comparison table for three ideas

	TastebudD	**Motion Master**	**Tabletop Chef**
			
Overall experience	Explorative	Emotional	Playful
Implication on food-interactions	May reduce food neophobia [19]	Achieve performance-dependent foods	Make cooking together fun
Personal implication	Expand taste palette	Expand the abilities	Engage with others
User agency	Keep the user in control but guide	Keep the user in control but guide	Entertain the user with more agency on technology
Related design implications (Paper 2 – Design implications – Chapter 4.1)	Breaking boundaries of food Create companionship for personalized food production	Include user in food-making Create memorable experiences	Food-making as a play activity Share eating and cooking

Case 1: Designing Foodiebuddy (FB)

For *Foodiebuddy (FB),* the main researcher used the research lab as the design team and herself as the design lead. While designing Foodiebuddy, we used an explorative iterative design approach. We generated a total of eleven iterations of the artifact and revised the user scenario (Figure 4) until it reached its final form (Paper 5 – FB in travel – Foodiebuddy as a Research Artifact).

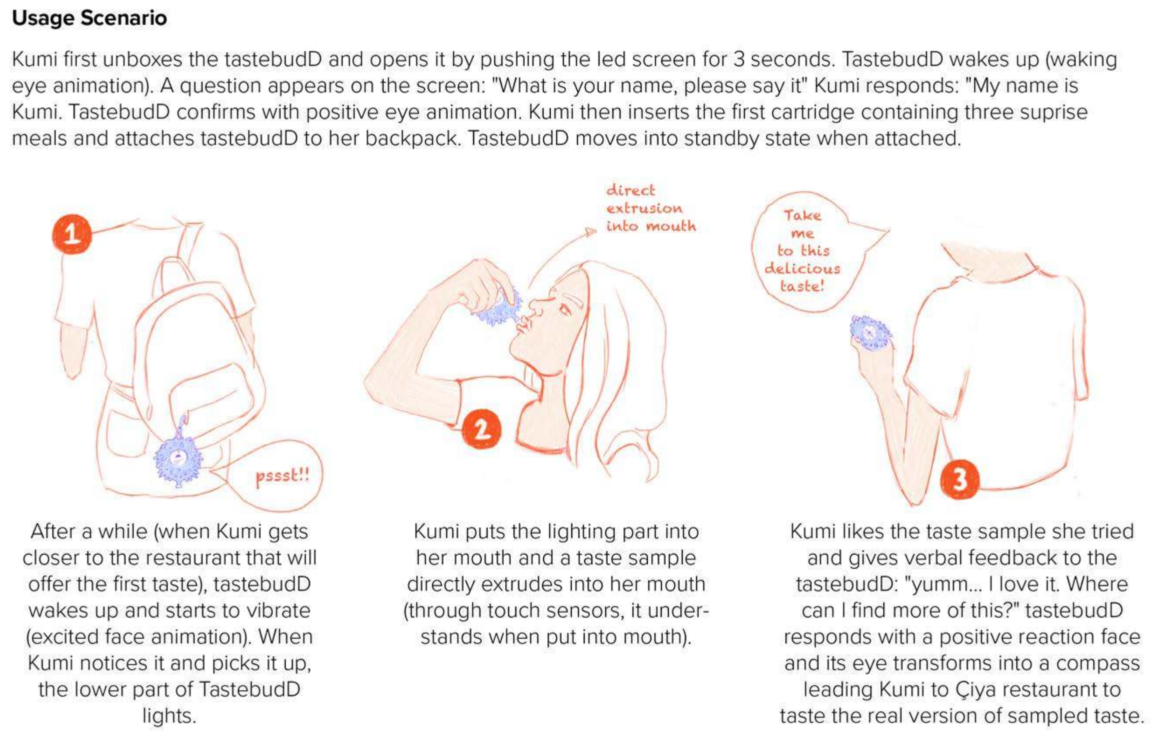


Figure 4: Initial user scenario of the Foodiebuddy (FB) concept.

Consulting expert feedback on designing the taste generation mechanism

Before we started prototyping the taste generation mechanism, we consulted food engineers who actively work in aroma synthesis and sensory analysis in the food industry. After the first meeting to introduce the concept, we made a site visit to an aroma factory to better grasp how aroma and taste are generated. On this field trip, we gathered feedback for the concept in general in terms of prototyping cultural tastes and offering samples to the user.

We made the following adjustments to the concept for better applicability before moving on to building on a prototype:

Limit the number of taste samples offered to the user: During the aroma factory site visit, we found that to generate tastes of real foods, our initial speculation of creating a mix of five basic tastes was not applicable. To recreate the food tastes, there needs to be a long research and development process. Thus, recreating “any” taste that users may come across when freely roaming around the city will require a highly advanced system. To overcome this challenge, we've decided to put a limit on the taste previews that Foodiebuddy will offer to its users.

Single-use taste cartridges: Our meeting with food engineers highlighted the hygiene of the product, which is an important aspect of FB. They also underlined that the perception of aromas is at stake if different samples contaminate the mixing chamber, causing the aromas to blend with each other. To overcome this issue, we've discussed designing single-use cartridges that contain predefined food samples, as in Bocusini [12]. In the design, we will separate the storage tube of every food aroma and their travel rails.

Designing the outer shell along with the main interactions

Overall, we made two initial design decisions based on food scientists' feedback: (1) Limit the number of taste samples offered to the user (to three), (2) Utilize single-use taste cartridges. While generating the iterations, we gathered continuous feedback from interaction design researchers in our lab (N=3).

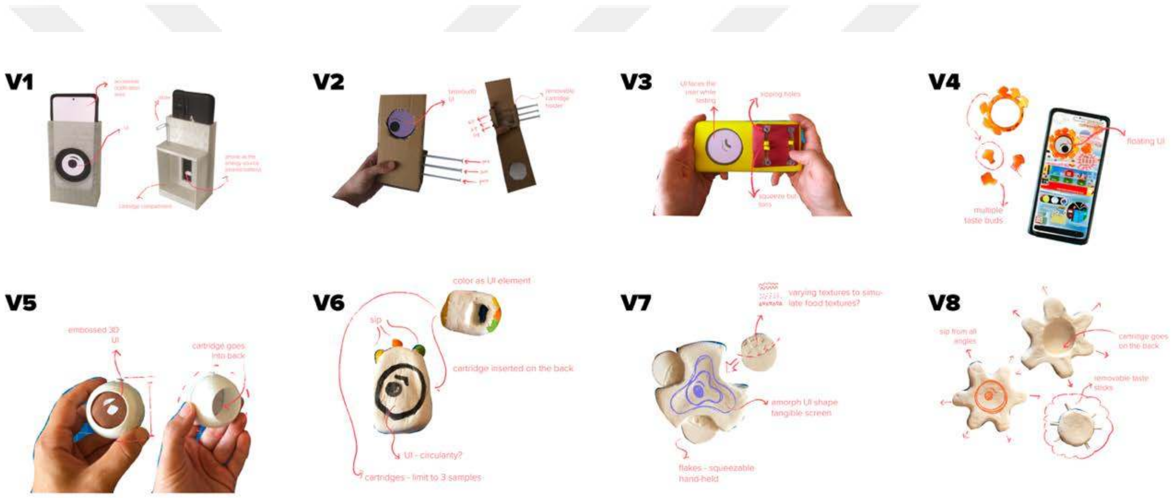


Figure 5: The first eight iterations of Foodiebuddy

In the earlier iterations, for the ease of building hardware in the further stages, we tried integrating the prototype into an existing technology at hand, a smartphone. We started by studying the form of the outer shell of the device. We 3D modeled and printed a smartphone case resembling a juice box, which ultimately suggests a mobile eating artifact (Figure 5 – V1). However, this design felt extremely bulky due to the limitations of the prototyping method employed. After building this first artifact, we took a step back and started sketching potential forms that feel more "natural" and are inserted like a "phone case" (Figure 5 – V2).

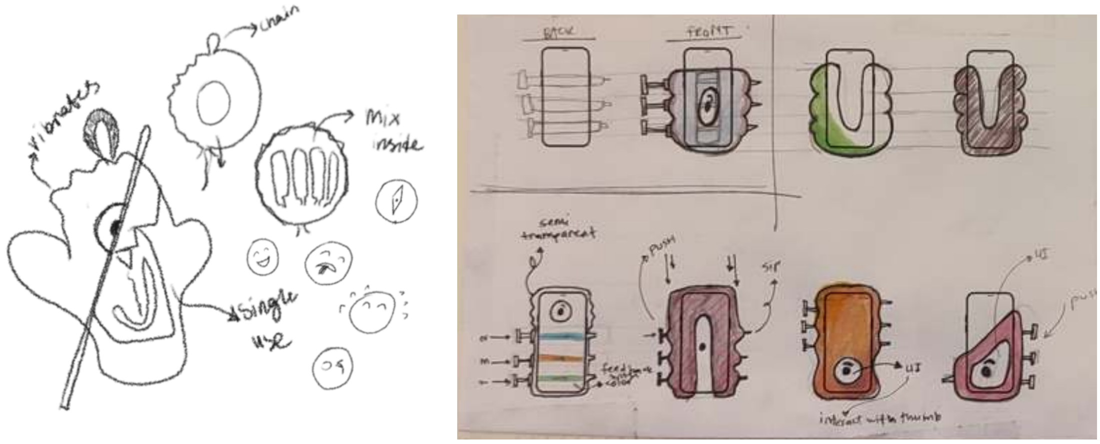


Figure 6: Initial sketches for phone-integrated Foodiebuddy.

This exploration led us to build forms with paper-like materials, and we started exploring potential forms with cardboard. Then, we decided to move on with a lo-fi prototype as it leaves ends open for participants to explore alternatives [23] and is a fast prototyping technique [75]. Thus, we built iteration V2 with cardboard for the outer form and some medical syringes for taste sample extrusion (Figure 6). The phone screen is covered in this design, and the user can only interact with the tastebudD UI. After we had built a paper prototype, we brought it to the interaction design researchers in our lab. We explained the concept and scenario to them and asked them to play with the prototype and explore alternative ways to use this object to sample tastes.

Overall, the screen-blocking design was found to be “big” and “bulky.” Participants removed the cartridge holder and explored potential sipping styles using only the cartridge holder (Figure 7). Participants explored different ways to attach the cartridges to their smartphone while they made the voices “click, click” for each action they imagined, suggesting a sound-based interaction. Inspired by the different sipping styles (top, front), participants experimented with the removable cartridge holder.

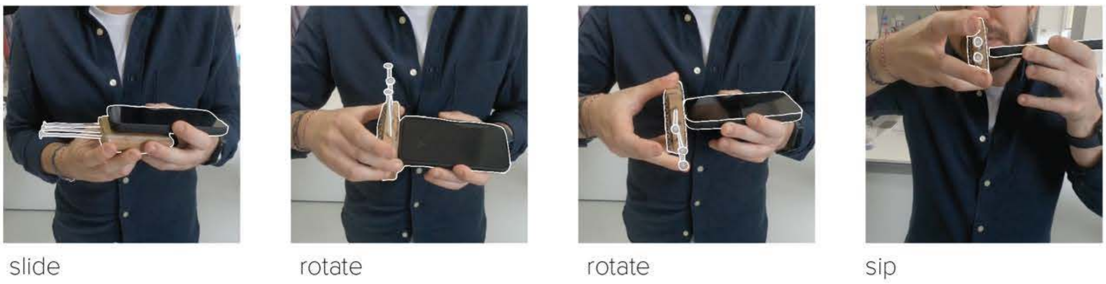


Figure 7: A participant exploring ways to activate the component

However, this design still did not meet the overall feedback, which mainly revolved around how "big" and "bulky" the design feels in one's hands and suggested making the device *smaller*. Afterward, we decided not to test iteration no.3 and moved on to ideate smaller concepts but still integrated them into a smartphone screen. This process resulted in the no.4 flower petal design (Figure 5 – V4). This design is inspired by the honeysuckle, which resembles a natural-tasting experience embedded in one's past.

Although the flower petal design is much smaller than the previous versions, this time, it received feedback about being a concept that is extremely fixed on the phone screen. At this conjunction, we questioned how being fixed on the smartphone screen shifts the focus from supporting taste exploration to the smartphone. This questioning steered the design process to a whole new direction. In the following stages, we started to work on designs that focused mainly on the core qualities identified in Table 1 and explored the potential devices for this prototype without using a phone.

Although the smartphone was initially suggested due to the technical advantages it potentially would provide in prototyping, it generally limited ideation and fixed the overall experience within the boundaries of an app. In this phase, we aimed to gain form freedom and used air dry clay. With this medium, we produced three objects, all of which were designs that could be easily carried by one hand and allow three or more tastes to be tried (Figures 5 – V8). Each object we produced during this process had a different exploration.

In no.6, we designed a portable buddy inspired by Tamagotchi, where we focused on making the object itself a companion/pet [55] (Figure 5 – V5). In V6, we explored using color as a UI element indicating different taste samples. However, the participants found the color indication to be vague. Here, participants started questioning whether sipping a small taste would immerse the users and asked how to provide food's texture.

Based on this feedback, we developed V7, where we searched for a concept that explored conveying the *food textures* and how FB might provide the experience of it. Conveying food textures accurately is also a challenge for 3D-printed foods, and in this design, we aim to explore if it would be possible through the devices that extrude food aromas. With this aim in mind, we have created two iterations inspired by the Fidget Spinners, a hand-held object (Figure 5 - V7 and V8). The bodily experience facilitated by fidget spinners inspired this design with the hope of creating a tangible and bodily bond between the user and the object [51]. The intent here is to adjust the user's mindset to experience this artifact with their body (hand and then tongue). By adding “flakes” as taste samplers, we explored whether their textures would provide a discussion on the perception of food textures. In V8, the exploration was similar but with an extensive set of taste samples (taste samples increased from 3 to 6). We gathered a final reflection on V7 and 8 and then moved on to 3D printing to build further prototypes. We mainly used PLA as a material and studied the form design of FB. We build prototype V9 in the next iteration with inspiration from fidget spinners (Figure 8).

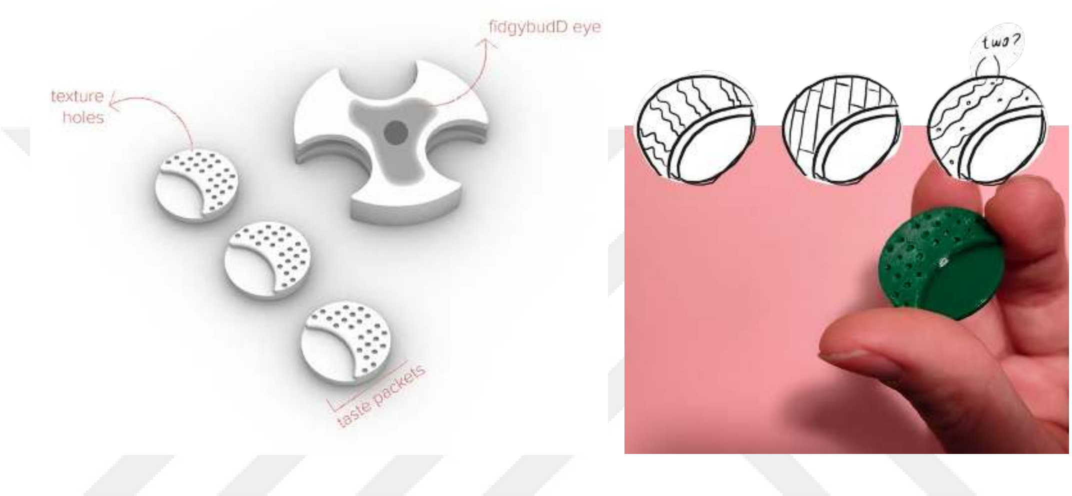


Figure 8: (left) 1st 3D model of Foodiebuddy and (right) the taste packets (V9)

We tested this version of the prototype (V9) in a pilot study in Kadıköy, where we investigated the effect of spatial parameters on the design of the object and also tested the study protocol (Paper 5 – FB in Travel - Participants and Study Procedure). During the walking tours, when participants handled the device, the tastebuds fell off on the ground, which made them unhygienic and refrained participants from putting the bits in their mouths. After this experience, we moved back to 3D modeling and reduced the dimensions of the gaps in which taste packets fit.

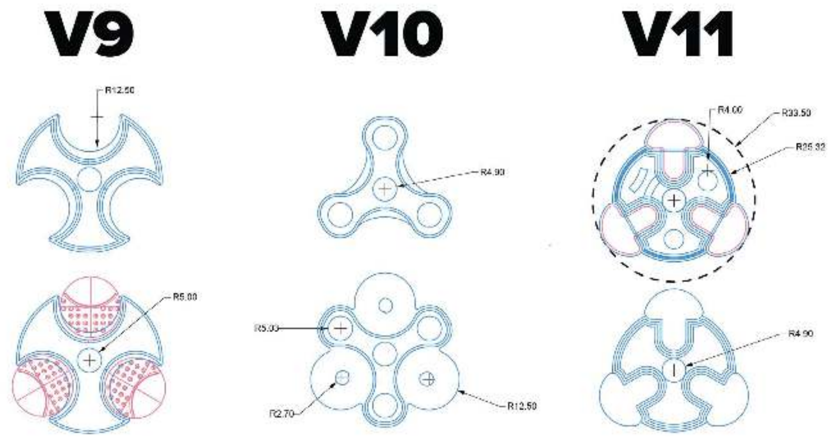


Figure 9: Prototype versions V9, V10 and V11 technical drawings. All given dimensions are in mm.

To prevent the taste buds from falling, we updated their mount on the main body to make them better fit. While changing the taste packet mounts, this detail affected the shape of the overall body and resulted in the second version of the 3D-printed model.

V10 resembled a flower with three taste buds sectioned by three petals (Figure 9). In V10, we tested adding sliders on the petals, aiming to provide an input mechanism for the device when loading taste samples. However, this design was not given much importance during the feedback, as designers questioned the “slider” function. For further iterations, we decided to leave this part of the prototype unfinished. Leading us to another design decision: Leave the user input mechanism open-ended. We reflected this design decision onto the prototype by adding holes at the tip of each petal, which left the functions unfinished. This decision later received attention from engineers in the pilot proof-of-concept studies. Even though we revised the taste packet mounts in V10, they kept falling. For this reason, in the next version of the prototype, we decided to update the shape of the taste packets (Figure 9). We updated their shape to better fit in the body and prevent them from falling.

With this new form, the mount on the main body was also affected. In this version, the petals of the body were enlarged, and they no longer resembled petals. In this geometry, we questioned whether each petal should have the same function (pilot finding). Thus, we changed the engraving on one of the petals into buttons. This design decision to create asymmetry in the functions leads us to the serendipitous discovery of the object functions. When this revision was prototyped, we realized that the UI of the prototype looked like a face. The new shape of the tastebuds prevented them from falling and solved the issue. After reaching this consistency in spinning and fitting tastebuds, we stopped the prototype development process and continued conducting walk, talk, and eat sessions (Appendix 7).

Although we no longer revised the prototype, we kept a record of the feedback participants made on the design of the FB.

After, we developed a probe kit and deployed it in real travel scenarios to collect experiences in situ. To start the studies, we completed the missing details on the design through FB experiencing protocol (Appendix 5) and instruction manual (Appendix 6). By deploying this conceptual prototype in real travel scenarios, we revealed design considerations targeting experiential, spatial, social, and personal aspects of eating while traveling. (Paper 5 – FB in Travel – Foodiebuddy as a Research Artifact). (Appendix 9)

Technical Evaluation of Foodiebuddy

While developing the Foodiebuddy (FB) concept, our main concern from the participants was the technical validity of the concepts. During user and design studies, we encountered questions relating to the functional capabilities and limits of the technologies at hand. In Paper 2 – Design implications - Discussions, we deeply discuss how this limitation shifted our trajectory from 3D Food Printing (3DFP) to food experiencing artifacts and interactions. In this chapter, we present our technical validation study for Foodiebuddy (FB) among the three prototypes we worked on in this thesis because it was one of the most controversial technologies that induced questions on its technical validity. Although it was not projected in the initial aims of this thesis, this study will be considered for a future publication (**Potential Paper 7**). We conducted two meetings with engineers, one during the development of prototype V10 and another after completing the walk, talk, and eat tours (Paper 5 – FB in Travel – Foodiebuddy as a Research Artifact).

Pilot meeting during prototype development

To address the above-mentioned issue, we went to the kitchen appliance industry experts. In this session, we discovered potential technical improvements in the prototype. After reaching the final version of the prototype and conducting pilot studies, we decided to assess the current state of the Foodiebuddy artifact from a technical perspective. Adding this perspective would also increase its relevance with the kitchen appliance industry.

We convened with engineers actively working in Arçelik (a kitchen appliance firm funding this research) and presented them the Foodiebuddy (FB) concept and the prototype. The pilot session was an in-person meeting with four participants, which involved one food engineer, one electrical engineer, and two mechanical engineers (N=5). We presented participants the FB prototype and briefly explained the user journey map. Later, we discussed how they envision this object to be realized in industry settings through discussions.

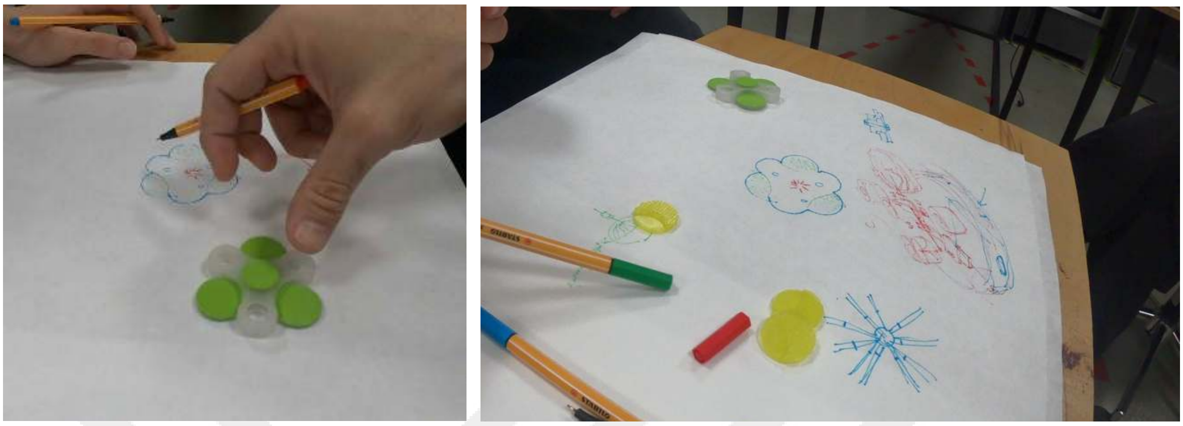


Figure 10: (left) Participant demonstrating how to insert the taste generators on the petals, (right) Final sketch illustrating the mechanical system.

Engineers attending the sessions made the following remarks for building FB in industry settings:

- Limit the taste samples offered to the user in user journey mapping. Consider the aroma catalog available in the market and by sorting and mapping the aroma mixtures to develop the final taste catalog of FB. This is found similar to a benchmarking study, which reviews the available aromas and their mixtures. This study would increase the number of taste previews that FB could generate in the product development process.

- They generated "taste generator" mechanisms that are inserted in the circular gaps on each of the petals (Figure 14). They sketched air-tight tubes to connect each taste generator to each other and placed microvalves on them to control the liquid flow. Aromas in liquid form move inside these tubes through capillary action and are mixed in the compartment placed in the middle. The mixed flavors are then sent to the taste buds placed on the device for the user to try. Developing an algorithm for controlling the liquid flow from the valves addresses the main function of the prototype (i.e., taste preview). Their drawing also included either a WIFI or Bluetooth module for connecting to the user interface and sending a recipe.

- If the taste preview is in liquid form, then the volume for each taste sample to best convey the target flavor requires empirical testing.

- Conveying the texture of the taste samples requires another empirical test that considers the various textures of food (e.g., crunchy, creamy).

- When designing the service side of the FB experience, the restaurant catalogs could be downloaded based on the travel destination. Experts suggested that the recipe data could be provided by the restaurants and are compiled in a larger database.

Literature search for technical validation

During the walk, talk, and eat tours, due to the arising concerns by study participants about the technical validation for how taste previews work, we surveyed HCI literature to explore potential technical platforms that could validate and contribute to the discussion for how to improve Foodiebuddy (FB) in the next iteration cycle. Overall, we reached three technical platforms that could help convey taste previews on the tastebuds (Figure 15) [63, 67, 79]. In the final report, we included a review of the capabilities of the three technical platforms. (Paper 5 – FB in travel - Technical Platforms Validating Foddiebuddy)

Figure 11: Three technical platforms that could validate the technical foundation of the FB concept.

Overall, each platform is limited in conveying complex and multiple taste previews, however, with its array-based, flexible, and light design, we find TactTongue the most appropriate for assuring the technical validity of the FB concept [67].

Consulting expert opinions for further technical improvements

To discuss potential technical improvements on FB, we convened again with three engineers from Arçelik. Each expert is specialized in a different engineering field (computer, food, and mechanical) and provided their perspectives on how to build the technical system of taste previews. In a one-hour-long focus group meeting, we first presented them the FB concept and then presented technical platform search [63, 67, 79]. We then consulted their expertise on how to build taste previews on this basis. After the meeting, we went through the voice recording of this meeting with an interaction design researcher and took notes on potential improvements suggested by engineers. We categorized the notes on a Miro board. The following list summarizes the three methods participants suggested as technical possibilities for conveying taste previews with FB.

1) *Using liquid premade flavor capsules and electrophoresis:*

  - Gas recognition of smells for sensing food contents

  - Mixing flavors and creating a catalog

2) *Using Tongue-Device Interactions:*

  - Combine tastebuds to increase the number of taste previews.

  - Vibration – food texture relation exploration

3) *Trigger reactions in the body to mimic taste perception:*

  - Using brain waves

  - Through storytelling

  - Inducing chemical reactions in the mouth (mint gum)

  - Synesthesia – multisensory experience exploration

Case 2: Designing Mobile Food Printer

As explained in the introduction of this chapter, we simplified the design Tabletop Chef concept and designed the Mobile Food Printer (MFP) that roams on a table and 3D prints food. To evaluate the concept, we did not present a usage scenario and explored its potential in the restaurant context (Paper 4 – MFP in restaurants).

We first initiated the MFP prototyping process by ordering a premade robotic platform with four omni wheels (Paper 4 – MFP in restaurants – Design and implementation of MFP prototype). We then moved on to designing an extrusion mechanism and developed two iterations using 3D modeling and printing. Here, we focused on squeezing material from a 60 ml medical syringe using rack and pinion gears and DC motors for actuators (Figure 14).

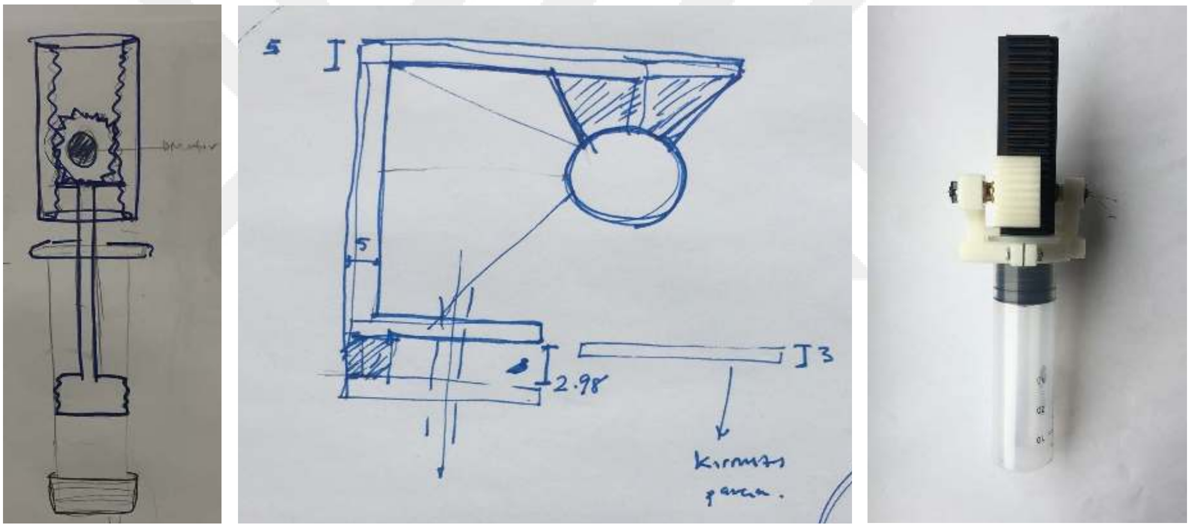


Figure 12: (left) sketches for the rack and pinion gears, (right) 3D printed

At this stage, an MA student from the Electronics Engineering Department of Koç University was hired for the project, and we co-developed the prototype and the focus group studies. The detailed production process and evaluation studies are presented in Paper 4 – MFP in restaurants.

Concept study: Designing Motion Master (MM)

For the Motion Master (MM) concept, we built a cinematic prototype [71] as building a semi-working or working prototype would not fit within the time constraints of this thesis. Considering this limitation, we collaborated with a senior bachelor's student from the Media and Visual Arts Department of Koç University. We tasked her to shoot a 1-min video for MM that focuses on illustrating the interactive elements of the concept. This project was completed as the student's graduation project, which was graded successful. As a result, this demonstration video is found to convey the main idea of the concept.

We believe that cinematic prototyping is an underexplored method in HCI that has great potential for effectively conveying the main idea of a technology concept without the need for a working prototype [71]. In another sense, we assert that the advantages of this method may be parallel to other commonly employed methods, such as WoZ [10] and Video Sketching [87]. To explore this opportunity, we initiated a cinematic prototyping project in which we aim to obtain a demonstration video of the Motion Master (MM) concept without building an actual working prototype.

The prototype process started by building the scenario and was followed by prototype development, video shooting, and post-production. The following sub-sections briefly summarize the tasks we completed to reach the final version of the video. (Appendix 1)

Scenario development

To start ideating, we first focused on the scenario and main theme of the video. To decide on the context, we first focused on identifying foods and recipes that would best demonstrate the functions of MM. In this discussion, we also considered the user data that this concept builds on to keep their emotional involvement when presenting the functions. In other words, we refrained from shooting a video that only focused on the functional aspects of the concept. To stay in this perspective, we focused on a cultural food, *sarma*. This food was inspired by the recent memory of the main researcher with her grandmother, where she demonstrated rolling *sarma* (Figure 10).

Figure 13: Grandmother and granddaughter rolling *sarma* together. (An autoethnographic visual note by the main researcher [49]).

After selecting the food, we started ideating on how the scenario would proceed and planning which interactions would be shown in which sequence of the video. By watching the video from Figure 10, we identified movements that the grandmother performed while rolling a *sarma* and identified a list of highlighted movements: 1) Place rice inside the leaf, 2) Fold the leaves and complete by rolling, and finally, 3) Throw the remaining rice back into the pot. We sketched a storyboard at the end to finalize the details (Figure 11). While sketching the scenario for the video, we considered the camera placements and angles that highlight the most critical interactions with the device while performing the movements listed above.

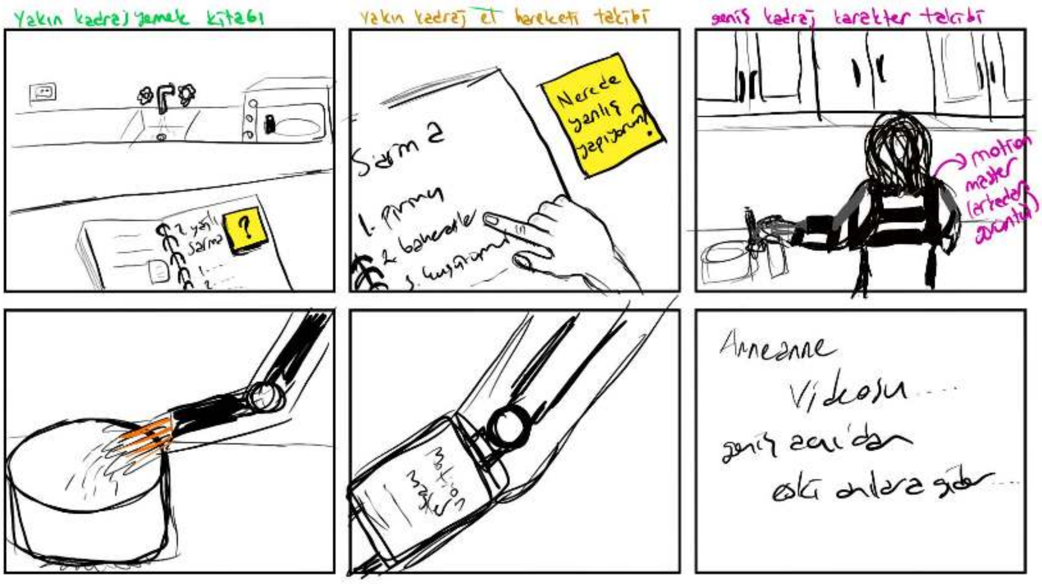


Figure 14: MM storyboard sketch.

Probe making

We designed a wearable only as a visual representation of the MM concept. The aim of this object is to show the key interactive elements to convey the main idea in the video. Thus, we made use of ready-made materials whenever we could when making the design decisions. We divided the prototype into three main parts: Hand cartridges (rings and capsules), interactive vest and the gearboxes (controlling the movement), and digital interface (cookbook, main interaction module).

Figure 15: (left) rings and tubes attached to the performers' arm, (right) screenshot from the video showing mobile phone as a digital interface.

For the hand cartridges, we combined elastic bands with medical tubes (Figure 12). We used rings to attach the tubes to the fingers. Finally, to demonstrate the digital interface, we used a mobile phone.

Shooting of the video and post-production

After the probes were completed, we started scouting for a location for making the video shooting. We toured two kitchens available on the Koç University campus and picked the one in the left image because its decoration feels more like a domestic space. This space was also appropriate for video shooting because it had a great opening behind the kitchen counters, which were later used for placing the production equipment (e.g., cameras, microphones, and lights) (Figure 13).

Figure 16: Two kitchens toured for video shooting.

After the shootings were completed, we compiled all recordings in a Google Drive file and started post-production. Here, we finalized the scenario and planned the transitions between the scenes. During the post-production, some extra scenes were shot (scenes with grandmother). The screenshots from the final video can be found in Appendix 1, along with a description of the scenario.

Chapter 6

STEP 4: DESIGN RECOMMENDATIONS

In this thesis, we revealed five design recommendations (DR), each focusing on a different topic in Human-Food Interactions (HFI) and are based on the RtD method as detailed in previous chapters: *(1) limits and boundaries of taste, (2) bodily food-experience activities, (3) sharing activities around food, (4) spatial elements that complete food experience and (5) the utility and pleasure tradeoff.* The five design recommendations are ordered by their novelties for the larger fields of HFI, HCI, and design research (Figure 16). A critical reflection on our main research question: *"What insights can we gain for design research and practice through designing human-food interactions that support everyday food experiences?"* indicates that many insights were reached throughout this research that uncover various topics for HFI artifact and interaction design. In the following sections, we will go through each DR and explain the relevant data collected.

		RESEARCH FINDINGS				CONTRIBUTIONS
		USER INSIGHTS	DESIGN IMPLICATIONS	CASE 1 EATING WHILE TRAVELING	CASE 2 DINING AND SERVING IN A RESTAURANT	
DR1	THE LIMITS AND BOUNDARIES OF TASTE	Liking to **try new foods** Search for **better foods**	Break boundaries with new foods and eating styles	Match **local food recommendations with users' diet**		novel approach to a negative phenomenon for HFI artifacts
DR2	THE VALUE OF BODILY ACTIVITIES IN FOOD INTERACTIONS	Thinking that **cooking is a fun activity** Joy of **bodily activities**	Approach food-making as play activity Include user into food-making	Design a **continuing** taste exploration journey	Build on the **authentic knowledge** base embedded in the restaurant when designing diner interactions	uncovered novel bodily food interactions embedded in HFI contexts
DR3	SHARING FOOD, COOKING AND FOOD-RELATED PERSONAL DATA	Cooking **every day** Many **agents** of cooking	Share eating and cooking Create companionship for personalized food production	Consider the **details of shared information** with the gadget (feedback on food, social dynamics, travel itinerary)	Consider the spatial movement of technology to **mediate communication** between the diner and chef	underlines the importance of sharing food and data
DR4	SPATIAL ELEMENTS THAT COMPLETE FOOD EXPERIENCE	**Eating out** at least a couple of times a month	Integrate into everyday objects	Incorporate **spatial, atmospheric, occasional and social elements** into the exploration journey	When conceptualizing mobility, assign objects and play with **boundaries, paths, or device proportions**	exemplify how spatial factors could be integrated into artifact design
DR5	BALANCE BETWEEN UTILITY AND PLEASURE	Having a mini oven, a multicooker, or a kettle **Ordering food** less than once a month	Allow eating anywhere Create memorable experiences Complement main dish	Adapt teste recommendation to **user types and travel modes**	Adjust the balance between **hedonic and utilitarian experiences**.	utilize device modes for balancingutility and pleasure

Figure 17: Five Design Recommendations, relevant research findings, and research contributions.

Design Recommendations for Food-Experiencing Artifacts and Interactions

Formulating the Design Recommendations

The design recommendations (DR) are multilayered because they are based on a dataset that includes both user and design insights. Each DR is formulated by discussing related 1) user and design insights, 2) findings from eating while traveling, 3) dining in a restaurant, 4) novelty, and 5) suggestions for future research and practice inquiries. We exemplify case-based results from Foodiebuddy (FB) and Mobile Food Printer (MFP) inquiries.

DR1: The limits and boundaries of taste

"Consider food-related boundaries positively and design celebratory interactions for them."

User and design insights: In the earlier steps, our focus on 3DFP has steered our trajectory into question participants' Food Technology Neophobia (FTN), which introduced the notion of *food-related boundaries* to this design recommendation [19, 38]. Supporting the course of knowledge in 3DFP adoption research, we confirmed the relation of FTN with users' interest in new food experiencing artifacts (Paper 1 – User exploration – Study 1 - Results). In fact, findings support that there is a constant search for new and better foods in everyday food interactions. Design concepts challenged this body of knowledge and produced concepts that transmute diet altogether through novel foods (e.g., insects) or restructure daily eating schedules (e.g., perpetual eating) (Paper 2 - Analyzing designers' ideas: Generating design implications).

Eating while traveling: Overall, this recommendation is shaped by the positive comments FB received and how travelers perceived it as a fun and useful tool for nurturing their curiosity about new tastes. We observed that focusing on taste exploration would entice users to try out new foods and improve their overall journey. (Paper 5 – FB in travel - Conclusions). However, users may need encouragement at certain times (e.g., in a rush). In that case, FB was found useful to nudge users positively in keeping up with the exploration. Many travelers stated that they would try more new foods using FB gadget.

Novelty: Previous research investigated ways to enhance food's desirability [76]. This design recommendation taps into the potential of another negatively perceived notion, food neophobia, and presents an approach that transforms a phobia into a celebratory technology through design inquiry [41].

Strategies for future research:

- This design recommendation points to extending the potential application areas for FTN by multiplying the research through design inquiries that solely focus on exploring new tastes and foods in different contexts (e.g., workplace, domestic space).

DR2: The underlying value of bodily activities in food interactions

Observe and identify context-specific physical and bodily interactions to inspire artifact design ideas. Look for the socio-technical context and authentic knowledge base embedded in the context (e.g., user journey map, gestural interactions) and implement this knowledge when conceptualizing artifacts.

User and design insights: The basis of *context-specific physical bodily activities* of this design recommendation is formulated on user insights collected in the early stages of the study. We identified that domestic kitchen users consider cooking to be a fun activity (Paper 1 – User exploration - Incorporating pleasure of cooking to achieve novel experiences). We also identified food-related physical activities and performances that users report to enjoy, which later inspired fruitful design concepts (Paper 2 – Design implications – 3. Incorporate user into food-making). In the in-depth interviews, one participant reported that they enjoyed watching a master cook, while another said that if they had a 3DFP, they would enjoy watching the machine operate during the food printing process. Another participant stated that she enjoyed watching her mother and cooking by mimicking her physical movements. We identified value in the physical interactions with food and food making, and we suggest that these interactions may be integrated into artifact designs.

Eating while traveling: In the analysis of traveler's reflections, we gained awareness of the temporal dimension of the travel experience and weaved *the socio-technical context* into this design recommendation. We initially designed FB to signal a food suggestion in a single moment during a walk. However, in the walk, talk, and eat tours, we realized that the physical bodily activity in the travel context is walking, and it is a longitudinal experience (Foodiebuddy (FB) journey map (Appendix 7)). Thus, concluded that the travel case should be treated as a continuous journey and in-motion, and we recommend travel eating experiences to be designed as journeys that span over time.

Dining in a restaurant: In the MFP case, the designer workshops and focus group sessions with novice chefs contributed to formulating the authentic knowledge into this design recommendation. We identified that bodily interactions may reside in social interactions with food service staff. Some of the authentic experiences here were referenced by the designers as *hand gestures with the waiters* (e.g., waving to call) or the chefs fulfilling their role as entertainers by serving food at the table with a bodily performance (Paper 4 – MFP in Restaurants – Design Consideration 1).

Novelty: Recent research highlights the importance of uncovering cultural and context-specific interactions to inform playful mealtime design speculations [5]. This design recommendation builds on this basis and shows the extensive scope of uncovered novel bodily food interactions embedded in everyday contexts such as traveling and eating out.

Strategies for future research:

- This design recommendation is rooted in identifying context-based bodily food interactions that elicit meaning through designing in-the-wild studies. Further ideation workshops should be designed using similar design-oriented research. Following **[5]**’s approach or new in-the-wild studies may be designed similarly to walk, talk, and eat tours described in Paper 5 – FB in travel – Methods.
- As a final step in this design recommendation, implement artifact features based on the physical bodily activities identified in the context (e.g., longitudinal tasting experience in traveling, gestural interaction with the waiter in a restaurant).

DR3: Sharing food, cooking and food-related personal data

Learn users through collecting food-related data (e.g., personal preferences) along with memories (taste reviews, taste history). Systematize the ways of sharing this information to elevate the food experience (e.g., personalized dish, emotional expression).

User and design insights: Based on the user exploration phase of our study, we formulated the basis of this recommendation on emotionally *elevating food experience by sharing food-related information*. We identified that domestic kitchen users often cook and share their cooking activities with other agents. Designers integrated sharing food-related activities into their concepts, in which participants communicate their values and cultivate emotional relationships with others.

Eating while traveling: Specific to the context of traveling, we reported users' willingness to share the local foods they had tried with their families or loved ones (e.g., mothers). Devices may allow travelers to record meals they tasted during travels and also allow travelers to share their travel food-tasting memories with their families and friends. The technology may support sharing food-related comments and may also collect place-based memories. The device may keep learning about travelers' food preferences and travel practices. It may allow receiving detailed feedback about the meal and lets the user synchronize with services they already use, such as Google reviews (Paper 5 – FB in travel – Results – Insight 3).

Dining out: The types of *food-related personal data* users were open to sharing contribute to specifying the focus of this design recommendation. Devices may elevate foods by customizing them based on personal information such as diners' background (e.g., hometown), health data, and food preferences.

Novelty: Previous research builds a basis for food-experiencing systems capturing and recreating food-related emotional memories and personalizing food based on activity data [36, 52]. This design recommendation underlines the importance of sharing food and data and takes into account the value of food-sharing practices embedded in contexts.

Strategies for future research:

- The first part of this design recommendation points to a research inquiry into unfolding the relationship between data sharing and food-related memories.
- After identifying the food-related data, this design recommendation unfolds an opportunity for generating data-sharing algorithms for food-related contexts.

DR4: Spatial elements that complete food experience

Integrate food technology into the space or design it with the space. Think of space and objects as a family of technologies and modify their boundaries, functions, routes, or dimensions to complete the eating experience.

User and design insights: The user insights contributed to the perspective of the family of technologies to this design recommendation. We concluded that there is a system of tools, recipes, and agents that accompany food-making in the domestic kitchen. Designers leveraged the tools and other objects that are part of cooking and developed concepts that add functions to those tools (e.g., butter printing knife).

Eating while traveling: Devices may support travelers on their quest to capture as many local experiences as possible. To satisfy their cultural hunger, devices may increase engagement with local culture and restaurantscape [11, 39]. When they have a tight schedule, travelers focus on experiencing as many novelties as possible within their time limits. This makes it critical to include spatial elements in the design of food gadgets for traveling for achieving. In many sessions with FB, participants enacted interactions with the objects around them using FB, such as the menu or the ice cream bar.

Dining in a restaurant: This recommendation is based on the designers' approach to integrating the concept of mobility by designing it *with the space*. Food-making devices should be designed to operate with environmental elements (e.g., menu, clothing, kitchen counter) and sometimes the space itself (e.g., 3D food printing restaurant) to complete the eating experience.

Novelty: Recent literature asserts that the perceived dining experience is heavily influenced by other tangible and intangible elements of the environment, such as the atmosphere, food service, or authenticity [48]. These elements also include the social context, the occasion, spatial design, and the design of surrounding objects [80, 85]. This design recommendation acknowledges the influence of external factors on food experiences and exemplifies how they should be designed in two different contexts.

Strategies for future research:

- This design recommendation points to studying possible interactions and users' interrelations with a system of products by designing artifacts that form a product ecology [1, 29].

DR5: Balancing utility and pleasure

Devices should have modes to target different user types and their states. Before designing, designers should collect context-based information and specialize device modes based on *identified social, temporal, and technological contexts.*

User's point of view: The user interviews and survey formed the basis of this design recommendation by revealing that many users approach food-making from a utilitarian perspective yet also find many joyful elements in food-related activities. While sharing cooking has a utility-oriented aspect, sharing food and cooking for others was found to have meaning (Paper 1- User exploration and Paper 2 – Design implications). Possible design implications show that there are many ways food artifacts can address issues in both domains such as offering new uses for food waste or facilitate memorable eating occasions.

Eating while traveling: Travelers' pleasure and function-oriented expectations vary according to different travel modes (Paper 5 – FB in travel – Discussion – Design Consideration 3). The device may function in modes that are adapted to travelers' itineraries. When they have a busy schedule and must move in a short time, the device may support the user in getting food recommendations that are fast and nutritional but still let them explore safely (e.g., tourist-friendly exploration mode). The device may also support the user at times when they feel more open to pleasure-orientated experiences that are long-lasting and nudge the user to take more risks. The device modes may vary depending on the purpose of the trip, the situation, time constraints, and external factors such as social settings or the purpose of traveling.

Dining in a restaurant: By analyzing designers' ideas, we concluded that while the function-oriented concepts may address the needs of the food service staff, concepts that provide entertainment and playful interactions may be offered to the guests (Paper 4 – MFP in restaurants – Design Consideration 2). Device functions and features may be adjustable depending on the utilitarian and hedonic expectations of different user types and modes.

Novelty: The hedonic and utilitarian affordances both contribute to the sensual and functional perception of a product [84]. This design recommendation points to an opportunity in HFI artifacts that could provide both utilitarian and hedonic affordances through device modes and user-type segmentation.

Strategies for future research:

- This design recommendation points to a design inquiry focusing on user types and exploring potential user types for speculative concepts.

Chapter 8

DISCUSSION AND CONCLUSION

Conceptualizing the Design Recommendations as Knowledge

This thesis proposes an inquiry that observe multiple realities rooted in the context of everyday food interactions using the research through design (RtD) method [73]. The findings are shaped by the heavy influence of the interactions between the researcher, the participants and the research objects throughout the research journey. This approach ensured the quality of the findings presented in this thesis to be credible, transferrable, confirmable and dependable.

We conceptualize the overall contribution of Design Recommendations (DR) with the strong concept of *mitigated novelty*. The *mitigated novelty* may simply be represented through introducing new products, services and systems that enhance an existing situation or implementing new features to existing ones. It represents the abstract space between the *known* and *unknown, new* and *old* and refers to the experiential qualities observed in using technologies [47].

In technology research, we link the roots of this notion to the diffusion of innovations which makes fundamental definitions for explaining social behavior towards new ideas, products and innovations. As put by Rogers, a technological innovation creates one kind of *uncertainty* (the unknown features) in the minds of potential adopters as well as it represents an opportunity for *certainty* (the known features) in another sense [74]. Hence, the mitigated novelty represents the features of a design in tackling with the two ends of this spectrum. Although discussing the *mitigated novelty* in other technology domains is beyond the scope of this thesis, we acknowledge that this strong concept would undoubtedly get richer by drawing on research in psychology (cognitive load balance) and usability (familiarity-novelty ratio). For discussing *mitigated novelty* in food-experiencing artifact designs, here we refer to the two cases we studied: 1) Foodiebuddy (FB) - a new way of tasting food, and 2) Mobile Food Printer (MFP) a new way of preparing and presenting food.

In the FB case, we focused on the notion of trying *new tastes* and developed a personal food tasting gadget that playfully supports food exploration. FB mediates the exploration of *new tastes* and elevates the cultural and social aspects of food while keeping user's preferences at the foremost. This approach presses upon the novelty end of the spectrum by introducing a *new technology* for trying *new tastes* in *new places*. To mitigate the novelty in such an experience, FB mindfully introduces *new tastes* to the user while keeping them in control of their palatal boundaries (DR1). To explain, this approach does not force novelty on the user but lets them choose when and how to explore. Moreover, addressing food's secondary meanings through cultural elements embedded in the local context (food, space, music, scenery, communication styles) allowed new interactions to emerge (DR4) that ultimately influence the perceived novelty of the experience. In other words, mitigating the novelty in food-experiences may be facilitated through considering user's current interactions with food and the environment.

In MFP, we developed a food printer that moves on various surfaces and focused on unlocking *a new way of preparing food and eating.* Our approach in MFP offers a new experience for both diners and food service staff, hence, the communication between them (DR3). This was the case when designers ideated scenarios focusing on traditional recipes and traditional gestural interactions to redesign the social settings. The traditional recipes and gestures directly affect how technology handles the mitigation of the new experience (DR2). With this outlook it is possible to mitigate the novelty by redefining ways to interact with traditional foods, which corresponds to the *known* end of the spectrum.

Revisiting Key Contributions

This dissertation presents our inquiry into discovering knowledge for research and practice through designing food experiences and interactions. In the research process, we examined the relevant literature, followed by a series of user and design studies that formed the basis. Overall, we reached the key contributions listed in Chapter 1. In the remainder of this chapter, we revisit our initial research approach diagram and assess how the research outcomes formed the Key Contributions (KC).

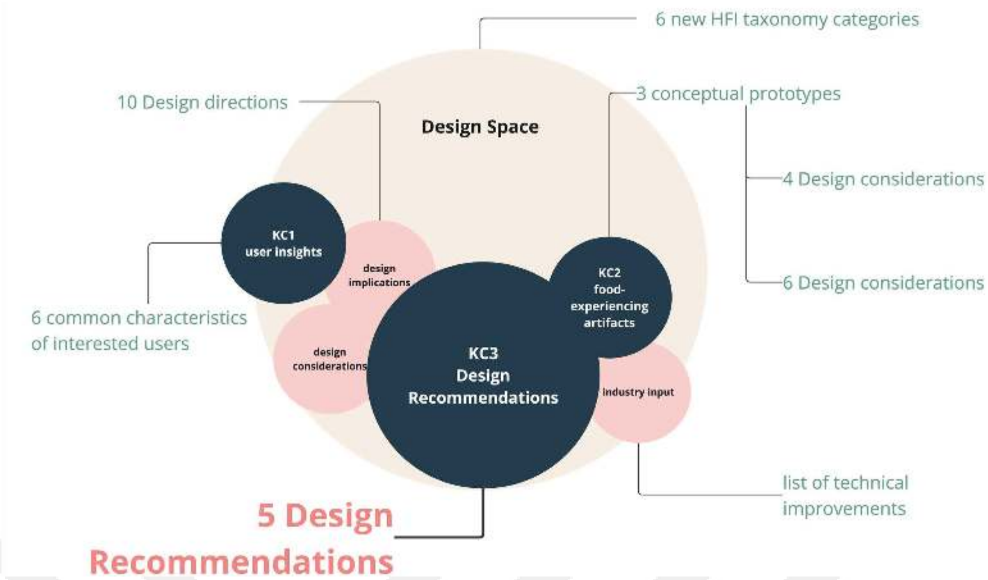


Figure 18: Reflecting findings on the research approach diagram.

KC1: User insights

In this thesis, we were able to obtain multilayered user insights that helped describe a user group that novel food experiences could target. Our inquiry revealed six characteristics that users interested in novel food technologies have in common (Paper 1 – User exploration) and three themes explaining their everyday food interactions (Paper 2 – Design implications). In the later phases of research, we collected in-situ user insights during concept evaluation studies. In walk, talk, and eat tours with Foodiebuddy, we collected in-depth information on users' preferred ways of interacting with the device in the context of traveling (Paper 5 – FB in travel). In the Mobile Food Printing study, we obtained insights about the challenges faced by chefs during kitchen management and dinner service workflows and collected foresighted opportunities (Paper 4 – MFP in restaurants). Compiling all these findings collected from each step of our inquiry contributes to our understanding of users' perception of food technologies in daily life.

KC2: Food-experiencing artifacts

We reached this KC by working with designers, illustrators, and engineers to develop conceptual prototypes. We contribute three conceptual prototypes, namely Foodiebuddy (FB), Mobile Food Printer (MFP), and Motion Master (MM). (Paper 4, Paper 5 and Appendix 1) Although we consider artifacts as contributions to literature, our approach takes designed objects as representations that embody the abstract design knowledge gathered by in-depth research [43]. To explain, the design of the artifacts we present in this study embodies user and design insights. Moreover, we present an annotated portfolio of speculative directions of HFI artifact and interaction concepts (Paper 2 – Design implications) and utilize this catalog of ideas for extending the HFI taxonomy with six new categories [3]. (Paper 3 – HFI design space extension)

KC3: Design recommendations

This KC was achieved at the end of the thesis, as it was formulated based on the cumulation of knowledge gathered throughout the research process. As our main research question indicates, we searched for knowledge by designing artifacts based on user insights. In the end, we reached five design recommendations for novel human-food experiencing artifacts and interactions (Chapter 6).

Putting Collaboration and Iteration at the Center of Design-Oriented HCI Research

In our understanding, the artifacts in RtD are representations of a solution that will help reveal propositional knowledge, practical experiences, and sensuous knowledge embedded in the context [43]. The conceptual artifacts we present in this thesis act as boundary objects that mediate interdisciplinary collaboration and discussion [45]. We put forth this lens in our design processes and adopted iteration and collaboration from the first step of design practices. We initially collaborated with interaction designers and kitchen appliance designers to ideate food-experience artifacts and interactions (Paper 2 – Design implications – Study 2: Exploring design instances). We then collaborated with an illustrator to develop conceptual visualizations. In the artifact development processes, we collaborated with other product development experts and updated our designs when a new insight was revealed. In Motion Master (MM) and Mobile Food Printer (MFP) projects, we actively collaborated with Master’s and Bachelor’s students working in our lab and co-developed the final prototypes. In each project, we intentionally left our feature proposals open-ended to create a space for our collaborators to reflect their own expertise on the design process. Accordingly, the fidelities and mediums of our final demonstrations were shaped based on the collaborator’s background. In MFP, we built a semi-working prototype by working with an electrical engineer, while in MM, we built a video because we worked with a visual arts student. To reach the final version of the FB prototype, we collaborated with the interaction designers in our research lab. We continuously consulted their opinions, treated their ideas as members of the design team, and revised our models based on their feedback. For FB, we also iterated the prototyping medium continuously by experimenting with new materials in each new version. After moving to 3D printing for the prototyping medium, the iterations focused on the physical features of the object, such as device dimensions, form, ergonomics, and UI. We completed the design of FB by creating a total of eleven iterations of the prototype. The first four iterations were prototyped in various mediums (e.g., cardboard, clay), and the last three were prototyped using 3D printing and modeling.

Iterating the physical forms and the features of the prototype was at the center of the design process. While making iterative decisions, we constantly searched for feedback from designers and experts working in product development. In that sense, the ongoing dialog between what is and what might be is informed by collaboration [70].

Pursuing a Research Agenda with the Oversight of Industry

The findings of this research are challenging to communicate with the industry as they mainly propose intellectual impact rather than financial benefits [44]. As an alternative approach to the common research contributions in HCI, which reportedly lack thinking about productization [44], the formal training of the main researcher in addition to the funding received by an industry partner guided our research agenda for pursuing an object oriented process if not a product.

This lens polarized the aim of this work on building tangible prototypes, while also considering their potentials in the industry by working with engineers and designers actively working in the industry. Collaborating with the industry helped us communicate this project to experts in technical evaluation studies. In return, we pointed to several directions for increasing the innovative potential of industry-based research.

To explain, we presented user characteristics (Paper 1 – User exploration) along with three themes explaining the everyday interactions with food, ten design directions (Paper 2 – Design implications) and design considerations for two cases (Paper 4 – MFP in restaurants and Paper 5 – FB in travel). These findings may be utilized in design futuring or codesign workshops as they uncover nascent areas for future artifact designs. Moreover, the Design Recommendations (DR) present actionable opportunities for research in industry, that may lead to innovative product solutions.

It is of course a challenging task for the industry to make use of these findings, yet we believe this project demonstrates a significant step towards bridging the forever debated gap between academia and industry. As the main researcher of this project, I will continue working in the industry and will try to take an active role for making this possible.

Limitations and Future Works

Our initial focus in this study was on the domestic kitchen, which we later broadened by working with designers and examining travel and restaurant contexts to make our final inferences. Yet, we acknowledge that the scope of the concepts we proposed in this study was limited. Although we are content that we achieved fruitful results that could inspire future product development processes, our concepts, and prototypes shed light on only a part of the picture. The study of design space that we propose in Chapter 4 is meaningful for discussing the broader impact of this thesis. However, that line of research could be grounded further by extending the speculative dataset of designer ideas (Paper 2- Design implications and Paper 3 – HFI design space extension). These designs could be replicated and trialed with rapid prototypes in more cases, expanding the data and case set. This study may yield future-oriented, user-based knowledge for the design space of future artifacts. To pursue this research path, we propose a two-stage roadmap that will increase the broader impact of this thesis.

Step 1: Extend the design interventions

One of the foremost potentials this thesis left untapped is publicizing the MM demonstration video and collecting user insights on the potential impacts of this concept. In addition to this study, we suspect the proposed artifacts' have hindered impacts in different contexts. To explain, a further inquiry would pursue a research question exploring Foodiebuddy in the domestic context. In this step, new possible research artifacts may also be developed. The main aim is to extend the cases to other contexts in which food is experienced (e.g., workplaces, educational spaces, public spaces, space missions). If this study is completed, this study may yield a future publication (**Potential Paper 6**)

Step 2: Map the design recommendations on the HFI design space

If the cases in the previous stage are multiplied enough to represent an image of the multilayered landscape of human-food interactions, a map can be generated from the design knowledge these inquiries reveal. Afterward, a study can be conducted in which the relationship of this map with the HFI design space and taxonomy is analyzed using quantitative and qualitative methods [3, 22, 35].

Reflections on the PhD Journey and Working in the HFI

Working with food was at first a little intimidating for a young researcher like me. After all, food is such a wide field of study, finding a focal point is highly challenging. In the earlier steps, during the interviews with kitchen users, I realized that talking about food experiences reveals intimate and personal memories. Almost all participants were eager tell stories about their everyday food experiences. All these stories about different diets, different cooking styles, recipes, habits, and preferences are in constant flux and are unique. I was either lucky to have talkative participants, or food is such a medium that pushes people to talk. I tend to believe the latter. This potential of food as a study subject helped me as a researcher to obtain quite fruitful datasets.

Building on this, integrating the walking and talking method at the final stage made me realize the diversity of study design possibilities in HFI research. Having participants engage in real-life and interact with food during the tours have significantly enhanced idea generation. This approach also enabled participants to better reflect their genuine thoughts. Similarly in brainstorming workshops, even though it was not part of the study itself, the snacks we provided to participants stimulated their brainstorming processes. Overall, my experience with food shows that it is something that breaks down social barriers and encourages individuals to be more playful. For this reason, studies related to food should not shy away from being “messy”. My biggest resentment regarding my PhD journey is that I did not embrace more “messy” study designs that involve food in a structured manner. Consequently, I recommend future research in the field of food design to incorporate food experiences as much as possible when designing studies. Thus, allowing a deeper exploration of the interactions with food and digital technologies.

Concluding Remarks

In this dissertation, we set out to understand *“What insights can we gain for design research and practice through designing human-food interactions that support everyday food experiences?”*. We achieved our expected key contributions by formulating *design recommendations (KC3)* that will guide future HFI innovations through designing *food-*

experiencing artifacts (KC2) based on *user insights (KC1).* The key contributions are the main outcomes that contributed insights into our main research question designed for HFI research and practice.

Based on this main aim and research we elaborately described in this thesis, we concluded by presenting five design recommendations (DR) that are ordered by their level of novelty: *(1) limits and boundaries of food, (2) bodily food-experience activities, (3) sharing activities around food, (4) spatial elements that complete food experience and (5) the utility and pleasure tradeoff.* As discussed in the thesis, DR has potential to provide direct input to the industry. We underline that this is the most striking aspect of this research, however, further experiments are needed to see how to reflect the outcomes as inputs for the industry. Overall, all outcomes of RtD in this research can be reported in a future publication (**Potential Paper 8**). In this respect, we explain the broader impact of each DR followingly:

1) This study is the first to link artifact design with the notion of taste limits and boundaries based on food technology neophobia (FTN). This is important because it relies on empirical user data, which forms a solid ground for shaping future HFI innovations. However, to verify the impact of focusing on these boundaries, future research is needed to collect wider user insights through artifact-based research. This study initiates the first insights into this inquiry, thus extending it to the applicable cases, which could be beneficial.

2) As we detailed in Chapter 2 and Chapter 6, previous research explored embodied interactions in HFI. The novelty of this study lies beneath the initial basis of bodily interactions in traveling and restaurants. We highlight the importance of uncovering authentic and valuable bodily interactions embedded in different contexts for inspiring design projects. However, conducting future inquiries in this direction may yield fruitful new research questions. In that sense, this study forms an initial basis that future research may build on.

3) Food-sharing practices have been previously investigated for fostering emotional connections in HFI [36]. In this study, we present comprehensive results showing which food-related data could be included in the design of HFI innovations. This is important because we present a more definitive basis for shepherding HFI innovations to be more adaptable to real-life scenarios. However, further elaboration of the food-related data and building an algorithm for information transfer may be

needed to achieve better product concepts.

4) External elements, especially the spatial design, affect the overall food experience. In this study, we exemplified in two cases how to transfer this knowledge while designing artifacts for real-life scenarios. Although implementing spatial components into the design of product systems is not new, we present the case of eating while traveling. The restaurant context was also commonly studied in HFI. However, we present a case focusing on designing a mobile device that confirms and extends the knowledge ecosystem in HFI. Based on this conclusion, we suggest that future inquiries may focus on new food-experiencing contexts when studying product families, as well as reevaluating existing contextual knowledge.

5) The field of HCI is swarmed with discussions that show how to design utility and pleasure in different contexts. We confirmed that these two affordances may be designed together based on device modes in two cases. Thus, we imply that this work sheds light on discussions on how to design HFI innovations.

In conclusion, the most novel finding of this research points to celebratorily approaching food-related limits and boundaries. Furthermore, this study is important because it presents results that confirm and extend the design knowledge on bodily experiences, food-sharing activities, spatial design, and how to design utility and pleasure. However, since the current study provides a case-specific account of designing HFI artifacts, further research is needed to interpret these findings to increase its broader perspective. In Chapter 8 - Reflections, we illustrated a two-step roadmap for increasing the broader implications of the current study. With this lens, the outcomes of this inquiry point to critical directions for future HFI innovations and open paths for future research.

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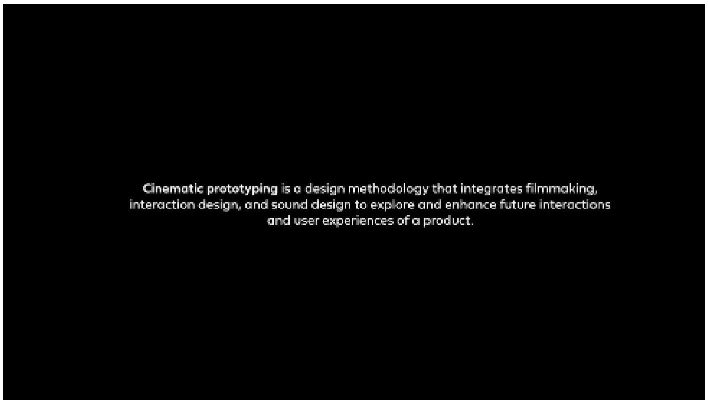
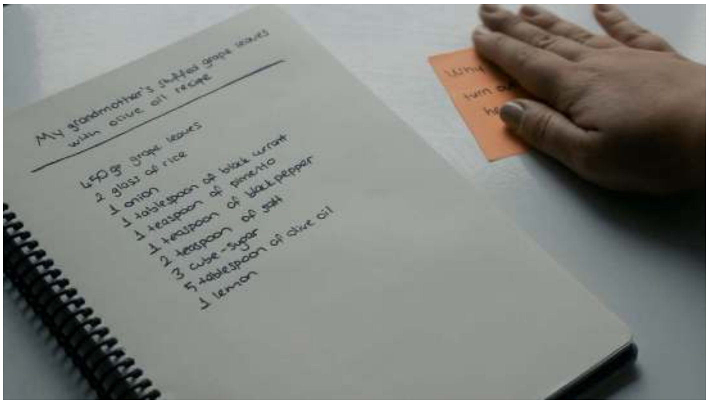
APPENDICES

Appendix 1 - Video screenshots of Motion Master (MM) cinematic prototype.



Intro about Cinematic Prototyping and Motion Master (MM) concept



User puts the note on their recipe book aside. There is sarma recipe written on the notebook.

User opens the MM package and takes out the digital screen to set up

Digital screen of MM

User takes dishes from kitchen counter

Places the dishes on the table to setup the mise en place for *sarma*

User pours oil using the hand cartridges

now pours tomato puree using the hand cartridges

User prepares the rice filling on stove

Sits on the table and takes out one leaf

[Flashback] Grandmother's hands rolling sarma

User starts rolling sarma with MM

completes the hand movement with the MM movement guidance

[Flashback] Grandmother carefully placing each sarma in the pot

User carefully places sarmas one by one with the guidance of MM

After they are cooked, user enjoys the sarmas

She looks at her initial note on the recipe book and throws it away

And finishes with a new note on the recipe book

Appendix 2 - User identification survey questionnaire.

3D Food Printer Teknolojilerinin Erken Adaptasyonuna Etki Eden Faktörlerin İncelenmesi

KATILIMCILAR

Bu araştırmada kullanılacak örneklem havuzu Arçelik A.Ş. tarafından sağlanacaktır. Şirket içerisinde olası araştırmalara katılmak üzere 'gönüllü katılımcı havuzu' oluşturulmuş ve bu araştırma için de bu havuzun kullanılması önerilmiştir. Araştırmaya katılımcılar şirket içerisinden yapılacak e-mail bilgilendirilmesi ile davet edilecek, ve takip eden 7(yedi) gün içerisinde soruları cevaplamaları beklenecektir. Örneklem havuzunda toplam 1096 potansiyel katılımcı bulunmaktadır. Önceki çalışmalara bakılarak bu çalışmada anlamlı bir veri elde edilebilmesi için katılımcı sayısı alt sınırı 50 kişi olarak belirlenmiştir. Ankete katılım oranı analize ve bu çalışmanın raporuna dahil edilecektir.

YER

Çalışmanın uzaktan gerçekleştirilen doğası gereği katılımcılar bu çalışmaya istedikleri herhangi bir yerden katılabileceklerdir. Katılımcılar ile soruları cevaplayabilecekleri link paylaşıldıktan sonra internet bağlantısı olan herhangi bir bilgisayar, cep telefonu veya tablet üzerinden soruları cevaplayabileceklerdir.

ANKET SORULARI

0. Introduction & Consent Form

BİLGİLENDİRİLMİŞ GÖNÜLLÜ OLUR FORMU

Koç Üniversitesi Medya ve Görsel Sanatlar Bölümü öğretim üyesi Prof. Oğuzhan Özcan tarafından yürütülen, Koç Üniversitesi Etik Kurulları'nın [Etik Kurul onay numarası] sayılı onayı ile izin verilen, 3D Food Printer Teknolojilerinin Erken Adaptasyonuna Etki Eden Faktörlerin İncelenmesi başlıklı araştırmaya katılımınız rica olunmaktadır.

Bu araştırmaya tamamen kendi iradenizle, herhangi bir zorlama veya mecburiyet olmadan gönüllü olarak katılımınız esastır. Lütfen aşağıdaki bilgileri okuyunuz ve katılmaya karar vermeden önce anlamadığınız her hangi bir husus varsa çekinmeden sorunuz.

ÇALIŞMANIN AMACI (Neden böyle bir araştırma yapmaya gerek duyuldu?)

Bu çalışma ileride geliştirilecek 3D Food Printer Tasarımları için kullanıcı odaklı veriler elde etmeyi hedeflemektedir. Demografik, sosyo-kültürel, sosyo-ekonomik ve yaşam biçimi etmenlerinin yenilikçi gıda teknolojilerine, özellikle de 3D Food Printing'e yaklaşım üzerine etkileri incelenecektir.

PROSEDÜRLER

Bu çalışmaya gönüllü katılmak istemeniz halinde yürütülecek çalışmalar şöyledir:

Bu çalışma online yürütülen bir anket çalışmasıdır.
Bu çalışmaya katılmak için sizinle paylaşılmış linkteki soruları internet erişimi olan herhangi bir cihazdan (bilgisayar, akıllı telefon, tablet vb.) cevaplamanız yeterlidir.
Anketi cevaplamak yaklaşık 15 dakika sürmektedir.

OLASI RİSKLER VE RAHATSIZLIKLAR

Bu çalışma normal yaşam deneyimlerini bozmayı veya manipüle etmeyi önermemekte ve herhangi bir yanıltma içermemektedir. Bu çalışmaya katılmanız sizin için günlük hayatta karşılaşabileceklerinizden daha fazla bir risk taşımamaktadır.

TOPLUMA VE/VEYA GÖNÜLLÜLERE OLASI FAYDALARI

Bu projede, geçtiğimiz yıllarda mutfak teknolojileri araştırmalarında oldukça popüler bir konu olan 3D Food Printer teknolojilerinin tasarlanması için kullanıcı odaklı kriterler ortaya çıkarmak hedeflenmiştir. Bu nedenle bu çalışma, yenilikçi mutfak teknolojilerinin geliştirilmesine yardımcı olacaktır.

Bu çalışmaya katılım size somut bir fayda sağlamamaktadır. Ancak bu çalışma sizlerin yenilikçi gıda üretim teknolojileri ve bu teknolojilerin olası kullanım alanları konusunda farkındalığınızın artmasına yardımcı olacaktır.

GİZLİLİK

Bu çalışmayla bağlantılı olarak elde edilen ve sizinle özdeşleşmiş her bilgi gizli kalacak, 3. kişilerle paylaşılmayacak ve yalnızca sizin izniniz ile ifşa edilecektir.

Vermiş olduğunuz tüm bilgiler, sınırlı erişime sahip güvenli ve şifreli bir veri tabanında tutulacaktır.

KATILIM VE AYRILMA

Bu çalışmanın içinde olmak isteyip istemediğinize tamamen kendi iradenizle ve etki altında kalmadan karar vermeniz önemlidir.

Katılmaya karar verdikten sonra, herhangi bir anda sahip olduğunuz herhangi bir hakkı kaybetmeden veya herhangi bir yaptırıma maruz kalmadan istediğiniz zaman ayrılabilirsiniz.

ARAŞTIRMACILARIN KİMLİĞİ

Bu araştırma ile ilgili herhangi bir sorunuz veya endişeniz varsa, lütfen iletişime geçiniz:

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Yukarıda açıklanan prosedürleri anladınız, sorularınız tatmin olacağınız şekilde yanıtlandıysa ve dilediğiniz zaman ayrılma hakkınız saklı kalmak koşulu ile bu çalışmaya katılmayı onaylıyorsanız lütfen aşağıda 'Çalışmaya katılmayı onaylıyorum' seçeneğini işaretleyiniz. Bu formun bir kopyasını elde etmek için lütfen araştırmacı ile iletişime geçiniz.

1. Demographics

1. **Yaşınızı öğrenebilir miyiz?**
   Dropdown list. 18-90

2. **Cinsiyetiniz?**
   Kadın
   Erkek
   Diğer…

3. **Hangi şehirde yaşıyorsunuz?**
   Türkiye şehirleri.

   3.1 *Condition*: If answer to 3 is 'İstanbul': İstanbul'da hangi semtte yaşıyorsunuz?
   İstanbul ilçeleri dropdown list.

4. **Kendinizi nereli olarak tanımlarsınız? Lütfen bir şehir belirtiniz.**
   Türkiye şehirleri.

5. **Sahip olduğunuz en yüksek eğitim derecesi nedir?**
   İlkokul mezunu
   Ortaokul mezunu
   Lise mezunu
   Lisans derecesi
   Yüksek lisans derecesi
   Doktora derecesi
   Diğer…

6. **Medeni durumunuz?**
   Evli
   Bekar
   Belirtmek istemiyorum.
   Diğer…

7. **Çocuğunuz var mı? Varsa kaç tane?**
   Yok.
   Çocuğum var.
   Belirtmek istemiyorum.

   6.1 *Condition:* If answer to 6 is 'Çocuğum var.'
   Kaç çocuğunuz var?
   1, 2, 3, 4, 5, 6, 7, 7+
   Belirtmek istemiyorum.

   6.1.1 *Condition*: If answer to 6.1 is '1'
   Çocuğunuz hangi yaş aralığında?
   0-5 , 6-12 , 12-18 , 18 ve üzeri
   Belirtmek istemiyorum.

   ***Condition*: If answer to 6.1 is '2' or '3' or '4' or '5' or '6' or '7' or '7+'**
   Çocuklarınız hangi yaş aralıklarında? Lütfen tüm çocuklarınızın yaş aralıklarını işaretleyiniz.
   0-5 , 6-12 , 12-18 , 18 ve üzeri
   Belirtmek istemiyorum.

2. Socio-cultural factors

8. Geçtiğimiz hafta içerisinde aşağıdakilerden hangilerini güncel haberleri takip etmek için kullandınız? Lütfen size uygun olduğunu düşündüğünüz tüm seçenekleri işaretleyin.

Televizyon
Radyo
Gazete
Basılı Dergi
Bilgisayar (Masaüstü veya Dizüstü)
Cep telefonu (örn. Akıllı telefon)
Tablet
Smart TV
Diğer…

9. Güncel haberlerle ne kadar ilgilisinizdir? (5-point Likert scale)

1.Çok ilgiliyimdir - 7. Hiç ilgilenmem

10. Aşağıdakilerden hangileri güncel haberleri takip ettiğiniz kaynaklardandır? Lütfen size uygun olduğunu düşündüğünüz tüm seçenekleri işaretleyin.

Televizyon haberleri
İnternet blogları
Sosyal medya (Twitter, Instagram, Facebook vb.)
Haber siteleri
Cep telefonu uygulamaları
Diğer…

11. Bir günde kendinize kaç saat vakit ayırırsınız?

1-24 Slider

12. Boş zamanlarınızda yapmaktan en çok hoşlandığınız aktivite nedir?

Açık uçlu cevap

13. Bir önceki soruda belirttiğiniz boş zaman aktivitesini ne sıklıkta yaparsınız?

Günde 1'den fazla
Her gün
Haftada 2-3
Haftada bir
Ayda bir
Diğer…

14. Peki bu boş zaman aktivitesini daha sık yapmak ister miydiniz?

Evet
Hayır

15. Sosyal medya'da günlük ortalama ne kadar vakit geçirirsiniz?

0-24 slider

16. Lütfen aşağıdaki ifadelere ne derece katıldığınızı işaretleyiniz.

(5-point Likert / 1-Kesinlikle katılmıyorum / 5-Kesinlikle katılıyorum.)

Sosyal medyada oldukça aktif biriyimdir.

Haftada bir sosyal medyada paylaşımda bulunurum.

Güncel teknolojilerdeki gelişmeleri takip ederim.

Merak ettiklerimi araştırmak için harcadığım zaman benim için vakit kaybıdır.

Boş zamanlarımı yemek yaparak geçirmek beni memnun eder.

3. Socio-economic factors

17. Yaşadığınız evde aylık gelirin yaklaşık yüzde kaçı sizin kazandığınız payı oluşturuyor?
Slider (1-100 arası)

18. Hanenizin toplam aylık geliri hangi aralıkta kalır?
1.000 tl'den az
1000 – 3000 arası
3000 – 5000 arası
5000 – 10000 arası
10000 +
Bu soruya cevap vermek istemiyorum.

4. Accomodation & Daily life (food culture)

19. Yaşadığınız evi aşağıdakilerden hangisi en iyi tanımlar?
1+0
1+1
2+1
2+2
3+1
3+2
4+1
4+2
Diğer…

20. Yaşadığınız evde kaç kişi yaşıyor?
Sayı ile belirtiniz…

21. Ne kadar zamandır bu evde yaşıyorsunuz?
Dropdown list (0-1 yıl, 1-2 yıl, 3-5 yıl, 5-10 yıl, 10-15 yıl, 15-20 yıl, 20-30 yıl, 30 yıl'dan fazla)

22. Yaşadığınız evde yemek yapma sorumluluğunun yüzde kaçı sizdedir?
Slider (0-100)

23. Günde ortalama kaç saatinizi yemek yapmaya ayırırsınız?
Slider (0-24)

24. Lütfen aşağıdaki ifadelere ne derecede katıldığınızı işaretleyin.
(5-point Likert / 1-Kesinlikle katılmıyorum / 5-Kesinlikle katılıyorum.)

Yeni teknoloji mutfak aletleri kullanmak yemek yapmayı kolaylaştırır.

Boş zamanlarımda yemek yapmak beni mutsuz eder.

Mutfakta kullandığım araçların sık sık değişmesi beni rahatsız etmez.

Yeni yiyecekler denemekten keyif alırım.

Yemek yapmak eğlenceli bir aktivitedir.

Birisiyle birlikte yemek yapmak beni eğlendirir.

Sosyal medyada yemekle ilgili sayfalar takip ederim.

25. Gıda alışverişinizi nerelerden yaparsınız? Lütfen size uyduğunu düşündüğünüz tüm seçenekleri işaretleyiniz.
Süpermarket

Yerel market zincirleri
Manav
Bakkal
Mandıra
Pazar
Organik dükkanlar
Online market (Migros, getir, banabi vb.)
Diğer…

26. Aşağıdaki aktiviteleri hangi sıklıkta yaparsınız? Lütfen bugün içinde bulunduğunuz koşulları düşünerek cevaplayınız.

Evde yemek yapmak

Yemek yemek için dışarıya çıkmak

Eve yemek sipariş etmek

Başka birisi için yemek pişirmek (komşu, arkadaş, ev arkadaşı, akraba vb.)

Hiçbir zaman
Günde 1'den fazla
Günde 1
Haftada birkaç kez
Haftada 1
Ayda birkaç kez
Ayda 1
Ayda 1'den az

5. Familiarity to kitchen technologies

27. Mutfağınızda aşağıdakilerden hangileri var? Lütfen size uyan tüm seçenekleri işaretleyin.

Beyaz eşyalar:
Standart buzdolabı
Akıllı buzdolabı
Derin dondurucu
Bulaşık makinesi
Pişiriciler:
Ekmek makinesi
Tost makinesi
Ekmek kızartma makinesi
Çok amaçlı pişirici
Slow cooker
Fritöz
Yumurta pişirme makinesi
Ankastre fırın
Mini fırın
Ocaklı fırın
Mikrodalga fırın
Buharda pişirici
İçecek hazırlama:
Türk kahvesi makinesi
Filtre kahve makinesi
Çay makinesi
Kettle
Katı meyve sıkacağı
Kahve Öğütücü
Karıştırıcı & doğrayıcı:

Blender
El blenderı
Mikser
Doğrayıcı
Mutfak robotu
Kıyma makinesi
Yoğurt yapma makinesi

28. Evinizde bulunmasını istediğiniz başka bir cihaz var mı?
Same list as above.

29. Mutfağınızda bulunduğunu belirttiğiniz ev aletlerinden en sık kullandığınız hangisidir?
Single choice

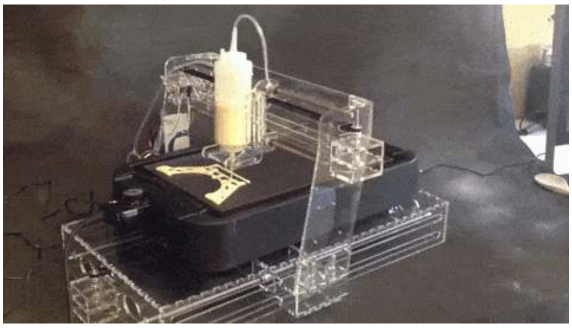
30. Mutfağınızda bulunduğunu belirttiğiniz ev aletlerinden en az kullandığınız hangisidir?
Single choice

31. Aşağıdaki teknolojilerden hangilerini daha önce duydunuz?
3D Printer
3D Food Printer
CNC Kesici
Su jeti ile doğrama
Lazer kesici

32. Aşağıdaki teknolojilerden hangilerini daha önce kullandınız veya kullanıldığını gördünüz?
3D Printer
3D Food Printer
CNC Kesici
Su jeti ile doğrama
Lazer kesici

6. Willingness to try Food Printing

3D Food Printer şırıngası içerisinde bulunan püre halindeki gıda malzemesini katmanlar halinde üst üste dizerek, bilgisayar ortamında tasarlanmış 3 boyutlu formlar oluşturabilen cihaza verilen isimdir.



3D Food Printer Örneği

Bu çalışmanın ana konusu olan 3D Food Printer'ların tasarımı için kullanıcı ihtiyaçlarının anlaşılması gelecekte mutfak araştırmalarının gelişimi için büyük bir öneme sahiptir. Bugüne kadar yapılan çalışmalar bu teknolojinin bize sağlayabileceği avantajlar ve dezavantajlardan bazılarını aşağıdaki gibi göstermişlerdir.

Bu avantajların bazıları şunlar:
- Çok farklı şekillerde / formlarda estetik görüntüye sahip yiyecekler üretmek.
- Besin değerlerinin dijital olarak kontrol edilebilirliği.

- Gıda atığını azaltma potansiyeli.
- Yemek yapan kişi için yaratıcılık yelpazesinin genişlemesi.
- Çok tekrar eden / yorucu işlerin yerini almak.
- Et alternatifi yiyecekler üretmek için bitki veya hayvan proteinleri kullanabilir.

Bu teknolojinin dezavantajları ise:
- Gıda üretim süresinin oldukça yavaş olması.
- Yalnızca püre halindeki malzemelerin kullanulabilmesi.
- Mutfakta bugün kullandığımız malzemelerin (örn. Domates, biber) kullanılabilmesi için ön işlem gerekmesi.
- Üretilen geometrik formların tabakta uzun süre stabil biçimde kalması zor.
- Üretilen yiyeceğin pişirme sırasında formunun bozulması.

3 boyutlu şekerlemeler

Hayvan veya bitki proteini kullanılarak üretilmiş bir et alternatifi

Yeme zorluğu çekenler için püre halinde üretilmiş yiyecekler

(Daha fazla bilgi sahibi olmak ve kaynak listesine erişmek için araştırmacı ile iletişime geçebilirsiniz.)

33. Yukarıda okuduklarınızı ve varsa geçmiş bilgilerinizi göz önünde bulundurarak siz 3D printer ile üretilen bir yiyeceği tüketmeye nasıl bakarsınız? (7-point Likert scale)

7. Food Technology Neophobia Scale (FTNS [2-4])

****Translation is done using Back-translation method.** [5]

34. Lütfen aşağıdaki ifadelere ne derece katıldığınızı işaretleyin. (7-point Likert scale)
(1-Kesinlikle katılıyorum / 7-Kesinlikle katılmıyorum)
((R) ile işaretlenmiş sorularda ölçek, anlam zıtlığından dolayı tersine çevrilmiştir.)

Yeni yiyecek teknolojileri gerekli değildir.

1. **Çevremizde halihazırda yeterince lezzetli yiyecek olduğundan, yeni yiyecek teknolojilerini kullanarak daha fazlasını üretmeye ihtiyacımız yok.**
2. **Yeni yiyecek teknolojilerinin yararları fazlasıyla abartılıyor.**
3. **Yeni yiyecek teknolojileri, yiyeceklerin doğal kalitesini düşürüyor.**
4. **Tükettiğim yiyecekler zaten yeteri kadar iyi olduğundan, yüksek teknoloji kullanılarak üretilen yiyecekleri denemek anlamsızdır.**
5. **Yeni yiyecekler, geleneksel yiyeceklere göre daha sağlıklı değildir.**
6. **Yeni yiyecek teknolojileri emin olmadığım bir konudur.**

Risklerin algılanması

7. **Toplum, yiyecek ile ilgili sorunlarını çözmek için ağırlıklı olarak teknolojiye bağımlı kalmamalıdır.**
8. **Yeni yiyecek teknolojilerinin, uzun vadede olumsuz çevresel etkileri olabilir.**
9. **Yeni yiyecek teknolojilerine çok hızlı geçişin riskleri olabilir.**
10. **Yeni yiyecek teknolojilerinin, uzun vadede sağlığımıza olumsuz etki etmesi pek mümkün değildir. (R)**

Sağlıklı seçim

11. **Yeni yiyecek teknolojileri kullanılarak üretilen yeni ürünler, insanların dengeli beslenmesine yardımcı olabilir. (R)**
12. **Yeni yiyecek teknolojileri, insanlara yiyecek seçimleri için daha fazla kontrol hakkı tanır. (R)**

Bilgi-Medya

13. **Medya, genellikle yeni gıda teknolojileri için dengeli ve tarafsız bir bakış açısı sağlamaktadır. (R)**

8. Bir sonraki aşamaya katılım

Bu çalışmada verdiğiniz cevaplar, çok aşamalı bir araştırmanın ilk aşamasının değerlendirilmesinde kullanılacaktır. Bundan sonraki aşamalara katılımınız, bu aşamada olduğu gibi sizin tercihiniz doğrultusunda belirlenecektir.

Sonraki aşamaların yürütülebilmesi için araştırmacı sizinle iletişime geçecektir, bunun için e-posta iletişim adresinizi araştırmacı ile paylaşmanız rica edilmektedir.

GİZLİLİK

Bu çalışmayla bağlantılı olarak elde edilen ve sizinle özdeşleşmiş her bilgi gizli kalacak, 3. kişilerle paylaşılmayacak ve yalnızca sizin izniniz ile ifşa edilecektir. Vermiş olduğunuz tüm bilgiler, sınırlı erişime sahip güvenli ve şifreli bir veri tabanında tutulacaktır.

Çalışmanın bundan sonraki aşamalarına katılmak istiyorsanız, lütfen aşağıdaki soruda 'Sonraki çalışmalara katılmak istiyorum.' seçeneğini işaretleyerek e-posta iletişim bilgilerinizi paylaşınız. Sonraki çalışmalara katılmayı tercih etmeniz durumunda, her aşamanın başlangıcında katılım şartlarınızı onaylamanız için tekrar bir form doldurmanız rica edilecektir.

35. Bu araştırmanın sonraki adımlarına katılmak istiyor musunuz?
Sonraki çalışmalara katılmak istiyorum.
Sonraki çalışmalara katılmak istemiyorum.

35.1 Condition: If answer to 35 is '*Sonraki çalışmalara katılmak istiyorum.*'
Sizinle iletişim kurabilmemiz için bizimle e-posta adresinizi paylaşabilir misiniz?
Açık uçlu cevap

9. z

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6. Eray Yurtseven, Fatma Eren, Suphi Vehid, Selçuk Köksal, Ethem Erginöz, and M Sarper Erdoğan. 2014. Beyaz Yakalı Çalışanların Beslenme Alışkanlıklarının Değerlendirilmesi Investigation of Nutritional Habits in White Collar Employees. *Kocatepe Tıp Dergisi Kocatepe Medical Journal 15*, 20–6.

Appendix 3 - Semi-structured interview questionnaire.

EK 2 - Araştırma Protokolü

3D Food Printer Teknolojilerinin Potansiyel Erken Kullanıcı Görüşlerinin Derinlemesine Anlaşılması Araştırma Soruları ve Materyalleri

A. KATILIMCILAR

Katılımcılar, 2020.356.IRB2.094 etik kurul karar no.'lu çalışmada, sonraki aşamalara katılmayı istediklerini belirterek iletişim adreslerini paylaşan katılımcılar arasından seçilecektir.

Önceki çalışmanın analiz sonuçlarına göre katılımcılar 3 kategoride gruplandırılacaktır (1. early adopter, 2. enthusiast, 3. non-adopter). Seçilen 3 katılımcı bu 3 grubun her birinden 1 katılımcı olmak üzere seçilecektir. Belirlenen 3 katılımcıdan olumlu geri dönüş alınamadığı durumda çalışmaya davet edilmek üzere, bu kategoriler içerisinde kalan yedek katılımcılar belirlenecektir. Belirlenen 3 kişi ile e-mail yoluyla iletişime geçilerek uygun bir randevu günü ve saati belirtmeleri istenecektir.

B. YER

Çalışma uzaktan gerçekleştirilecektir. Zoom platformu üzerinden (her katılımcı ile ayrı bir toplantı linki paylaşılacaktır) yapılacak görüşmeler sırasında katılımcılardan yaşadıkları evin mutfağında olmaları rica edilecektir. Katılımcılar, Zoom platformunu kullanabilecekleri ve çalışır durumda bir kamerası olan herhangi bir cihaz üzerinden (bilgisayar, tablet, cep telefonu) çalışmaya katılabileceklerdir.

C. GÖRÜŞMELERDE KULLANILACAK SORULAR

0. Bilgilendirilmiş Gönüllü Olur Formu

Bu form, görüşmenin başlangıcında katılımcı ile dijital bir link olarak paylaşılacaktır, katılımcı onayladığı takdirde görüşmeye başlanacaktır.
Form linki: http://koc.ca1.qualtrics.com/jfe/form/SV_eb7dqb8vVDhFcWh
Bu aşamada sadece onam formunu doldurunuz. Sizden sekmenizi açık tutmanızı rica ediyorum. Bu formdaki diğer soruları görüşmenin en sonunda doldurmanızı rica edeceğim.

Bilgilendirilmiş Gönüllü Olur Formu
Koç Üniversitesi Medya ve Görsel Sanatlar Bölümü öğretim üyesi Prof. Oğuzhan Özcan tarafından yürütülen, Koç Üniversitesi Etik Kurulları'nın [Etik Kurul onay numarası] sayılı onayı ile izin verilen, **'3D Food Printer Teknolojilerinin Potansiyel Erken Kullanıcı Görüşlerinin Derinlemesine Anlaşılması'** başlıklı araştırmaya katılımınız rica olunmaktadır.

Bu araştırmaya tamamen kendi iradenizle, herhangi bir zorlama veya mecburiyet olmadan gönüllü olarak katılımınız esastır. Lütfen aşağıdaki bilgileri okuyunuz ve katılmaya karar vermeden önce anlamadığınız her hangi bir husus varsa çekinmeden sorunuz.

ÇALIŞMANIN ADI
3D Food Printer Teknolojilerinin Potansiyel Erken Kullanıcı İhtiyaçlarının Derinlemesine Anlaşılması

ÇALIŞMANIN AMACI (Neden böyle bir araştırma yapmaya gerek duyuldu?)
Bu çalışma ileride geliştirilecek 3D Food Printer Tasarımları için kullanıcı odaklı veriler elde etmeyi hedeflemektedir. Günlük hayattaki gıda tüketim alışkanlıkları ve 3D Food Printing'e yaklaşım derinlemesine incelenecektir.

PROSEDÜRLER
Bu çalışmaya gönüllü katılmak istemeniz halinde yürütülecek çalışmalar şöyledir:

Öncelikle size uygun bir görüşme zamanı belirlenecektir.

Belirlenen zamanda araştırmacı sizinle Zoom platformu üzerinden 90 dakikayı aşmayacak bir görüşme gerçekleştirecektir.
Bu görüşme sırasında yaşadığınız evin mutfağında olmanız rica edilmektedir.
Görüşmeler yalnızca analizde kullanılmak üzere kayıt altına alınacaktır.
Bu görüşme kapsamında araştırmacı size yenilikçi gıda teknolojilerine bakış açınıza, günlük yemek yapma pratikleriniz, mutfağınızda kullandığınız araçlar ve elektronik eşyalara dair sorular yöneltecektir.
Bu çalışmadaki soruların herhangi bir doğru cevabı yoktur. Sizin deneyimlerinizi ve görüşlerinizi öğrenmek amaçlıdır.

OLASI RİSKLER VE RAHATSIZLIKLAR
Bu çalışma normal yaşam deneyimlerini bozmayı veya manipüle etmeyi önermemekte ve herhangi bir yanıltma içermemektedir. Bu çalışmaya katılmanız sizin için günlük hayatta karşılaşabileceklerinizden daha fazla bir risk taşımamaktadır.

TOPLUMA VE/VEYA DENEKLERE OLASI FAYDALARI
Bu projede, geçtiğimiz yıllarda mutfak teknolojileri araştırmalarında oldukça popüler bir konu olan 3D Food Printer teknolojilerinin tasarlanması için kullanıcı odaklı kriterler ortaya çıkarmak hedeflenmiştir. Bu nedenle bu çalışma, yenilikçi mutfak teknolojilerinin geliştirilmesine yardımcı olacaktır.
Bu çalışmaya katılım size somut bir fayda sağlamamaktadır. Ancak bu çalışma sizlerin yenilikçi gıda üretim teknolojileri ve bu teknolojilerin olası kullanım alanları konusunda farkındalığınızın artmasına yardımcı olacaktır.

GİZLİLİK
Bu çalışmayla bağlantılı olarak elde edilen ve sizinle özdeşleşmiş her bilgi gizli kalacak, 3. kişilerle paylaşılmayacak ve yalnızca sizin izniniz ile ifşa edilecektir.
Vermiş olduğunuz tüm bilgiler, sınırlı erişime sahip güvenli ve şifreli bir veri tabanında tutulacaktır.
Görüşmelerin kayıt altına alınması yalnızca analiz amacıyla kullanılacaktır. Alınan kayıtlar araştırmacı dışında hiç kimsenin erişimine açık olmayacak ve sizinle eşleşmiş herhangi bir görüntü sizin izniniz olmadan kullanılmayacaktır.

KATILIM VE AYRILMA
Bu çalışmanın içinde olmak isteyip istemediğinize tamamen kendi iradenizle ve etki altında kalmadan karar vermeniz önemlidir.
Katılmaya karar verdikten sonra, herhangi bir anda sahip olduğunuz herhangi bir hakkı kaybetmeden veya herhangi bir yaptırıma maruz kalmadan istediğiniz zaman ayrılabilirsiniz.

ARAŞTIRMACILARIN KİMLİĞİ
Bu araştırma ile ilgili herhangi bir sorunuz veya endişeniz varsa, lütfen iletişime geçiniz:

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Yukarıda açıklanan prosedürleri anladınız, sorularınız tatmin olacağınız şekilde yanıtlandıysa ve dilediğiniz zaman ayrılma hakkınız saklı kalmak koşulu ile bu çalışmaya katılmayı onaylıyorsanız lütfen aşağıda 'Çalışmaya katılmayı onaylıyorum' seçeneğini işaretleyiniz. Bu formun bir kopyasını elde etmek için lütfen araştırmacı ile iletişime geçiniz.

1. *Çalışmaya katılmayı onaylıyorum.*
2. *Çalışmaya katılmak istemiyorum.*

1. Yemek alışkanlıkları

Merhabalar, öncelikle görüşmeye katılmayı kabul ettiğiniz için teşekkür ederiz. Bu görüşmenin ilk kısmında size yeme alışkanlıklarınızla ilgili sorular yönelteceğim. İkinci kısımdaysa daha çok 3D food printerlar ve olası kullanım alanları üzerine derinlemesine konuşacağız.

Size tekrar hatırlatmak isterim ki bu görüşmedeki soruların herhangi bir doğru cevabı yoktur. Tamamen sizin görüşlerinizi ve deneyimlerinizi öğrenmek amaçlıdır. Bu anlamda soruları gönül rahatlığıyla istediğiniz gibi cevaplayabilirsiniz. Cevaplamak istemediğiniz soruları geçebilirsiniz.

2.1 Gıda tüketimi

1. Bir günde ortalama kaç öğün yemek yersiniz ve/veya hazırlarsınız? Neler yediğinizden biraz bahsedebilir misiniz?
2. Bu sıralar en sık tükettiğiniz yiyecek/yiyecekler nelerdir? Hangi durumlarda sık yediğiniz yiyecekler değişir?

2.2 Yemek yapma

3. Yemek yapma konusunda kendinizi nasıl bulursunuz? (Örn. Çok iyi yemek yaparım, herkes bana tarif sorar.)
4. Yemek yeme ve yemek yapma alışkanlıklarınızdan ne kadar memnunsunuz? Değiştirmeyi düşünür müsünüz? Neden?
5. Hazırladığınız yiyeceklerin besin değerlerinin sizin için önemi nedir?
6. Tekrar eden veya uzun süren / yorucu, sıkıcı aktiviteler sizce nelerdir mutfakta? Bunları gerektiren yemekleri yapmak size nasıl hissettiriyor?
7. Pratik yemek hazırlamak ne kadar önemlidir? Hangi durumlarda önemlidir sizin için?
8. Sizin için hazırladığınız bir yiyeceğin görünüşü ne ifade eder? Veya size sunulan bir yiyecek?

2.3 Yiyecek alışverişi

9. Nerelerden gıda alışverişi yaparsınız? Aradıklarınızı bulabildiğinizi söyler miydiniz?
10. Bulamadığınız şeyler olduğunda ne yaparsınız?

2.4 Kişisel / yakın çevre ile yapılan yeme ritüelleri

11. Yemek yeme ritüelleriniz var mı? (örn. Pazar kahvaltısı)
12. En son ne zaman size 'özel hissettiren' bir yemek yediniz/hazırladınız? Biraz bahsedebilir misiniz?
13. Sizce yemekle ilgili önemli gelenekler var mı? Evde uyguladığınız şeyler? Bunlardan bahsedebilir misiniz? (örn. Ailenin birlikte sofraya oturması)

2.5 Kültürel yeme ritüelleri

14. Bildiğiniz gibi yılın bazı dönemlerinde kültürel olarak yaptığımız yemekle ilgili şeyler var. (Örneğin ramazanda oruç tutmak, yılbaşı sofrası, aşure dağıtmak vb.) Sen kendini bu aktivitelerle ne kadar ilgili görüyorsun? Bunlardan gerçekleştirdiklerin var mı? Senin için önemi ne?

2.6 Mevsimlere bağlı yeme alışkanlıkları

15. Mevsimlerin değişmesi yemek yeme / yemek yapma aktivitelerinizi nasıl etkiliyor? (Yazın karpuz, kışın balkabağı, yazın hafif yiyecekler tüketmek)

2. 3D Food Printing

3.1 Food printing konsepti

Biliyorsunuz sizinle bir anket çalışması yaptık. Bu ankette 3D Food Printer'lardan bahsetmiştik. Şimdi size 3D Food Printerın ne olduğunu, nasıl çalıştığını hatırlatan bir video izleteceğim. [3D

Food Printer videosu gösterilir]. Videoda gördüğünüz gibi, 3D food printerlar, bir 3D printer aracılığıyla yenilebilir şeyler üretilmesini sağlar. Şimdi size bu ürün ile ilgili birkaç soru sormak istiyorum.

Video linki:
https://drive.google.com/file/d/1AIKr2HSIZ4KYII1Rai2saawFAa3EWI7o/view?usp=sharing

16. Sizce böyle bir ürün size günlük hayatınızda size nasıl faydalar sağlayabilir?
17. Bu ürün hangi durumlarda hayatınızı kolaylaştırır?

3.2 Düşünme kartları

Şimdi sizinle bir link paylaşacağım. [Miro Linki] (https://miro.com/app/board/o9J_lcSmael=/) Bundan sonraki sorularda 3D food printerı kullanabileceğinizi düşündüğünüz ve kullanarak üretmek isteyebileceğiniz yiyecek türlerine yoğunlaşacağız. [Şablon 2 gösterilir] Bu şablonun amacı, sizin isteklerinizi ve beklentilerinizi ifade etmenize yardımcı olmaktır. Burada olmayan ama sizin önermek istediğiniz bir yiyecek varsa boş kutulara yazabiliriz.

18. 3D food printer kullanarak hangi tür yiyecekleri üretebilmek isterdiniz?
19. 3D food printer size bu yiyeceklerin üretiminde nasıl bir fayda sağlardı? [Kullanıcının seçtiği tüm yiyecek türleri için bu soru sorulacak]

Şimdi de 3D food printerı kullanabileceğiniz yemek yapma pratikleriyle ilgili konuşacağız. [Şablon 3 gösterilir] Bu şablonun amacı, sizin isteklerinizi ve beklentilerinizi ifade etmenize yardımcı olmaktır. Burada olmayan ama sizin önermek istediğiniz bir fonksiyon varsa boş kutulara yazabiliriz.

20. 3D food printerı hangi fonksiyonlar için kullanabilmek isterdiniz?
21. Bu fonksiyonlarda 3D food printer size nasıl bir fayda sağlardı? [Kullanıcının seçtiği tüm fonksiyonlar için bu soru sorulacak]

Son olarak;

22. Satın alacağınız birden fazla 3DFP seçeneği olsa, sizin için hangi özellikleri önemli olurdu?

3. Food Technology Neophobia Scale (FTNS [1])

Form linki: http://koc.ca1.qualtrics.com/jfe/form/SV_eb7dqb8vVDhFcWh

1. Lütfen aşağıdaki ifadelere ne derece katıldığınızı işaretleyiniz. (7-point Likert scale) (1-Kesinlikle katılıyorum / 7-Kesinlikle katılmıyorum)
((R) ile işaretlenmiş sorularda ölçek, anlam zıtlığından dolayı analiz aşamasında tersine çevrilecektir.)

Yeni yiyecek teknolojileri gerekli değildir.

1. **Çevremizde halihazırda yeterince lezzetli yiyecek olduğundan, yeni yiyecek teknolojilerini kullanarak daha fazlasını üretmeye ihtiyacımız yok.**
2. **Yeni yiyecek teknolojilerinin yararları fazlasıyla abartılıyor.**
3. **Yeni yiyecek teknolojileri, yiyeceklerin doğal kalitesini düşürüyor.**
4. **Tükettiğim yiyecekler zaten yeteri kadar iyi olduğundan, yüksek teknoloji kullanılarak üretilen yiyecekleri denemek anlamsızdır.**
5. **Yeni yiyecekler, geleneksel yiyeceklere göre daha sağlıklı değildir.**
6. **Yeni yiyecek teknolojileri emin olmadığım bir konudur.**

Risklerin algılanması

7. **Toplum, yiyecek ile ilgili sorunlarını çözmek için ağırlıklı olarak teknolojiye bağımlı kalmamalıdır.**
8. **Yeni yiyecek teknolojilerinin, uzun vadede olumsuz çevresel etkileri olabilir.**
9. **Yeni yiyecek teknolojilerine çok hızlı geçişin riskleri olabilir.**
10. **Yeni yiyecek teknolojilerinin, uzun vadede sağlığımıza olumsuz etki etmesi pek mümkün değildir. (R)**

Sağlıklı seçim

11. **Yeni yiyecek teknolojileri kullanılarak üretilen yeni ürünler, insanların dengeli beslenmesine yardımcı olabilir. (R)**
12. **Yeni yiyecek teknolojileri, insanlara yiyecek seçimleri için daha fazla kontrol hakkı tanır. (R)**

Bilgi-Medya

13. **Medya, genellikle yeni gıda teknolojileri için dengeli ve tarafsız bir bakış açısı sağlamaktadır. (R)**

4. Referanslar

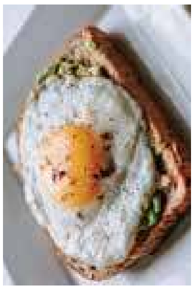
[1] D. N. Cox and G. Evans. 2008. Construction and validation of a psychometric scale to measure consumers' fears of novel food technologies: The food technology neophobia scale. Food Quality and Preference 19, 8: 704–710. https://doi.org/10.1016/j.foodqual.2008.04.005

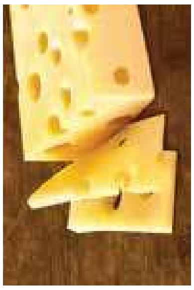
Appendix 4 - Study materials (food images and keywords) used in brainstorming workshops with designers.

Food images and participant reported recipes provided as ideation material in brainstorming workshops.

Omlet / Yumurta

“Sadece bir dakika pişer omletin dışı normalde. Hani kafelere gittiğinizde omlet getirirler ya dışı falan yanmış. O omlet değil. Omlet bildiğiniz bembeyaz bir şey aslında ama bizim ağız tadımıza uygun olan kısmı böyle hafif iyice pişmiş bir omlet. Omleti görüntü olarak 3DFP verirken lezzet olarak elin verebileceğini düşünüyorum, o lezzeti hangisi tutturabilir çok emin olamadığım için ortada kaldım.”
-P9





Peynir / Vegan Peynir

“Bitkisel yoğurt yapabilseydi ben hep vegan beslenirdim herhalde. Ya da kremanın saklama da olabilir. Yoğurt, krema, hatta peynir de yapabiliriz belki. Bu sektörde çok katkı sağlardı bence bu tarz aletler özellikle vegan sektöründe yani. Ben domates soslu şeyleri çok severim. Sos ve krema giriyorsa içine... Nasıl söylenir yani peynir eridiğinde bir görüntü oluşuyor ya, akışkan şeylerden çok hoşlanıyorum soslu vs. o tarz şeyler belki etkili olabilir yani görünüşte diye düşündüm.
-P0, P18

Anime foods

“Animede o yemek sahnesini çok güzel bir şekilde çiziyorlar ve doğraması falan yemek yaparken çıkan bütün sesler çok net bir şekilde... Yani deneyimi çok iyi aktarıyorlar. O yüzden o hem beni görsel olarak çekiyor hem de algımı değiştiriyor yemeğe karşı olan. Hiç lezzetli olmayacağını düşünsem bile, içinde bambaşka hiç sevmediğim sebzeler olsa bile deneyimi çok iyi aktardıkları için canım çekebiliyor. Aslında uzak doğu mutfağını hiç sevmem. Sahne beni çekiyor ve deneyebileceğim ve sevebileceğim şeyleri araştırıp yapma isteği oluşturuyor bende.”
-P19

Bowl / Noodle

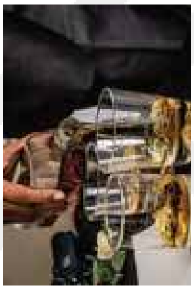
“Kendim eksik kaldığım kısımları oradan tamamlamayı tercih ederim ama şöyle de diyebiliriz mesela bir bowl yapabilmek güzel olur ”
-P14

“Noodle’lar var ya onların içindeki bir baharat beni rahatsız ediyor. Tadını çok seviyorum ama daha sonra o baharat bir problem yaratıyor bende o yüzden onu bırakma sebeplerimden biri oydu yani tamamen bırakmadım ama çok baya azalttım yani.”
-P11

Ahtapot köftesi / Sebze köftesi

“Ahtapot normalde kayış gibi olur ama daha ağızda dağılan bir etkiye gelmesi için iyice püre haline getirip o laktik asidi oluşturan şeyleri uzaklaştırıp sertleşmesini engelleyebilirsiniz. “
P17

“Falafeller pişirirken çokdağılıyor. Ona göre bir çözüm getirilebilir. Mesela mercimek köftesi, nohut köftesi yapabilsem çok güzel olurdu.”
P18



Whiskey

“O yıllanmış tadı yapabiliyorsa bekletmeden önemli olur. Yıllanmış şarap ve viski özelinde önemli olan şey tadı da çok çok çok çok daha güzel oluyor. Pek bilmiyorum ama o yüzden o isterim. Yüz yıllık şarap viski hiç tatmadım ben ama ulaşması zor olan şeyler olduğu için yani pahalı olan şeyleri bize ucuz hale getiriyorsa o benim için çok değerlidir.”

-P10

Biberli et

“Mesela et yaparken önce tam pişmeye yakın biberleri iki parçaya ayırıp -uzun çarliston biberini- böyle bir tat versin diye ekliyoruz. Direk eti kızartmıyoruz sadece aslında yanına biber de atıyoruz.”
-P10

Tavuk dürüm

“Tavuk dürüme önemsiz demek istiyorum, çünkü onun yapılışını falan her şeyini görebiliyorum. İçine konan her şeyi görebiliyorum. Dürüm hazırlama sürecini gözlemleme imkanım oluyor usta yaparken. Bu beni mutlu ediyor bana keyif veriyor izlemek. Keyif veriyor o hazırlanışı izlemek. Yazıcıda öyle değil. Yazıcıda biraz daha katman katman ilerliyor ama bunu başkası hazır ederken gerçek yiyecekleri, gerçek baharatları, gerçek malzemeleri kullanarak yapması daha keyif veriyor.”
-P8

Tarhana (tostu)

“En yakın arkadaşımı ziyaret etmeye gittiğimde orada yapmıştı bana öyle öğrenmiş oldum. Tarhana, yulaf, yoğurt, yumurta ya da alternatifi varsa işte - mesela nohut suyunu karıştırıyoruz. Ondan sonra tost makinesine yağlı kağıt koyup bunu döküyoruz biraz sertleştikten sonra arasına istediğimiz malzemeleri koyup katlıyoruz ve tarhana tostu oluyor. Ki ben tarhana çorbasından çok haz etmem ama tarhananın iyi bir şey olduğunu biliyorum. O yüzden bu şekilde tüketmek beni mutlu etmişti ve evde onu hazırlama süreci beni mutlu ediyor. Onun hamurunu karıştırmak, sonra içine koyacağım domatesleri dilimlemek peyniri dilimlemek beni çok şey yapıyor... Kendime zaman ayırıyorum hissi geliyor. Ve güne onunla başlamak, kendim için bir şey yaparak başlamak beni tatmin ediyor.”
-P12

Paketsiz Gıda

“Atık bazında da düşünecek olursak kabuklu sebzelerin yemekleri ve paketlenmiş halde giren her şey. Bu mercimek de olabilir, kuru fasulye de olabilir, barbunya da olabilir. Markette paket içerisinde satılan herhangi bir şey olabilir. Buna abur cuburları da sokabiliriz hatta.”

“Ben şey de gördüm bu arada, atıştırmalıklardan bir tanesine vegan yazmışlar arkasında süt ürünü var. Yani kontrol eden bir tane bile insan yok biz her şeye tek tek bakmak zorunda mıyız?”
-P12

Hamza Burger

“Bir burger yapıyorlar böyle hamburger gibi düşünebilirsiniz ama içi birçok farklı malzeme ile doldurulmuş durumda yani işte her hamburgerde olan işte sarı peynirinden bütün işte değişik burger etinden falan bunlar hepsi bir arada ve bunlar burger ekmeğine değil de biraz daha böyle poğaça gibi veya pide gibi yapılıyor. Yapması daha zor daha zahmetli bir şey ve onun sıcaklığını ayarlamak işte optimum uygun şeyini susamının detaylarını falan ayarlamak oldukça sıkıntılı dolayısıyla böyle bir şeyi 3 boyutlu yazıcı ile yapabilecek olsam üç boyutlu yemek yazıcısına verirdim. Bence üç boyutlu yemek yazıcısının bunu yapması önemli.
-P8

Turşu

“Şeyden emin değilim mesela uzun sürede olan fermente olması gereken turşu gibi şeyleri 3DFP’dan direk çıkartabilir miyiz? Turşuyu yapabilse önemli olurdu. Çünkü beklemek gerekiyor.”
-P12

List of in-vivo keywords from interviews provided as ideation material in brainstorming workshops.

warn	remind	try
try a new recipe	aspire	seasonality
normal breakfast	goes well together	pandemic
weekdays	quicken	same foods
cultural	crazy food	do not feel like eating
one course meal	pot meal	treat someone
personalize	groundbreaking recipes	combine
fulfilling food	pleasurable	delightful
togetherness	inviting	quickly make
cook sth with	eat alone	accompany
freshly cooked	warm food	simultaneously
being disturbed	visit a friend	have guests
make fancier	ease	share
search	transform	troubleless
troublesome	delight	use my talents
spare time	diligence	go beyond boundaries
keep some people out	common tastes	collaboratively making

List of in-vivo keywords from interviews provided as ideation material in brainstorming workshops.

keep hands busy	remove	have fun
develop	make healthier	order food
peel / remove pits	detoxify	aromatize
more access	change taste	enrich taste
handmade food	vegetarian foods	more variable foods
hard to cook	engineering foods	fresh foods
unite	access local produce	reduce waste
feel like home	exceptional	remembering
childhood favorite	cheaper food	sauces and side dishes
guilt foods	stimulate taste buds	rare foods
mastered foods	suprise myself	suprise others
failed experiments	personal touch	avoid monotony
mouthwatering foods online	pickled food	crazy food
go beyond boundaries	bring industrial production to home	task delegation

Appendix 5 – Foodiebuddy (FB) prototype experiencing protocol (instructions and questionnaire).

Foodiebuddy (FB) Prototype Experiencing Protocol

What do we expect from you in this study?

We expect you to take the prototype we provided when you go out for a meal, either alone or with your friends, and imagine using it, drawing inspiration from the question list below. Throughout this entire experience, actively carry the FB prototype with you and try to use it. While using it, try to imagine the possible features in the most ideal way (without being restricted by technical limitations) and record your thought process.

Throughout the experiment, we kindly ask you to record audio during the experience and share with us the most interesting points of prototype usage through videos and photos. (At least three photos and one video for each step below.)

Contact details to communicate at every stage of the study and for file transfer afterward:

-
-

1. On your way to a meal:

You started walking with Foodiebuddy (FB). At one point during the walk, it paused and gave you a suggestion. Now, take the taste spoons and place them on your tongue. Imagine that you are tasting the food it suggested through the holes on the spoons.

- What might FB have suggested to you? What did the thing you tasted resemble?
- How would you tell FB that you liked or disliked it?
- How would you like to communicate with FB during the walk?
- What other information would you want to share with FB?
- If FB hadn't been there, how would you have chosen a place to eat on today's outing? How did FB change that?

2. During the meal

Now, you have arrived at the restaurant.

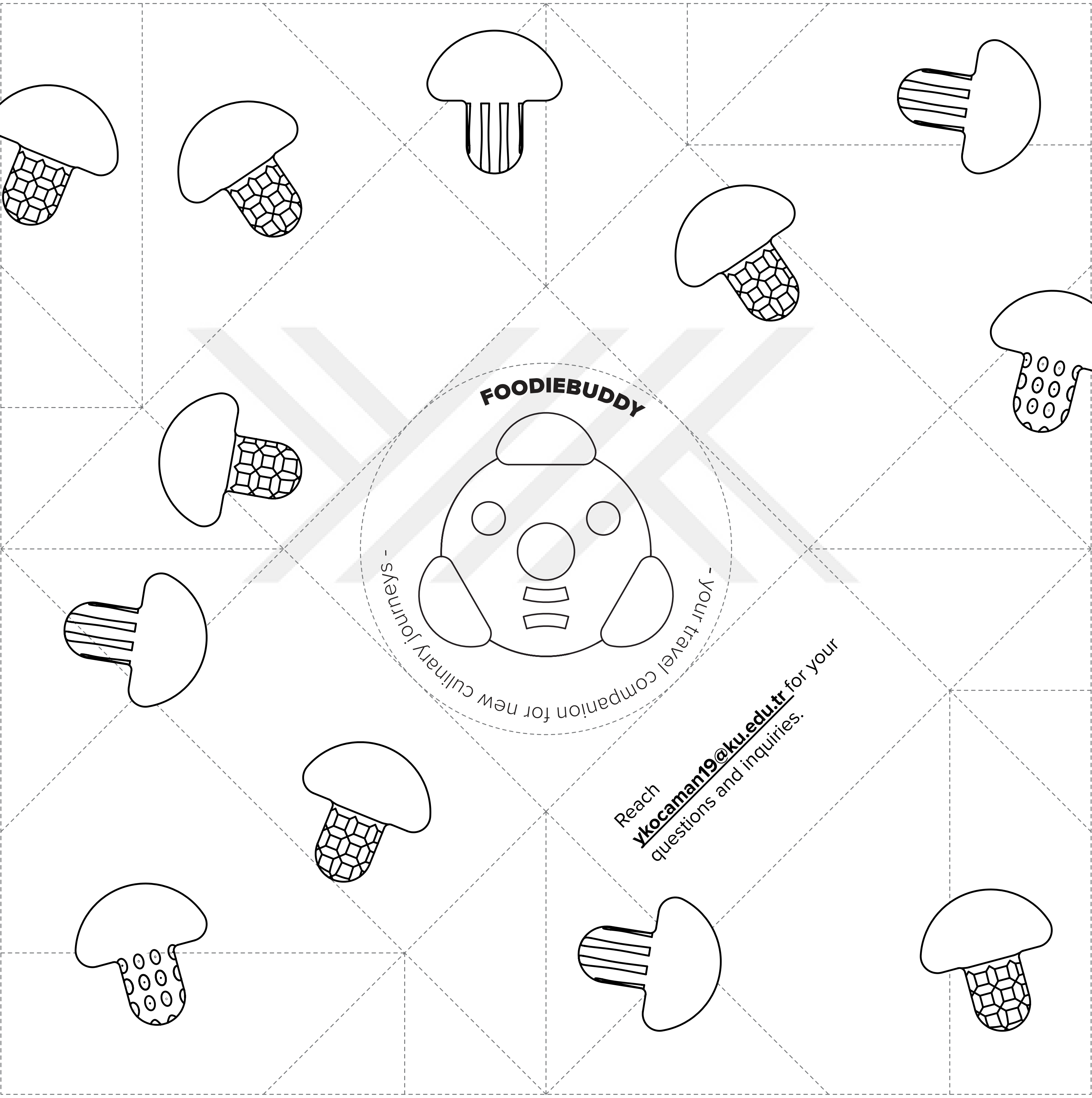
- What was your first impression of this place when you arrived?
- How would you describe the taste you just tried with FB when ordering at the restaurant? How would you use FB for this purpose?
- Could you continue the exploration process with FB in the restaurant you went to? How?
- After placing your order, what would you like to do with FB while waiting for your meal?
- Would you like to continue interacting with FB while eating your meal? How?

3. After the meal

You've finished your meal. Now, you may be completely done with FB. Or maybe not...

- What would you like to do with FB in the final stage of the experience?
- Where would you place FB or what would you use it for?

Appendix 6 – Foodiebuddy (FB) instruction manual and box.


FOODIEBUDDY
- your travel companion for new culinary journeys -
Reach ykocaman19@ku.edu.tr for your questions and inquiries.

FOODIEBUDDY
User Manual

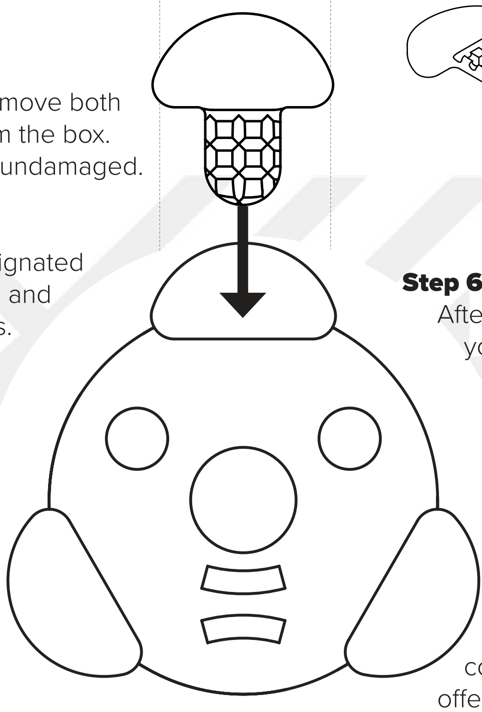
Welcome to a food adventure with Foodiebuddy (FB), your ultimate companion for exploring culinary delights in the city! This user manual will guide you through the steps to make the most out of your FB experience.

Step 1: Unboxing

Carefully open the FB packaging and remove both the FB device and the taste packets from the box. Ensure all components are present and undamaged.

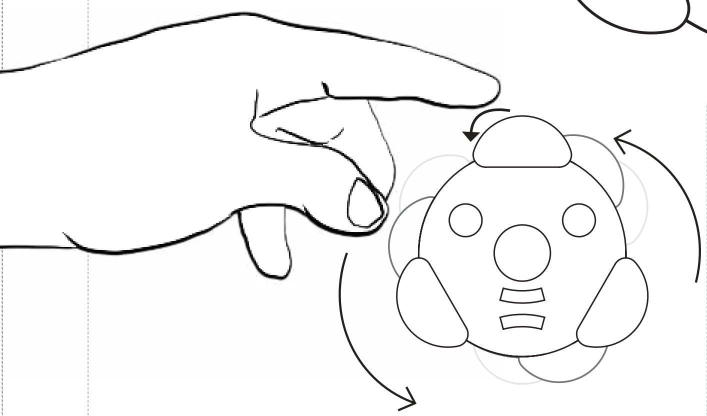
Step 2: Inserting Taste Packets

Locate the holes on your FB device designated for taste packets. Take the taste packets and insert them into the corresponding holes. Pay attention to the orientation: the textured bits of the taste packets should remain inside the FB.



Step 3: Activation

Place your finger on the nose of the FB and spin it twice. This action will activate your FB.



Step 4: Explore!

Once activated, take your FB with you as you explore the city. Keep playing with your FB, as it will stop spinning when it has a suggestion for you.

Step 5: Sampling Tastes

When your FB indicates a suggestion by being stuck, it's time to sample a taste! Place your finger on any of the taste packets and remove it from the FB. Put the texture in your tongue and experience the flavor.

Step 6: Providing Feedback

After tasting, it's time to give feedback to your FB.

If you liked the taste sample, select the like option ( ). Your FB will wink with excitement and will transform into a compass to lead you to the restaurant!

If you disliked the taste sample, select the dislike option ( ) on FB and continue your exploration. Your FB will offer a new taste suggestion for you to try.

Resetting FB

If you don't like any of the foods from the FB's suggestions, spin your FB twice and it will reset its suggestions.

Additional Tips

Charge your FB regularly to maintain optimal functionality. Clean your FB as needed to keep them free from debris and maintain hygiene. Remember, it is dishwasher safe!

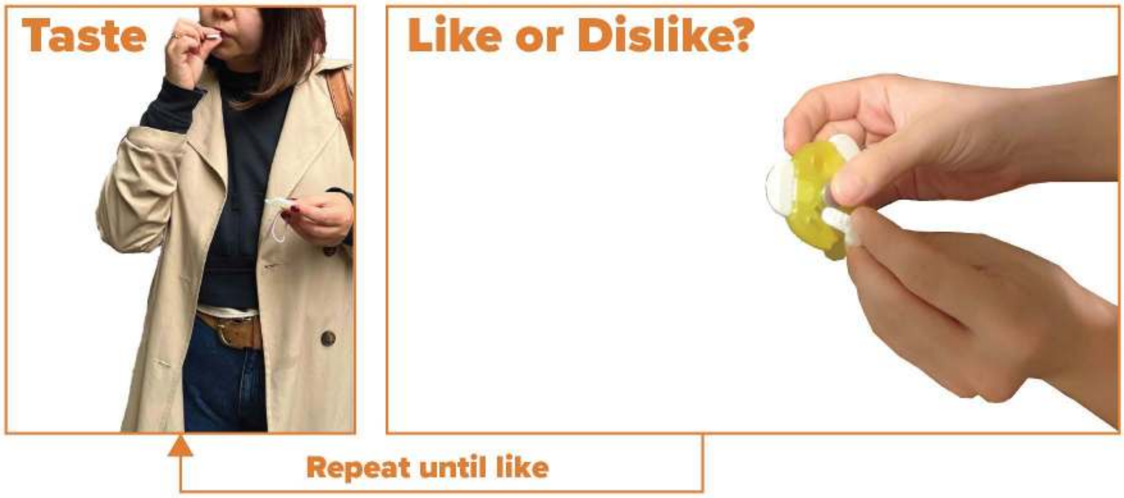
Congratulations! You are now ready to embark on a flavorful journey with your FB. Enjoy exploring the culinary delights with your companion by your side.

Appendix 7 – Foodiebuddy (FB) usage scenario.

Stage 1
Introduction & getting to know the kit.

Stage 2
Starting taste exploration.

Stage 3
Taste sampling and giving feedback.



Stage 4
Walking to and eating the real version of sampled food.

Appendix 8 – Thematic map of designer's ideas.

Idea clusters

1 Finding new uses for food waste

66 Foodmolds
48 Food Saviour
14 Pestil TV
8 Food Waste for Social Good
69 Waste Chips
60 rotofood
71 I'm the ruler

10 Breaking the boundaries

introduce new foods / break the food

49 migration companion
56 Shifter
79 Food rastifier
46 De-Prejudicifier
57 Food Amplifier
47 De-Toxifier
58 Replica Foods (RF)

introduce new eating style / break the routine

31 Spill & Fill
23 Pomodoro Printing

introduce new printing style / break the 3DFP

7 FoodFarm
63 Mine!
28 Food Stuffer
43 Food Binder

3 3DFP complements main dish

35 3D Food Polisher
55 FormBot
27 Formbooster
17 Asure-le

2 Include user into food-making

16 Performer
62 Make Me Cook!
12 I made dis!
54 Minichefs
39 Cook without thought
76 Food Playground
73 Pleasure in Limited Time
38 We are both involved!
36 Who made dis?

5 Create memorable experiences

13 Ayşe Kadın Twist
64 Explosion in Mouth
45 Let's make it special
72 Grandparents' house
21 PrintFairy
33 Mom?!
25 sensensense
5 Taste Finder
6 Taste Replicator

4 Share eating and cooking

30 I'm with you
3 Eat & Meet
24 Virtual Dinner Party
19 Sharing is Loving
44 BeMyGuest
52 FoodInsta / FeedFood
70 Food Cam
68 Printit app
78 Digital Food Sharing Network
20 RemoteHands
65 Foodshare
32 Delegator

7 Create companionship for personalized food production

59 FeedUs
50 Follow Me
4 Saat & Saat
22 GymBro
15 Fifty Shades of Chocolate
74 No Room for Mistakes
29 Layered Cakemaker
67 BUILDR
51 3DFPO

6 Integration/combining with surroundings

1 Food Stalker/Grapple
40 Slice n Snack
41 SoupSpoon
77 3DFP for ALL

8 Food-making as play activity

42 Print Dash
11 Hunters and Gatherers
18 Kuzartma Köprüsü
34 Guess the food

9 Eat anywhere

2 Cook Away
26 Home Bakery
9 Daily Eats
53 All Day Feeder

Appendix 9 – Thematic map of walk, talk and eat tours.

Thematic map of findings from walk, talk and eat tours

INCLUDED PAPERS

Paper 1 – User Exploration

Exploring Users Interested in 3D Food Printing and Their Attitudes: Case of the Employees of a Kitchen Appliance Company

[Kocaman, Y., Ermiş Mert, A., & Özcan, O. (2022). ***Exploring Users Interested in 3D Food Printing and Their Attitudes: Case of the employees of a kitchen appliance company.*** International Journal of Human–Computer Interaction.]

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Exploring Users Interested in 3D Food Printing and Their Attitudes: Case of the Employees of a Kitchen Appliance Company

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CASE REPORT

Exploring Users Interested in 3D Food Printing and Their Attitudes: Case of the Employees of a Kitchen Appliance Company

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ABSTRACT

3D Food Printing (3DFP) technology is expected to enter homes in the near future as a kitchen appliance. On the other hand, 3DFP is perceived as a non-domestic technology by potential users and domestic users' attitudes and everyday habits received less attention in previous 3DFP research. Exploring their perspective is needed to reflect their daily kitchen dynamics on the design process and discover possible new benefits situated in the home kitchen. On this basis, this study focuses on finding potential 3DFP users and explores their attitudes towards using 3DFP technology in their home kitchens through a two-stage study: First, we prioritized potential users based on their relationship with food through a questionnaire and found six factors that positively affect their attitude towards 3DFP: cooking every day, ordering food less than once a month, eating out at least a couple of times a month, having a mini oven, a multicooker, or a kettle, liking to try new foods, thinking that cooking is a fun activity. Second, we conducted semi-structured interviews with seven participants to discuss the possible benefits and drawbacks of 3DFP technology for their daily lives in the kitchen. Results revealed two new benefits that 3DFP at home may provide: risk-free cooking and cooking for self-improvement. We discuss the potential implications of these two benefits for design and HCI research focusing on how to facilitate automation and pleasurable aspects of cooking into future 3DFP devices.

1. Introduction

3DFP (3D Food Printing) is a food-making technology that creates edibles using specialized 3D printers (Khot et al., 2019, p. 282). The expanding research field of 3DFP is racing to understand and meet the demands of different user groups (Brunner et al., 2018; Gayler et al., 2018; Lin et al., 2020; Lupton & Turner, 2018). Benefits offered by the technology span from pushing the limits of food tastes, textures, and shapes (The Sugar Lab, 2020), controlling the nutritional parameters of food (Khot et al., 2017; Sun et al., 2015), and reducing the transportation costs and volumes (Soni et al., 2022; Wang et al., 2017). Despite the richness in the current benefits, 3DFP technology is perceived as more beneficial in non-domestic contexts (Gayler et al., 2018), as they mainly target niche (e.g., astronauts, dysphagia patients) or expert user types (i.e., chefs) (Soni et al., 2022). However, 3DFP technology also has the potential to enter domestic kitchens in the coming years, and research in the domestic settings is yet to accumulate (Dolejšová et al., 2020).

The benefits that 3DFP technology may offer to the domestic context is an underexplored area and the multifaceted nature of the domestic kitchen entails potentials waiting to be discovered. In addition to the tools, tasks, and ingredients involved in cooking in the home kitchen, there is also a broad range of users that 3DFP technology may offer to advance their everyday lives. We believe that revealing user perspectives can be the first step toward untangling the complexity in the domestic kitchen to reflect on future 3DFP designs. If given attention, investigating the dimensions in the human-food relationship would provide rich inputs for generating design concepts in future 3DFP studies.

Building on previous research, we investigated the domestic lives of a user group likely to exhibit early adopter characteristics (i.e., kitchen industry professionals) and explored their attitudes towards using 3DFP devices in their home kitchens (Brunner et al., 2018; Gayler et al., 2018). Our primary aim in this research is to explore the common food-related characteristics of potential 3DFP users and potential benefits that the technology may provide them. On this basis, this study mainly explores two things: (1) whether characteristics of domestic users interested in 3DFP could be identified, and (2) the potential benefits and drawbacks of the technology for the interested domestic users. To investigate this issue, we implemented a two-step study: First, we conducted a self-completion questionnaire ($N = 146$) with employees of a kitchen appliance company in Turkey and found six shared characteristics of interested prospective 3DFP users: cooking every day, ordering food less than once a month, eating out at least a couple of times a month, having a mini oven, a multicooker, or a kettle, liking to try new foods, thinking that cooking is a fun activity.

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These deduced user characteristics enabled the prioritization of participants in the following study. Second, we conducted semi-structured in-depth interviews with seven questionnaire participants to further explore the potential benefits and opportunities they envision for 3DFP at home. Results revealed two new benefits that previously have not been discussed for 3DFP technology: risk-free cooking and cooking for self-improvement.

Despite being a case study, our results indicate that focusing on interested user groups provides novel design directions for 3DFP to build concepts, scenarios, and prototypes. The user characteristics presented in this study demonstrate an initial step towards describing domestic users for 3DFP that could be beneficial for building user models in future concept evaluation studies. Moreover, our participants' attitudes showed that future research would benefit from a deeper understanding of the situated practices and sensitivities of the human-food relationship and exploring how the 3DFP technology could be adapted to this bilateral relation.

2. Related works

In this section, we summarize the gaps we identified in previous research. This summary helped this research find the missing user types in 3D Food Printing (3DFP) research and showed the plurality of everyday kitchens, where the future of 3DFP underlies.

2.1. 3DFP users and potential benefits

The potential benefits of 3D Food Printing (3DFP) technology are mainly discussed in accordance with the prospective user groups. In the current state of the 3DFP technology, it is perceived as more beneficial in non-domestic contexts (Gayler et al., 2018). However, 3DFP devices are expected to enter homes in the coming years (Dolejšová et al., 2020).

Previous 3DFP research reveals three areas to advance the lives of its potential users: increasing *creativity and fun*, reducing *transportation and storage costs* of food, and increasing *accessibility to healthier foods*.

3DFP technology is expected to expand the *creative space* for users in terms of shape, taste, and texture (Mizrahi et al., 2016). Expanding such aspects of the creative palate is found to be most beneficial for chefs in professional kitchens (Dankar et al., 2018; Soni et al., 2022; Sun et al., 2015). In addition to allowing the creation of engineered tastes and textures, the technology also offers to create foods in various shapes. This benefit of the 3DFP technology may relate to lay consumers who reportedly perceive cooking with 3DFP as a fun activity (Brunner et al., 2018).

Another potential benefit points to reducing the *transportation and storage costs* of food. Although advancing the transportation of foodstuffs is found useful for it may reduce the food prices for domestic users, it is found to be more impactful for niche scenarios (e.g., space or military missions) (Soni et al., 2022; Wang et al., 2017). For instance, reducing the space and weight of foods would reduce costs during transportation, and increasing the shelf life of foods would be extremely helpful for providing those who work in extreme conditions. In another study, early adopters report valuing 3DFP if used in extreme cases, for example, in emergency aid contexts, emphasizing that they do not perceive 3DFP as a domestic device (Gayler et al., 2018). It is also reported that users perceive foods that are 3D printed as not "real" or "natural" (Lupton & Turner, 2018).

Prior studies show that 3DFP increases *access to healthy foods*. This is especially important not just for the nutrition-aware users (Brunner et al., 2018) but also for those who are not able to get nutritionally rich foods (Soni et al., 2022). Through integrating technologies such as microencapsulation with 3DFP, it is possible to computationally alter the nutritional content of ingredients and provide those with limited access to food (Sun et al., 2015).

The puree form of the output allows making visually appealing foods for those who have chewing difficulties (i.e., dysphagic patients) (Pant et al., 2021). The technology could also be used to give medications to people as additives to food materials. In this trajectory, the technology is at the spotlight of nutrition specialists and medical experts (Burke-Shyne et al., 2020). In the domestic context, this could be extremely important especially for those in the rural areas or with limited access to medical care. With 3DFP technologies, industrial supply chains could be regulated to provide food for those in need of a personalized diet (Rogers & Srivastava, 2021).

The technology is also found useful for sourcing and preparing food more sustainably as it can repurpose food waste (Doleweerd & Broeken, 2019; Rogers & Srivastava, 2021). Effectively completing such tasks in the kitchen is found especially important for convenience-oriented users who want to minimize the effort they spend on cooking (Brunner et al., 2018). Although 3DFP is promoted as an extravagant product, automating all the cooking tasks *for* the user is criticized as being techno-centric (Dolejšová, 2020). Due to this approach, the agency of the user vanishes. Such systems are mainly criticized for delineating the user from the commonsense knowledge of food-making (Dolejšová et al., 2020). The techno-centric approach neglects the user element thus, may be one of many reasons that prevent the 3DFP technology from entering homes.

2.2. 3D Food printing and the domestic kitchen

The everyday lives of domestic users and issues in their everyday kitchens received less attention in previous 3D Food Printing (3DFP) research. Understanding the user's relationship with food and cooking is vital for any technology to enter the kitchens. Considering the number of tools (e.g., measuring cups, pots and pans), tasks (e.g., frying, boiling, cutting), and ingredients (e.g., meats, vegetables, spices) that are part of cooking, we believe cooking at home is a multifaceted notion. Further, cooking skills can be thought of as a combination of practice, the senses, and memory (Yasmeen, 2012). From this perspective, the user's agency is vital in the everyday kitchen and each of the aforementioned components of cooking can be a potential path for future queries on smart kitchen research.

Despite the manifold potentials in the everyday kitchen, we only encountered two studies that explore the experience of cooking to reflect on designing 3DFP devices (Khot et al., 2017; Devendorf & Ryokai, 2015). Both studies craft novel methods to make food with a 3DFP. Devendorf and Ryokai (2015) proposed an alternative interaction model for making pancakes. In their system, the user controls the printing mechanism manually, and the computer guides the user with a laser pointer. Through this spontaneous interaction the outputs are unique to the moment and the person who creates it. This example shows how rethinking the user's actions and interactions with the tools in each step of making food might propose rewarding outcomes, illustrating the importance of the user's personal relationship with the food in the domestic context for exploring implications for 3DFP device designs.

As discussed in the previous chapter, the potential users who may benefit from 3DFP technology are mainly identified either from extreme (e.g., astronauts) or broad perspectives (e.g., professional chefs) (Soni et al., 2022; Wang et al., 2017) yet, the specific user types and their situated practices in the domestic kitchen are less studied. For this reason, it is essential to uncover the potential needs of multiple personalities of the domestic kitchen to develop smart kitchen tools that root in cooking at home.

2.3. Implications of specifying users for 3DFP design studies

Food is an essential element of all life, and the course of life depends on the food consumption of every living being. Therefore, the user scope for 3D food printing (3DFP) can be significantly broad, especially in the domestic context. For this reason, prioritizing relevant participants to conduct user studies is a considerable topic of discussion for 3DFP research. None of the previous studies focused on specifying domestic user groups and explored potential benefits for them.

Some 3DFP user studies chose to reach out to user groups without any prior elimination depending on the study's purpose and method (Brunner et al., 2018; Lupton & Turner, 2018). Alternatively, in-the-wild studies relied on convenient sampling methods such as snowballing to find participants interested in the system (Khot et al., 2017). Participants' interest is substantial not just because they must agree to deploy the system in their homes but also spend the time and effort throughout the study. Khot et al. (2017) particularly noted the enthusiastic approach of a participant who initially did not fit the study's selection criteria. In the end, this participant offered valuable insights due to their enthusiasm towards the study. We believe that interested participants can be found in any context by developing relevant user selection criteria and approaching it from multiple angles. This could contribute to gathering richer and diverse insights from participants.

Gayler et al. (2018)'s approach has a direction in this sense. They surveyed three communities they expect to be early adopters of 3DFP (3DFP mailing list, 3D printing forums, and computer science students). Despite being a small-scale study, the results create novel and fertile courses for 3DFP research. We believe this fertility of results is related to participants' interest, who were willing to offer their ideas related to 3DFP. The predispositions of interested participants may entail opportunities in the product development process. For example, we may expect a fruitful approach from those who are more familiar with technology in general, as Gayler et al. (2018) showed in their study. These participants may be more open to talking about issues related to the development of the technology.

Although Gayler et al. (2018) managed to reach 3DFP early adopters, it is challenging to reach these groups because 3DFP technologies have not entered the local market yet. For this reason, it might be challenging to prove our participants are early adopters. Therefore, we choose to implement the term *interested in 3DFP* in the scope of the current study. We suggest that communities that are likely to include interested participants (i.e., kitchen industry professionals) can be studied discretely to identify enthusiastic participants for design research.

3. Study 1: Identifying domestic users based on their relationship with food in everyday life

As highlighted in recent research, there is a broad range of potential users for 3DFP technology. Focusing on interested participants has value for novel food technology design. Based on this motivation and building on previous research, our inquiry focuses on identifying users interested in 3DFP technology within a convenient user group of potential early adopters (i.e., kitchen industry professionals) (Brunner et al., 2018; Gayler et al., 2018).

3.1. Materials and methods

We created a self-completion questionnaire that aims to reach those who might be potential users of 3D Food Printer (3DFP) (Brunner et al., 2018; Gayler et al., 2018; Lee et al., 2021). Among the total of 44 items in the questionnaire, 13 were from Food Technology Neophobia Scale (FTNS) (Cox & Evans, 2008), and one was the willingness to consume 3D food printing (Brunner et al., 2018). Fifteen were added to collect demographic data. The last 15 questions were control variables related to one's kitchen habits and the position of food in their everyday lives (Table 1). Participants could participate using any kind of device (e.g., mobile phones, tablets) with an internet connection, and it took approximately 15 min to complete the questionnaire. We conducted the questionnaire on Qualtrics, and the company's UX team distributed the link to their in-house participant pool, consisting of voluntary employees (see 3.4. Participants). The data collection was operated in August 2020. Due to the pandemic, our participants mainly worked

Table 1. Questionnaire flow and variable selection rationale.

Category	Variables
Food Technology Neophobia Scale	13-item scale (Brunner et al., 2018; Cox & Evans, 2008; Gayler et al., 2018; Lee et al., 2021)
Frequency of engagement with cooking activities in the home kitchen	One's cooking responsibility in the household
	Time spent cooking in a day
	Cooking frequency
	Eating out frequency
	Food ordering frequency
Perception of cooking	Whether one finds cooking fun
	Whether one finds cooking with someone fun
	Whether one likes to try new foods
	Whether one follows food-related pages on social media
	Whether one finds spending free time for cooking as bothering/pleasurable*
Feelings of tools and technologies used in kitchen	Whether one thinks using new technology kitchen equipment eases cooking
	Whether one is bothered by frequently changing items in the kitchen
	Kitchen appliances one owns
	Kitchen appliances one wishes to own
	Most and least used kitchen appliances (see Appendix Table B1)
Willingness	Whether one would try 3D printed food

Notes. *Two contrasting statements were added for the internal reliability test.

remotely during the data collection period. Thus, our participants were most likely to be in self-quarantine conditions.

3.2. Variables

The following sections explain how we select, apply, and analyze the variables we employed in the questionnaire.

3.2.1. Food technology neophobia scale

The 13-item Food Technology Neophobia Scale (FTNS) is the first of two outcome variables we used to measure interest in 3D Food Printing (3DFP) (Cox & Evans, 2008). The FTNS helps identify population segments based on their neophobia towards novel food processing technologies (Cox & Evans, 2008). Although the scale was initially constructed to measure neophobia towards technologies such as genetic modification (GM) and pasteurization, it is also applied and verified as useful in recent 3DFP user research (Brunner et al., 2018; Gayler et al., 2018; Lee et al., 2021). For instance, Brunner et al. (2018) used FTNS to measure the change of attitude towards 3DFP, while Gayler et al. (2018) used it to identify specific communities as early adopters of 3DFP. Our questionnaire used FTNS as one of the main indicators for detecting one's interest in 3DFP technology. We translated the FTNS items into Turkish with the back-translation method (Prieto, 1992) (see Appendix Table C1).

3.2.2. Willingness to consume foods produced by a 3D food printer

The second variable we used for measuring interest in 3D Food Printing (3DFP) is participants' willingness to consume foods produced by 3DFP (Brunner et al., 2018). As the last question in the questionnaire, we provided a basic introduction to 3DFP. This introduction included a GIF showing a close-up example of colored food material being extruded from a nozzle. We chose this example to demonstrate a basic 3D food printing process (the user draws a shape on a tablet, and the printer extrudes an edible gel from the nozzle drawing the same shape).

We provided example images of food created by 3D food printers: sugar cubes from The Sugar Lab (The Sugar Lab, 2020), a meat alternative produced with plant proteins (Redefine Meat, 2018), foods produced for patients with dysphagia (Biozoon, 2019) to support the introduction and refrain from the influence of the shown example on participants. We also included a list of potential advantages and disadvantages that are so far identified in 3DFP research (see Appendix Table C2). Following this introduction, the participants rated a question on a seven-point scale stating their willingness to try a food produced by 3DFP.

3.2.3. Control variables

The control variables used in the analysis mainly focused on one's everyday food making and consumption habits. Table 1 presents the summary of the variables included in the analysis. For creating the control variables, we focused on learning about participants' food-related everyday lives under three topics: (1) frequency of engagement with cooking activities in the home kitchen, (2) perception of cooking, and (3) feelings of the tools and technologies used in kitchen. All food-related questions asked in the questionnaire are presented in Table 1.

3.2.4. Measures

All items in the questionnaire were measured using Likert scales (Likert, 1932). Participants rated each item in the FTNS on a seven-point Likert scale (1= "strongly disagree," 7= " strongly agree"). Similarly, willingness to consume a food created by a 3DFP device is measured on a seven-point scale (1= "would definitely consume," 7= "would never consume"). We reversed the scale in the willingness to consume a food created by 3DFP to ensure its compatibility with FTNS. Since FTNS measures phobia, a high score in interpretation means a negative result. Thus, we measured the willingness to try 3D printed food with an opposite scale to achieve this rapport.

The FTN score of participants is calculated by adding each numerical value of every individual item in the 13-item scale, making it possible for the scores to range from 13 to 91. Each participant is assigned an FTN score, which corresponds to their responses to the FTNS items.

Frequency statements are also rated using seven-point scales that measure frequencies (1= "never", 7=" more than once a day"). The remaining were rated with five-point Likert scales (1= "strongly disagree", 5="strongly agree"). Since we cannot change the measures used in FTNS, we chose to use a 1-5 Likert scale in the questions we created to avoid creating a cognitive overload on the respondents, considering that the questionnaire includes several matrix questions (Stieger & Reips, 2010).

We evaluate participants' interest based on the associations of two outcome variables (FTN score and willingness to try 3D printed food) and the remaining control variables. We divided FTN scores of participants into three bands (1="low FTN", 2="medium FTN", 3="high FTN"). The FTN category thresholds are calculated by adding and subtracting one standard deviation from the mean scores (see Appendix Table A1). Based on this classification, participants in the low FTN band are expected to be less afraid of the risks and ambiguity of novel food technologies. Therefore, those in the low FTN band are more likely to have more interest in novel food technologies. Hence, participants in the high FTN band have more food technology neophobia and are less likely to be interested in novel food technologies. Similar to the FTN score, as participants' willingness to try 3D printed food increases, their likelihood to have a high interest in 3DFP increases, and vice versa.

3.3. Analysis

Descriptive statistics, Spearman's rank-order correlations (Spearman, 1904), and ordered logistic regression models (McCullagh, 1980) are implemented for analysis. Before proceeding with our ordered logistic regression models, we ran generalized ordered logistic regressions (Williams, 2006) to test parallel lines assumptions using .01 level of significance for all models. While few of the models[1] were problematic and hence not presented in the paper, except Model 1 of Appendix Table B1 in which only a few variables did violate the proportional odds assumption, in all others (including our main model corresponding to the central interest of this study, see Table 4) proportional odds were met. To be able to discuss all components in the same methodological context, we decided to implement ordered logistic regressions since also as stated, in most of the models and especially the primary analyses, all explanatory variables met the parallel lines assumption.

3.4. Participants

We distributed the questionnaire to a convenient directory formed among voluntary employees of a leading industry firm that designs, manufactures, and sells kitchen appliances in Turkey. Their operation includes design, R&D, and production of mainly kitchen appliances. The company is known for manufacturing the first refrigerator in Turkey (Arçelik, n.d.). They entered the global market around the 2000s. Since then, it has been considered one of the leading companies in the local household appliances market. The main reason for working with this company directory is that we expected it to contain at least some individuals with an early interest in 3DFP technologies because their day jobs are closely related to developing kitchen appliances. Moreover, the theory of diffusion suggests that those classified higher in socioeconomic status (SES) are more likely to show more novelty-seeking behaviors—i.e., willing to take the risk of purchasing a new product before others (Rogers, 1983). This is suggested as an indicator of being an early adopter. For this reason, we started our research with mid-to-high SES participants.

The company's user experience (UX) research department often distributes surveys and user studies to their in-house directory and collects insights that guide their product development processes. We retained this sample in our study as it has been a convenient and fast-resulting option for the company's user research. Due to the sample's composition, all our participants are of working age, and their day jobs are closely linked to designing, manufacturing, and selling kitchen appliances.

The questionnaire is distributed to the entire directory consisting of 1096 participants. One hundred sixty-four participants visited the link shared, and 146 participants completed the questionnaire (response rate 13.3%). The data was collected from participants in 10 different cities in the country, while most of them live in Istanbul (i.e., the largest metropolitan of the country) (62.1%). Those who participated in the study are between the ages of 23 and 58. Almost half of the respondents are between the ages of 23 and 34 ($N = 65$, 44.5%), 46.6% are between 35 and 49 years old ($N = 68$), and 8.9% are aged 50 or above. Most of them are married ($N = 105$), and more than half have children ($N = 84$). The higher percentage of our participants are men comprising 62.3% of the sample ($N = 91$), while women are 37.7% ($N = 55$). This resulted in a relative underrepresentation of women in the sample compared to men (see Appendix Table A2).

While 88.4% of the participants ($N = 129$) reported that they had heard about 3D printing before, only 46.6% ($N = 68$) reported having heard about 3DFP. Only 10% of the participants ($N = 15$) indicated that they either witnessed 3DFP in action or used one. However, most of them reported seeing a 3D printer ($N = 109$, 74.6%) or a CNC cutter ($N = 115$, 78.7%) in action before.

3.5. Results

Overall, the results revealed an association between interest in 3D Food Printing (3DFP) and six factors related to food in everyday life (Table 2). These results provided an idea for common food-related characteristics of the participants who might be interested in using 3DFP technology at home. Below, we explain how we reached these results in detail.

3.5.1. Association of food consumption and making on interest in 3DFP

A Spearman's rank-order correlation (Spearman, 1904) test revealed the associations of food-related variables with FTN bands and willingness to consume 3D printed food. The results showed a negative correlation between FTN bands and the following variables: thinking that technology makes cooking easy, liking to try new foods, thinking that cooking with someone is fun, and cooking frequency (rho values are provided in Table 3). The interpreted results are all statistically significant. All significant results showed a negative association between higher involvement in food-making practices and FTN, meaning that participants who are more involved in food-making showed a higher interest and less fear of novel food-making technologies.

In another Spearman's rank-order correlation (Spearman, 1904) we tested the associations of food-related variables with the willingness to consume 3D printed food. Among the indicators related to daily food consumption and making, we revealed a positive association between willingness to consume food produced by a 3DFP and the following variables: thinking that technology makes cooking easy, liking to try new foods, thinking that cooking is fun and cooking frequency (rho values are provided in Table 3). This result is in line with the results we found in relation to FTN bands, meaning a positive influence of higher involvement in food-making practices on one's interest in 3DFP technology.

3.5.2. Influence of food consumption and making on FTN and willingness to consume 3D printed food

In the ordered logistic regression models with both outcome variables (FTN and willingness to consume 3D printed food) and predictor variables related to food making and consumption, the share of cooking responsibility in the household, average time spent daily for cooking, and frequency of cooking for others showed no significant results (Table 4).

Statistically significant results show that relative to individuals who cook more than once a day, those who cook once a week are more likely to be in a higher FTN band with the ordered log odds of 2.98. Respectively, compared to individuals who cook more than once a day, those who cook less than several times a week are statistically significantly less likely to have a higher willingness to consume 3D printed food when other variables are held constant. Coefficients are provided in Table 4. The results showed a significant relationship between one's cooking frequency, FTN, and willingness to consume 3D printed food. In addition, findings demonstrated that a higher cooking frequency at home indicates more interest in 3DFP technology.

Results also indicate that relative to individuals who order food less than once a month, those who order food more often (once a week and several times a month) are less likely to have a higher willingness to consume 3D printed food with the ordered log odds of −1.57 and −1.79 consecutively when other variables held constant (Table 4). These results refer to a relationship between ordering food frequency and willingness to consume 3D printed food. To specify, our results showed that those who order food less often are less likely to be interested in 3DFP technology when compared to those who order food more often, although there is no continuous pattern. However, their food technology neophobia did not indicate a significant relationship.

On the contrary, rather than going out to eat less than once a month, going out to eat more often (more than several times a week, once a week, and once a month) makes it more likely to have a higher willingness to consume 3D printed food with the ordered log odds of 2.64, 2.18 and 1.90 when other variables in the model are held constant. The interpreted results are statistically significant (Table 4). Surprisingly, these results suggest that those who go out to eat are more likely to be more interested in 3DFP technology when compared to those who practice it less.

Table 2. Summary of findings.

User characteristics that are associated with a higher interest in 3DFP technology
Cooking every day
Ordering food less than once a month
Eating out at least a couple of times a month
Having a mini oven, a multicooker, or a kettle
Liking to try new foods
Thinking that cooking is a fun activity

Table 3. Spearman correlation coefficients for the association of Food Technology Neophobia bands and whether one is willing to consume 3D printed food with potentially related predictor variables.

N = 146	FTN bands (1-Low, 2-Mid, 3-High)	Willingness to consume 3D printed food (1= "would never consume," 7= "would definitely consume")
Food consumption and making		
Time spent daily cooking	−0.18	0.16
Technology makes cooking easy	−0.21*	0.21*
Changing items in the kitchen	−0.18	0.12
Like trying new foods	−0.21*	0.43***
Cooking is fun	−0.07	0.21*
Cooking with someone is fun	−0.20*	0.18
Follow pages on social media related to cooking	−0.09	0.17
Cooking responsibility in the household	−0.04	0.16
Cooking frequency	−0.27**	0.36***
Eating out frequency	0.18	0.08
Ordering food frequency	−0.0008	−0.07
Cooking for someone frequency	0.003	−0.07

($p < .05$=*, $p < 0.01$=**, $p < 0.001$=***).

Table 4. Ordered logistic regression model for predicting the likelihood of having Food Technology Neophobia and consuming 3D printed food (with food consumption and making components as predictor variables)

Variable name ($N = 146$)	Model 1 FTN bands (1-Low, 2-Mid, 3-High)	Model 2 Willingness to consume3D printed food (1= "would never consume", 7= "would definitely consume")
Cooking responsibility (High responsibility (65+%): ref. cat.)		
Medium responsibility (35–64%)	−0.05	−0.36
Low responsibility (0–34%)	−0.83	0.58
Time spent cooking in a day[a] (None: ref. cat.)		
1 h	−1.07	−0.27
2 h	−1.22	−0.58
Cooking frequency (More than once a day: ref. cat.)		
Once a day	0.87	−0.22
Several times a week	1.53	−2.25**
Once a week	2.98**	−2.52**
Several times in a month	1.32	−3.15***
Once a month	2.86	−3.56*
Less than once a month	2.42	−4.53**
Ordering food frequency (Less than once a month: ref. cat.)		
More than several times a week	−0.82	−0.86
Once a week	0.29	−1.57**
Several times in a month	0.18	−1.79**
Once a month	−0.61	−1.30
Eating out frequency (Less than once a month: ref. cat.)		
More than several times a week	0.23	2.64**
Once a week	0.64	2.18*
Several times in a month	−0.12	1.13
Once a month	−1.13	1.90*
Cooking for others frequency (Less than once a month: ref. cat.)		
More than several times a week	0.12	−0.32
Once a week	0.69	−0.61
Several times in a month	−0.10	0.73
Once a month	−0.82	1.09

Notes. [a]No responses recorded over 2 h in time spent cooking in a day (results omitted).
($p < 0.05$=*, $p < 0.01$=**, $p < 0.001$=***).

A final ordered logistic regression model is presented for FTN bands and the kitchen items one owns. Results showed that relative to not owning a mini oven, a multicooker, and a kettle, having one makes it statistically significantly less likely to be in a higher FTN band with the ordered log odds of 1.32, 1.39, and 1.04 when other variables are held constant. The results are statistically significant and are provided in Appendix Table B1 to save space as there is a long list of kitchen appliances. These results suggest an association between one's interest in 3DFP technology and their past experiences with kitchen appliances they already own in their kitchen. In our case, owning kitchen tools that offer practicality—a common point of the found appliances—influences 3DFP attitude positively.

3.5.3. Internal reliability tests

We used Spearman's rank-order correlation (Spearman, 1904) analysis to test internal reliability by adding two contrasting statements to the questionnaire. Results show a statistically significant negative correlation between the two variables associated with these statements referring to a satisfactory level of internal reliability (rho = −0.61). Another Spearman's rank-order correlation analysis showed that the Food Technology Neophobia (FTN) Scale has a high level of internal reliability (statistically significant) ($\alpha = 0.83$) compared to the scores of the initial scale validation studies (Cox & Evans, 2008) ($\alpha = 0.84$).

Table 5. Spearman correlation coefficient for the association between Food Technology Neophobia bands and whether one is willing to consume 3D printed food.

$N = 146$	FTN bands (1-Low, 2-Mid, 3-High)
Would consume 3D printed food	−0.38***

($p < 0.001$=***).

A Spearman's rank-order correlation (Spearman, 1904) analysis is run to determine the association between the two dependent variables: (1) FTN bands and (2) willingness to consume 3D printed food. Results reveal a highly statistically significant negative correlation between the two variables (Table 5) (rho = −0.38), meaning that as one's willingness to consume 3D printed food increases, the FTN band they belong to decreases indicating they would have a lower neophobia towards food technologies. We also ran an ordered logistic regression model using only the two main outcome variables we used for measuring interest in 3DFP (Table 6). We found that compared to those in the low FTN band, respondents in the medium and high FTN bands are statistically significantly less likely to report higher levels of willingness to consume 3D printed food, with the ordered log odds of 1.45 and 2.71. These results confirm that respondents in the low FTN band are more likely to consume 3D printed food relative to those in medium and high bands.

When compared with previous studies, the FTN mean score (49.21) of our sample is lower than those in the scale validation studies (Cox & Evans, 2008) but is higher than the sample means of each of the communities associated with being early adopters suggested previously (Gayler et al., 2018) (see Appendix Table A1). This result suggests that our sampled community shows less tendency to be an early adopting community when compared to the communities previously investigated (e.g., 3D printing forums).

4. Study 2: Exploring the attitudes of interested domestic users

4.1. Semi-structured interviews

Our primary focus in the interviews was to understand which foods, functions, and potential benefits of 3DFP are essential for users interested in 3DFP technology. To investigate, we conducted semi-structured in-depth interviews with participants from Study 1 who agreed to join the next phases of our study. Due to the Covid-19 restrictions, the interviews were conducted remotely via Zoom and Miro.

Participants granted consent prior to joining the study, following the ethical guidelines of Koç University. We started the interviews by showing the participants an introductory video containing four 3DFP devices available as either Kickstarter or R&D projects (byFlow, 2015; Creative Machines Lab, 2020; Natural Machines, 2014; Team Bocusini, 2015). The video then briefly demonstrates how a 3DFP device is used in three steps: (1) capsule filling, (2) adjusting print settings, and (3) printing.

Table 6. Ordered logistic regression model for predicting the likelihood of consuming 3D printed food (FTN bands as the predictor variable).

$N = 146$	Willingness to consume 3D printed food
FTN bands (Low FTN score (13–37): ref. cat.)	
Medium FTN score (38–60)	−1.45***
High FTN score (61–91)	−2.71***

($p < 0.05$=*, $p < 0.01$=**, $p < 0.001$=***).

Following the introductory video, we asked about their first impressions of the potential benefits of 3DFP technology. After, we moved on to Miro to converse their deeper opinions on 3DFP through a think-aloud session (Fonteyn et al., 1993). We provided participants with a template in Miro containing several food items, potential benefits, and potential functions for 3DFP to trigger participants' thinking (see Appendix D).

We urged participants to explain the reasons for their decisions by asking about their envisioned scenarios as they rearranged the items (Figure 1). For each item in the given template, we asked participants to evaluate its importance for their everyday life and what 3DFP would contribute to that item. We also encouraged each participant to provide other food, function, or benefit of their choice as an addition to the list we provided. Each interview session took approximately 30 min. All interviews were voice recorded.

4.2. Participants

We invited five individuals from each FTN band, to include potential users from diverse perspectives. Among the invited 15, seven participated in the interviews: three from the low FTN band (i.e., higher interest in 3DFP), three from the medium FTN band, and one from the high FTN band (i.e., lower interest in 3DFP). Four were women, and three were men. Their age range between 30 and 47 (mean = 39.28). Most of them are married ($N = 6$), and five have children. Most participants stated that they enjoy trying new foods in the questionnaire (mean = 4.71), showing a considerably high interest in new foods. All of them spend time for cooking at home (Table 7).

4.3. Analysis

To analyze the interview transcripts, we employed a thematic analytic approach that focused on exploring the patterns of meaning and issues of interest in the dataset (Braun & Clarke, 2006). We recruited three external researchers for the analysis to approach the dataset from multiple

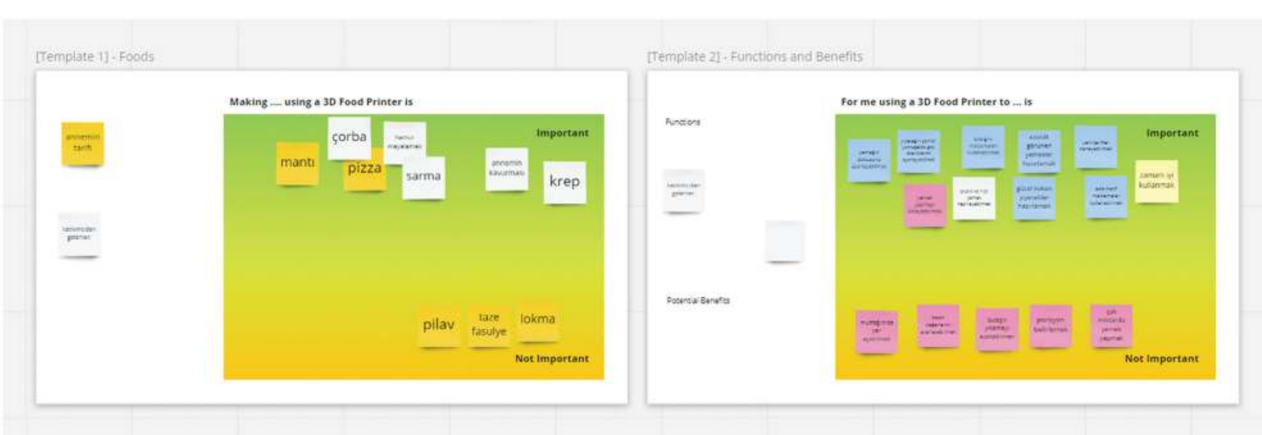

Figure 1. Miro boards after a participant rearranged the items (P7).

Table 7. Questionnaire responses of interview participants.

#	Age	Gender	Department	Likes to try new foods	Cooking at home frequency	Goes out to eat	FTN scores & bands	Willingness to consume 3D printed food (1-Definitely, 7-Never)
P1	30	M	Sales Office	4	Several times a week	Less than once a month	76 (high)	5
P2	44	M	Office worker	5	Every day	Less than once a month	28 (low)	1
P3	47	M	Manager	5	Several times a month	Once a week	48 (mid)	3
P4	34	W	Manager	5	Several times a week	Never	35 (low)	1
P5	45	W	Office worker	5	Every day	Less than once a month	36 (low)	1
P6	34	W	Occupational safety specialist	5	Several times a week	Less than once a month	41 (mid)	3
P7	45	W	Lab specialist	4	Every day	Less than once a month	38 (mid)	1

perspectives. The analysis began with transcribing each of the interview recordings for the researchers to familiarize with the dataset. After this step, each coder read the transcripts assigned to them and created codes from participants' answers. While creating codes from words, phrases, and topics, coders did not specifically search for recurrence in the data but focused on the relevance to the research motivation (Braun & Clarke, 2006). For this reason, the analysis includes not just the patterns in the data but also single statements of participants that were found related to the main research motivation.

Each transcript is coded two times: once by an external researcher and once by the main researcher. Afterwards, the researchers gathered and compared their codes to discuss the final version of the coding system. With the final code tree, each coder went through the documents once again. MAXQDA software package was used both for transcription and coding. A final meeting was held with all the external researchers and the main researcher to discuss potential themes resulting from the final code system. The main researcher later finalized the themes based on the issues raised in the discussions.

4.4. Results

Overall, we discovered drawbacks and potentials for the 3D Food Printing (3DFP) technology in the interviews. Our participants were curious and asked for details about how the machine operates and processes food while watching the introductory video (P2, P5, P6). One participant even mentioned that they looked up online about 3DFP technology after receiving the study invite (P4). One stated their amazement of the 3DFP video as they highlighted their love for technology in general (P7).

4.4.1. Concerns Related to 3D food printing

Participants' major concerns about owning a 3DFP product at home were related to unfamiliarity with the food materials, the distrust in the given information about the foods, and potential negative effects on taste and texture.

Most of our participants struggled to imagine what a 3D printed food would taste and feel like. Considering that none of our participants had tried 3D printed food before, this was an expected result. They tended to compare it with the foods they regularly eat to better estimate the experience of 3D printed foods. The hardest thing for the participants to accept was the "puree form" of the foods printed. They asked several times to confirm if the foods must be pureed since food in real life is usually not in puree form. One participant hesitated to trust the given information about the ingredients used: "*They would make us eat potatoes as if it is meat…*" *(P2).* Two participants stated that they are concerned that device might be incompatible with the practices in their kitchen (P3, P6).

> My oven has many functions… yet they mean nothing to me. The device may have many functions but what matters is how much they address my everyday life.

Lastly, they mentioned if the device fails to reduce considerable effort, they would not prefer to use it. This indicates that participants expectations from new kitchen appliances is to ease cooking at least to a certain extent.

4.4.2. Risk-free cooking

One of the focuses of our participants' expectations from 3DFP technology revolved around the support that the device can provide to reduce potential errors in the cooking process. We discovered three areas 3DFP could support the user's cooking process in the domestic kitchen to provide a risk-free cooking experience: preventing small accidents, following the recipe precisely and motivating taste experimentations.

The first expectation we discovered around risk-free cooking with 3DFP is to *prevent the small accidents* that occasionally happen in the everyday kitchen. Our participants stated that they would rely on the 3DFP technology for computational aid in incidents such as accidentally messing up the ingredient amounts (P3, P6, P7). One highlighted that the device would provide alternatives for the missing ingredients while cooking at the home kitchen (P3). These two examples suggest that our participants were open to help while manipulating ingredients.

Another way to provide a risk-free cooking experience was related to *following the recipes precisely*. Our participants mentioned that it is sometimes challenging to pin down the recipe demands, and 3DFP could support them in this effort (P4, P6, P7). To demonstrate, one participant highlighted the value that human-factor adds to cooking:

> Two people use the same recipe, but they never end up with the same result. This is a little about people. It is also about the ingredients we use but also about people. With such devices, I think we can achieve the right result with the right inputs. (P7)

Participants emphasized their trust in the computer-aid in 3DFP technology to *achieve consistency and precision* between different cooks. This was noted to be extremely helpful for cooking meals with personal meanings, such as mom's meals which were found important by most of the participants. Some stated that following the recipe precisely is especially difficult while trying new things.

> I tried drying fruits in the oven, but I couldn't do it, I couldn't set the right temperature, so they burnt. But many of my friends can do it. I would like a kitchen tool that will guide me and prevent me from burning the food I've prepared. (P6)

Participants mentioned that 3DFP technology would make trying new recipes much easier (P1, P4) and that they would do it more often if they had a 3DFP device supporting them: "*I find this (3DFP) extremely useful for trying out every new recipe I see online…* " *(P4)* Here the participant suggested printing taste samples of recipes they saw on the internet.

Some participants stated that while trying new things in the kitchen, 3DFP products could support them to *be experimental* and prevent possible negative outcomes. They expected 3DFP to support their experimental motives in cooking and encourage them to try new things:

> Let's say you are trying out a new soup, and you want to try adding new ingredients, but you are not sure if it will turn out well… This device (3DFP) could encourage you for trying it out by suggesting better taste matches for the experimentation… (P4)

4.4.3. Cooking for self-improvement

The other focus of participants' expectations from 3DFP technology was related to the values the device would introduce to their personal lives. In general, the technology was found to have the potential for improving their bond with food. Participants reported three food-related personal traits that 3DFP products could support improving: cooking skills (P2, P3, P5, P6), food-based prejudices (P1), and palate (P1).

One participant mentioned that they would improve their *cooking skills* if the device offered them new recipes (P2). Two others stated that they would like to get help making certain foods either because the food's making process is too complex or they are unsure what the outcome will be like (P4, P5). In line with this finding, one participant mentioned that they expect 3DFP to offer a *comfortable cooking experience* (P3). Our participant with the highest food technology neophobia reported that they would feel happy if the device helped them achieve the foods tailored to their personal palatal preferences (P1). Our participant with the lowest food technology neophobia reported that the manual labor in the cooking process adds value to the resulting food item. They prefer to do most tasks by hand (e.g., cutting onions) and highly enjoy doing so (P3). One participant stated that they enjoy cooking with their children and would not prefer to transfer those activities to a machine (P3).

Making the decorations pleases me a lot because we do it with the kids, and it is something we do to spend time together. We create something with them we all put our efforts. I would not want it (3DFP) to take this away from me… (P3)

The participant with the highest food technology neophobia mentioned that they are open to using a 3DFP product while tasting new foods for the first time to *overcome their prejudices and expand their palate* (P1). They stated that they are willing to take tasting suggestions from a 3DFP for foods in other cultures which use the same ingredients they are familiar.

5. Discussion

Overall, our results showed that the sampled community in this study (i.e., kitchen industry professionals) is less likely to be an early adopting community when compared to the other communities previously suggested as potential early adopters of 3DFP (e.g., 3D printing forums). However, our results revealed that an individual's interest in 3DFP is not limited by their adoption behavior.

In the interviews, we explored the attitudes of participants with differentiating food technology neophobia (FTN) to user insights for 3DFP design research. Results showed a distinction between participants from different FTN bands. We found that although those in the low and mid FTN band (P2, P3, P4, P5, P6) responded positively to using 3DFP devices in their homes, they were concerned about the unfamiliarity of the ingredients, the distrust in given information about food materials and potential negative effects on taste and texture. On the other hand, our only participant in the high FTN band (P1) envisioned novel opportunities for the technology to make sense in their everyday life. In fact, their fears (e.g., prejudices about foods in other cultures) encouraged them to picture scenarios using 3DFP technology. However, our results also suggest that participants' involvement in cooking activities highly influences their attitude towards using 3DFP devices in their homes. Taken together, these results suggest an opportunity for future 3DFP research to deliberately focus on the intimate dimensions of users' personal relationship with food.

5.1. Specifying the user characteristics for domestic 3DFP

Our first study explored the attitudes and common characteristics of potential users of 3DFP technology and found six characteristics that positively influence one's interest in 3DFP technology. Recent research has brought up the influence of the daily food consumption routines on users' perception of novel food-making technologies (Dolejšová, 2018). The characteristics outlined in our first study specify this perspective and strikingly indicate that individuals who cook frequently and order food less are more likely to have positive opinions about 3DFP technologies.

Going out to eat a couple of times a month turns out to be another characteristic of those interested in 3DFP in our sample. Eating out as a design space for 3DFP is being practiced by FOOD INK (3DFP Ventures Ltd., 2016) a conceptual pop-up dinner series. At the FOOD INK restaurant, every item is 3D printed (e.g., furniture, utensils), and chefs prepare food with a 3DFP in front of customers creating a one-of-a-kind culinary experience. We believe such concepts that create unique experiences by utilizing 3DFP devices in professional kitchen contexts could also be extended to domestic kitchens. To clarify, most of our participants perceived 3DFP as a non-domestic technology in line with the previous research. They found 3DFP to be most useful in the domestic context for making foods that they normally are not able to make due to a lack of cooking skills or limited access to special ingredients. 3DFP technology can create alternative ingredients by replicating the taste of food materials (Soni et al., 2022). As envisioned by our participants, the technology can be designed to improve one's cooking skills. Moreover, our participants envisioned scenarios where they are supported by a 3DFP to expand their recipe repertoire. Thus, we believe future 3DFP concepts could extend the experience of a professional kitchen into the domestic context through tastes, textures, and recipes.

Further, we found that those interested in 3DFP tend to *have a more upwards attitude toward food-related activities* (e.g., by reporting that cooking is a fun activity and liking to try new foods). Most of the interview participants were into trying new recipes frequently, and they expected the technology to ease cooking, especially when trying new recipes both when following recipes and experimenting with ingredients.

Results also imply that *having a multicooker, a mini oven, or a kettle* is a common characteristic of those with a higher interest in 3DFP. In other words, those who have home appliances that offer speed, efficiency, and practicality showed more interest in 3DFP in our sample. It is stated that one's current interactions with artifacts may be signifiers of future interactions (Köpsel & Bubalo, 2015). Our findings specifically show that current experiences with kitchen appliances that broadly offer practicality may be a factor signifying a positive attitude towards 3DFP.

5.2. Adjusting the level of computer aid

Our participants projected five ways that the computer aid could be useful in the everyday kitchen: prevent *small accidents*, provide *recipe precision*, advance *cooking skills*, support and guide *experimentation*, and prevent *unexpected changes*.

Previous research has been considered how the kitchen tasks are supported by 3D Food Printing (3DFP) devices. Although full automation in 3DFP is criticized as being technology-centric (Bertran et al., 2019; Dolejšová et al., 2020), a hybrid approach to the devices that will be introduced to the domestic kitchen may also help fit the user's life (Mizrahi et al., 2016). Instead of fully completing the cooking tasks for the user, supporting them to complete tasks by themselves is found meaningful for Human-Food Interaction (HFI) research (Bertran et al., 2019). Supporting this view, our results suggest that such a hybrid course aligns with the user expectations from 3DFP in the domestic kitchen. Any device that would be a part of cooking in the home kitchen should incorporate the user in ways they are encouraged and supported while they engage with cooking (e.g., experimentation, advancing in cooking skills). For instance, our participants were open to trying new taste samples and new foods from other cultures. Our interview participants mainly enjoy experimenting with new tastes and ingredient combinations. Meanwhile, they would like to oversee the flow of the experimentation process as well. While being experimental with a 3DFP product in the kitchen, our participants expected motivational support, access to quick taste samples, and recommendations from the device. Future 3DFP designs may foster such experimental instances as a direction for adapting the technology to the everyday lives of domestic users.

Our results also highlight that a certain level of automation is valuable for everyday kitchen if the device considers the user's preferences and daily practices. Although cooking is a pleasurable, social and cultural activity, it is often perceived as a chore. For convenience-oriented users, especially those who frequently cook at home, the device is expected to provide consistency and risk management. Although it is previously asserted that computational aid in the kitchen can help achieve a variety of results with the same recipe (Mizrahi et al., 2016), our results showed that domestic users expect to achieve consistent meals. Moreover, our participants emphasized the importance of reaching the same result regardless of the cook's skills. In this trajectory, future design research may focus on maximizing recipe consistency and minimizing error through user modeling. Designers could create personas or use scenario-based methods to accommodate the empirical user data in their early design stages (Hasdoğan, 1996). Further, these findings together may inspire designers to advance *the symbiotic relationship between the users and their products* with well-balanced automation and support.

5.3. Incorporating Pleasure of cooking to achieve novel experiences

Cooking with 3D Food Printing (3DFP) is found to be related to the hedonic aspects of cooking and eating: going out to eat, cooking as a fun activity, putting shared effort, the value of manual labor, and trying new things.

Previous research emphasizes the incompatibility between the current world of smart kitchens with the notion of eating as pleasure and cooking as a form of expressing love and attachment (Bell & Kaye, 2002). The kitchen is a unique space in the home. We have seen in our study that our participants enjoy doing specific activities as they cook (e.g., cutting onions, decorating). Yet, they perceive 3DFP and, in some cases, other kitchen appliances as a threat to losing the pleasure they obtain from doing those tasks. However, this potential drawback could be taken from a contrary perspective, and 3DFP products may be designed to incorporate pleasurable moments in the cooking process. The technology may even augment the joyful aspects when intersecting the digital and domestic worlds (Bell & Kaye, 2002).

One pleasing aspect of cooking we found that 3DFP could focus on is the *hands-on effort put into cooking*. Our results emphasized that putting effort into tasks such as cutting ingredients is perceived as an added value to food. In our case, those interested in the 3DFP technology perceive cooking and eating as pleasurable activities (e.g., liking to try new foods, thinking that cooking is fun).

Our results also emphasized that those interested in the 3DFP technology occasionally eat out and were also open to trying new foods. In accordance, interview results revealed that participants imagine 3DFP products as a taste-sampling tool for trying foods in other cultures they had never tried before. These findings together suggest that 3DFP products could be designed to foster novel dining and cooking experiences at home that *recommend new tastes for the user*. In this course, future design research may focus on positioning novel flavors in everyday life. The technical advantage of 3DFP, which allows it to manipulate the food's internal structure, could be used to offer novel textural experiences at home (Lin et al., 2020). These experiences may further be designed together with other activities at home (e.g., watching movies) (Velasco et al., 2018).

6. Study limitations

The main limitations of our work are related to the generalizability of the findings and participants' backgrounds. First, due to the nature of a case study, the current study does not intend to draw a generalized definition of potential 3DFP users. We present an initial step towards understanding what matters to them. In fact, our study showed that studying specific user groups as potential domestic users of 3DFP technology is a fruitful path for discovering new benefits of the technology. Based on this motivation, we encourage future research to pursue exploring the attitudes of other user groups in the domestic kitchen.

Second, all our participants work in a company that designs, manufactures, and sells kitchen appliances. Hence, they may have a mere exposure bias towards novel food-making appliances such as 3DFP (O'Brien et al., 2014). However, their bias was advantageous for our study. In fact, our awareness of the participants' biases encouraged us to pursue this study. We believe that our practice shows how to sensibly approach potential biases in a convenient participant directory.

7. Conclusions and future directions

Our study highlights the importance of reaching out to users in the domestic context and explores their opinions of 3D Food Printing (3DFP) technology. Given that 3DFP products have not widely entered the consumer market yet, the current study set out to investigate whether any characteristics of interested users could be identified and what matters most to them.

In this path, we presented six user characteristics that could be relevant for future 3DFP design studies. These user characteristics demonstrate an initial step towards comprehensively describing domestic users for 3DFP. Further, we found two new benefits that 3DFP technologies may offer to domestic users who have regular day jobs: risk-free cooking and cooking for self-improvement.

These findings translate into two main opportunities for design and HCI research: First, during participant selection for design studies, the characteristics presented can be referred to for rapid participant recruitment, which has been an issue of consideration yet has not been discussed deeply (Khot et al., 2017). An empirical observation with more diverse participants is needed to expand the findings to broader populations. We suggest that future research may explore other specific cases with communities from different technology and food cultures to portray wider communities of interested users to contribute to user modeling in the future. Such explorative studies would likely expand the scope of 3DFP technology. Second, future design and HCI research may build on the two new benefits presented in this study by conducting ideation sessions with designers and interested users. In the sessions, the findings of this study could be presented as user insights. If the insights we present in this paper provoke designers to produce novel ideas, future research might carry these ideas one step forward by developing conceptual prototypes (e.g., scenarios, video sketches (Zimmerman, 2005), or WoZ prototypes (Dahlbäck et al., 1993)) and test them in-the-wild.

Note

1. In the first model of Table B1 (willingness to consume 3D printed food as the dependent variable using ownership of appliances as the predictor variables) numerical derivatives could not be calculated.

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Appendix A. Summary tables

Table A1. Mean scores of previous studies and the current study.

$N = 146$	Frequency	FTN score mean	Standard deviation (*sd*)
Current study	146	49.21	11.53
Initial scale validation study (Cox & Evans, 2008)	295	55.00	11.90
3DFP mailing list (Gayler et al., 2018)	24	41.54	12.00
3D printing forums (Gayler et al., 2018)	6	40.83	10.36
Computer Science Students (Gayler et al., 2018)	20	48.15	8.31

Table A2. Descriptive statistics of the sample.

$N = 146$	Frequency	Population percentage	FTN score mean	Standard deviation (sd)
Gender				
Men	91	62.33	49.41	12.90
Women	55	37.67	48.87	8.70
Age				
23–34	65	44.52	47.34	9.95
35–49	68	46.58	51.39	12.50
50 or above	13	8.90	47.00	11.86
Education				
High school	6	4.11	44.00	18.90
Associate degree	17	11.64	49.11	16.24
Bachelor's degree	57	39.04	49.32	10.58
Masters	59	40.41	49.64	10.36
Doctoral degree or higher	7	4.79	49.42	9.76

Appendix B. Ordered logistic regression models

Table B1. Ordered logistic regression model for predicting the likelihood to have Food Technology Neophobia bands and to consume 3D printed food (with Ownership of appliances as predictor variables).

$N = 146$	FTN bands (1-Low, 2-Mid, 3-High)
Ownership of appliances	
Steam cooker (do not have: ref. cat.)	0.39
Yogurt maker (do not have: ref. cat.)	−0.81
Meat grinder (do not have: ref. cat.)	0.20
Kitchen robot (do not have: ref. cat.)	−0.07
Chopper (do not have: ref. cat.)	0.80
Mixer (do not have: ref. cat.)	0.17
Hand blender (do not have: ref. cat.)	0.76
Blender (do not have: ref. cat.)	0.29
Coffee grinder (do not have: ref. cat.)	0.37
Juicer (do not have: ref. cat.)	−0.23
Kettle (do not have: ref. cat.)	−1.04*
Tea maker (do not have: ref. cat.)	0.24
Coffee maker (do not have: ref. cat.)	0.21
Turkish coffee maker (do not have: ref. cat.)	−0.74
Microwave oven (do not have: ref. cat.)	0.30
Oven with stove (do not have: ref. cat.)	−0.14
Mini oven (do not have: ref. cat.)	−1.32*
Built-in oven (do not have: ref. cat.)	−0.79
Egg cooker (do not have: ref. cat.)	−0.80
Deep fryer (do not have: ref. cat.)	−0.37
Slow cooker (do not have: ref. cat.)	−0.97
Multicooker (do not have: ref. cat.)	−1.39*
Toaster (do not have: ref. cat.)	0.22
Toaster (do not have: ref. cat.)	−0.66
Bread maker (do not have: ref. cat.)	−0.005
Dishwasher (do not have: ref. cat.)	1.08
Deep freezer (do not have: ref. cat.)	0.71
Smart fridge (do not have: ref. cat.)	0.89
Regular fridge (do not have: ref. cat.)	0.73

($p < 0.05$=*, $p < 0.01$=**, $p < 0.001$=***).

Appendix C. Questionnaire items

Table C1. The 13-item Food Technology Neophobia Scale translated into Turkish.

Scale item
Yeni Yiyecek Teknolojileri Gerekli Değildir
Çevremizde halihazırda yeterince lezzetli yiyecek olduğundan, yeni yiyecek teknolojilerini kullanarak daha fazlasını üretmeye ihtiyacımız yok.
Yeni yiyecek teknolojilerinin yararları fazlasıyla abartılıyor.
Yeni yiyecek teknolojileri, yiyeceklerin doğal kalitesini düşürüyor.
Tükettiğim yiyecekler zaten yeteri kadar iyi olduğundan, yüksek teknoloji kullanılarak üretilen yiyecekleri denemek anlamsızdır.
Yeni yiyecekler, geleneksel yiyeceklere göre daha sağlıklı değildir.
Yeni yiyecek teknolojileri emin olmadığım bir konudur.
Risklerin Algılanması
Toplum, yiyecek ile ilgili sorunlarını çözmek için ağırlıklı olarak teknolojiye bağımlı kalmamalıdır.
Yeni yiyecek teknolojilerinin, uzun vadede olumsuz çevresel etkileri olabilir.
Yeni yiyecek teknolojilerine çok hızlı geçişin riskleri olabilir.
Yeni yiyecek teknolojilerinin, uzun vadede sağlığımıza olumsuz etki etmesi pek mümkün değildir. (R)
Sağlıklı Seçim
Yeni yiyecek teknolojileri kullanılarak üretilen yeni ürünler, insanların dengeli beslenmesine yardımcı olabilir. (R)
Yeni yiyecek teknolojileri, insanlara yiyecek seçimleri için daha fazla kontrol hakkı tanır. (R)
Bilgi-Medya
Medya, genellikle yeni gıda teknolojileri için dengeli ve tarafsız bir bakış açısı sağlamaktadır. (R)

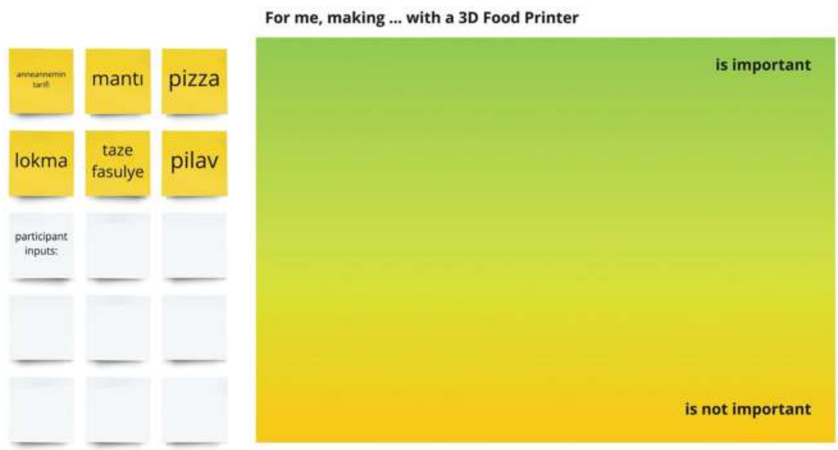
*Items marked with (R) are reversed in the analysis due to the contrast in meaning.

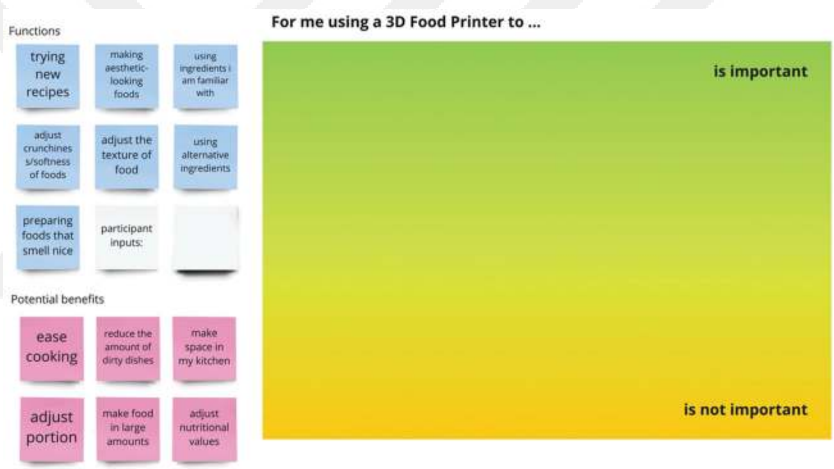
Table C2. The list of advantages and disadvantages of 3DFP presented to the participants in the questionnaire.

List of potential advantages and disadvantages of 3DFP technology
Advantages
Help produce aesthetic-looking foods with various shapes/forms.
Digitally control nutritional value.
Reduce food waste.
Expand the creativity spectrum for the cook.
Replacing repetitive/tiresome activities.
Use plant or animal proteins to produce meat alternatives.
Disadvantages
Food production time is prolonged.
Can only use pureed materials.
Pre-treatment is needed to use common ingredients (e.g., tomato, pepper) in the kitchen.
Post-treatment is needed for foods that require cooking.
Difficult for the produced geometric forms to remain stable on the plate for a long time.
The produced food deforms during cooking

This list is shown as an introduction to the willingness to consume 3D printed food question.

Appendix D. Templates given in the interviews





Paper 2 – Design implications

Discovering design implications for future food experiencing artifacts

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Jun 23rd, 9:00 AM - Jun 28th, 5:00 PM

Discovering design implications for future food experiencing artifacts

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Discovering design implications for future food experiencing artifacts

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Abstract: Despite the growing number of research in Human-Food Interaction (HFI), studies mainly adopt a technology-oriented approach. The field focuses on creating foods computationally, leaving the device design neglected. This paper addresses this oversight by focusing on a prominent technology as a case study (i.e., 3D Food Printing) and exploring new forms and meanings HFI technologies may embody. We first explored domestic users' food-related dynamics, habits, and preferences in everyday life (N=19). We then present the outcomes of design workshops with 25 professional designers, resulting in 73 unique concepts aligned with the insights from domestic kitchen users. Overall, we extracted ten design implications and developed three final concepts. The value of the design implications for HFI research unfolds in reconsidering definitions, limitations, and resource domains when ideating new technologies, thus extending the possibilities for future artifacts.

Keywords: product design; food experiencing artifacts; design implications

1. Introduction

Food is essential for all life, and the growing field of Human-Food Interaction (HFI) is studying how humans interact with food today and how to design alternative food futures. It is a recently populated field of study among Human-Computer Interaction (HCI) scholars, and topics vary from sourcing, eating, preparing, storing, and disposing of foods (Altarriba Bertran et al., 2019). Research in this trajectory investigates food as a social, playful, emotional, and experiential medium. An extensive portion of HFI research focuses on designing *foodstuffs* and approaching it as a computational medium to enhance taste-related experiences through designing *cyber-physical* foods (Deng, Olivier, et al., 2022; Deng et al., 2023; Gayler et al., 2022) or *gustatory interfaces* (Vi et al., 2017). For instance, researchers explored how to capture and regenerate personalized flavor cues to recall and recreate cherished food-related memories (Gayler et al., 2022). This idea builds on the uniqueness of food as a social messaging medium and its capacity to develop social ties (Wei et al., 2014). Others explored how to influence the perception of satiety through altering visuals (Lin et al., 2020).

Many foretold research relies on novel food fabrication technologies such as 3D Food Printing (3DFP) devices. These devices have gathered growing attention in recent years; however, most focus on designing interactions from function and utility-oriented perspectives and are criticized as techno-centric (Altarriba Bertran et al., 2019; Dolejšová et al., 2020). Although these contributions set the ground for 3DFP design space, even the most provoking ways of integrating these computational artifacts into everyday food routines do not generate extensive guidelines for *designing food-experiencing artifacts* and call forth alternative food futures. Our study recognizes the untapped potential in developing design knowledge for food-experiencing artifacts emphasizing the multifaceted human-food-machine relationship.

While research agrees on the potential of designing human-food interactions to mediate novel experiences, few research alternated artifact designs. Given the limited variety in device design within the Human-Food Interactions field, we turn to 3DFP technology as a case study to generate design knowledge for food experiencing artifacts in a broader sense. To that end, we explore the following question in this study: **How might we develop design knowledge for food experiencing artifacts that focus on the human-food-machine relationship?** Here, we present a two-step research approach (Figure 1).

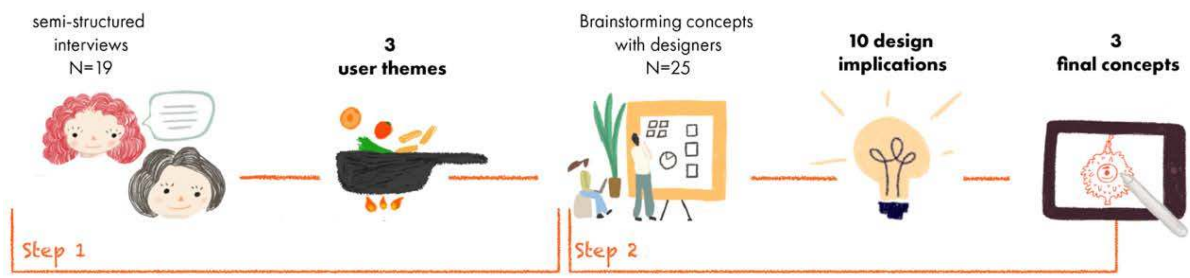


Figure 1 The two-step research approach applied in the current study.

We first explored domestic users' everyday food preparation, consumption, shopping, and sharing routines and how they envision 3DFP support in semi-structured interviews (N=19). We used the user insights as inputs in brainstorming workshops with 25 professional designers from academia and industry, in which they generated a total of 73 ideas. We generated ten design implications by analyzing designers' ideas through thematic analysis (Braun & Clarke, 2006). We sketched more complete design concepts by combining the key ideas under the design implications linked to the same user theme. Finally, we reflect on our process and discuss our learnings. With this outlook, this research aims to contribute to interaction design research as follows:

- A set of design implications derived from user and designers' perspectives pinpointing opportunities to enhance user-centered food experiencing artifacts.

- Design concept sketches representing diverse forms and affordances that food experiencing artifacts can embody to support the human-food-machine relationship.

We believe our findings not only expand the design space for 3DFP device and their potential to enrich everyday life but also inform the design of future food experiencing artifacts in a broader sense.

2. Related Works

2.1 Bridging conventional and digital

Food preparation is increasingly represented as a recreational and leisure activity in literature, yet it is often a messy process as well (Kocaman et al., 2022). The multiple agents that take part in the cooking process contribute to the messiness, while there is an undeniable topography of emotions and social relations embedded in the fabric of the home kitchen (Meah, 2016). There is also a great knowledge base embedded in the everyday kitchen. Such aspects of the everyday kitchen are valued by Human-Food Interaction researchers, which has resulted in growing concerns about how fully automating food-making alienates the user from tacit food knowledge. How this negligence might infer social food practices and traditions remains unknown (Dolejšová, 2019). Research highlights the significance of integrating the existing know-how in the kitchen to keep users as active agents in cooking (Altarriba Bertran et al., 2019). Preserving users' presence in food-making allows them to enjoy the pleasant aspects of cooking when the digital and physical worlds meet (Bell & Kaye, 2002).

2.2 Addressing human-food-machine relationship through device design: 3D Food Printing Case

3D food printing (3DFP) technology has great potential to bridge the physical and digital worlds. Their entrance into everyday kitchens could lead to many changes in the lifecycle of the human-food-machine relationship from consuming to disposing of foods. Thus, it is crucial for designers to deeply understand and overwork the current limitations of these novel devices.

The scientific literature on 3DFP heavily relies on empirical data mastering the printability parameters for today's foodstuffs (e.g., potatoes (Liu et al., 2018), chocolate (Lanaro et al., 2017), or cheese (Le Tohic et al., 2018)) and eventually finding the best formula for their adaptability to Additive Manufacturing. Currently, the main affordances 3DFP devices offer are commonly attributed in recent research as increased access to personalized foods and customized nutrition (Burke-Shyne et al., 2020; Sun et al., 2018; Yang et al., 2017). From this perspective, the prospective application areas of 3D printed foods mainly encompass extreme scenarios such as space missions (Lipton et al., 2015) or emergency aid contexts (Gayler et al., 2018)), leaving domestic uses undervalued.

However, it is also asserted that instead of focusing solely on the practical aspects of human-food interactions, a "material-centered" approach in 3DFP signifies opportunities in food's aesthetic, sensory, and sociocultural qualities, which can be leveraged to influence users' engagement with food (Deng, Altarriba Bertran, et al., 2022). Recent research asserts that 3DFP technology has the potential to provide a risk-free cooking experience, emphasizing the messy and spontaneous nature of everyday food-making (Kocaman et al., 2022). A great example that unravels the potential beneath the messiness of everyday kitchens through a novel system design is Redeform (Devendorf & Ryokai, 2015b, 2015a). It is a system that transforms the user into a 3D printer with a laser pointer to trace the toolpaths generated from a digital model inputted by the user, giving the experience of a connect-the-dots game. This hybrid system mediates food-making due to the food's complex and spontaneous nature. In this example, even if the outcoming geometry of the foodstuff does not match the initial CAD model, it shows an alternate role the machine can play in the human-machine collaboration (e.g., a collaborator with unique talents). This novel collaboration is enabled by the unique device design. Hence, we infer that designing artifacts focusing on the varying dimensions of the human-food-machine relationship inherits novel experiences.

3. Study 1: Exploring the user perspective

As the potential future users of 3DFP technology may include a wide range of users, we interviewed participants from varying professions and lifestyles to explore the prospective use of 3D Food Printer (3DFP) in everyday life.

3.1 Participants

We made an open call to our study through a screening survey in which we collected demographics and day-to-day cooking and eating activity data (Figure 2). As the potential future users of 3DFP technology may include a wide range of users, we interviewed participants from varying professions and lifestyles: students from engineering and design fields; a retired stay-home mother; managers, lab technicians, and office workers from a kitchen appliance firm; an occupational safety specialist; urban and interior architects; an illustrator; and a Doctor of Veterinary Medicine. Although we made an open call to our study, those who responded were individuals who frequently cook. Most respondents prepare most of their daily meals at home as opposed to ordering in or going out to eat. Moreover, those with higher responsibility in household cooking declared a higher enjoyment of cooking in their spare time. However, regardless of their part in household cooking as a chore, most of our participants were confident in their cooking skills. They mostly referred to comments from their social circles to confirm that they can cook tasty meals.

All our participants reported minimal to no prior experience with 3D food printing (3DFP), while some had professional experience in other digital manufacturing technologies (e.g., 3D printing, laser cutting, CNC milling). Because none of our participants owned a 3DFP device in their home, the collected data mainly reflect how they envisaged using a 3DFP in their domestic environment rather than reporting actual experiences.

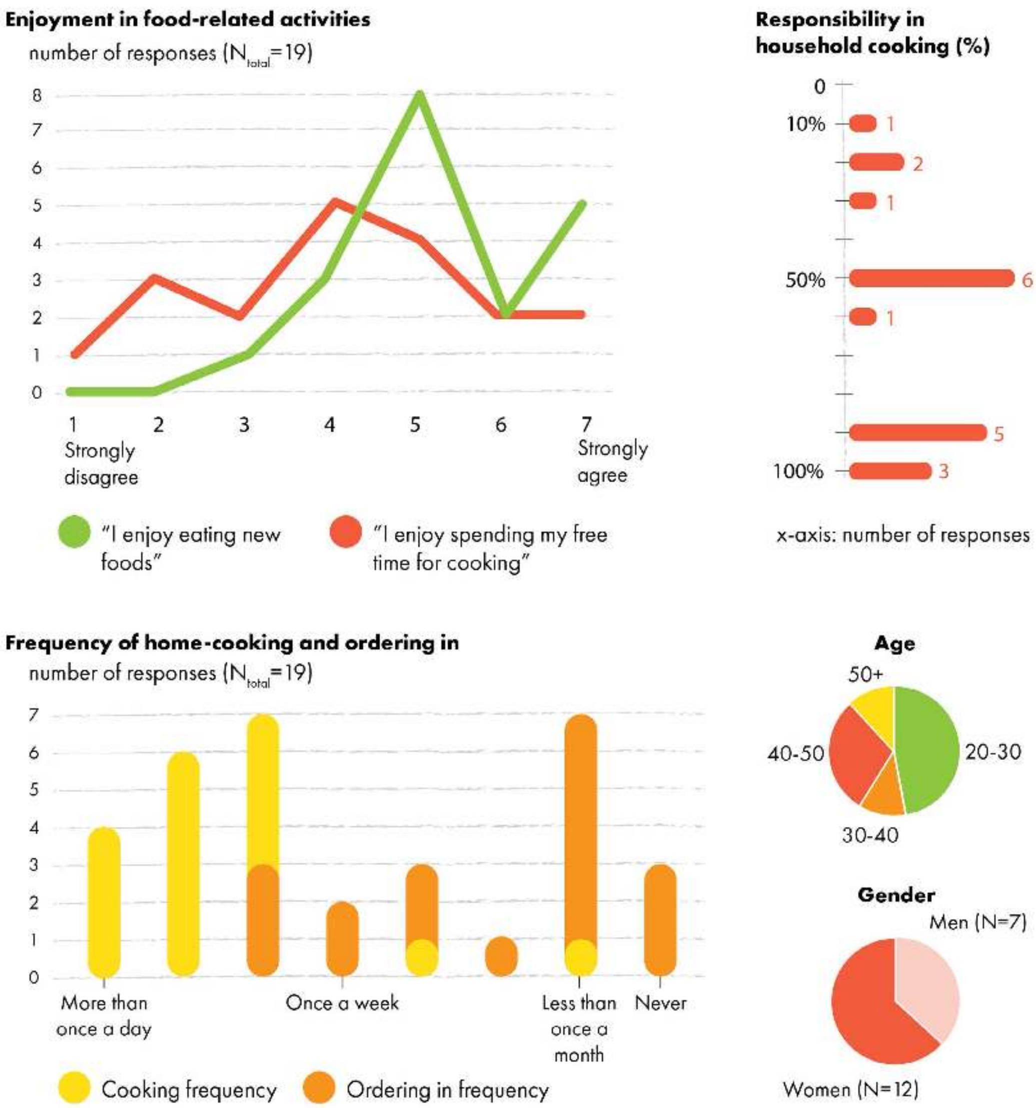


Figure 2 Top left: Participants' responses to statements (measured on 1-7 Likert scale); Bottom left: Participants' cooking and ordering in frequencies; Top right: Participants' share in household cooking (measured in %); Bottom right: Participants' age and gender distributions.

3.2 Study Procedure

We conducted semi-structured interviews divided into two main phases. We first talked about participants' everyday interactions in their kitchen to immerse them in thinking about their everyday food interactions and uncover their unique perspectives. With this intention, we asked about their eating habits, routines, and preferences; cooking practices; their perception of cooking and challenges; and the social rituals, routines, and experiences with cooking and eating.

In the second phase, we discussed their perspectives on using 3DFP in everyday food interactions. Before we moved on to this phase, we showed participants an introductory video containing a few example 3DFP devices and explained the current state of the technology briefly. The video demonstrates how these devices are used in three steps: 1) capsule filling,

2) adjusting print settings, and 3) printing. Then, we asked participants to elaborate on which foods, benefits, and functions they find the most suitable for 3DFP at home. Although we prompted participants to think about the 3DFP technology, the scope of our findings is not limited to envisaged 3DFP usage but extends to advancing food-related experiences with automation, robotics, and digitalization.

Each interview lasted approximately 45 minutes. We analyzed the data obtained with qualitative and thematic analysis (Braun & Clarke, 2006; Miles & Huberman, 1994). The three themes we present here represent user-prioritized dimensions with justifications from relevant research that can serve as inspiration when designing 3DFP devices.

2.1 Theme 1: The search for better food

Throughout history, humans have always been on the lookout for better-tasting and more nutritious foods (Cerpina & Stenslie, 2022). In line with this trajectory, we discovered varying definitions for better foods that can be achieved by using a 3DFP in everyday life. Some of them were convenience-oriented in line with the 3DFP literature (e.g., impact diet positively through nutritionally tailored foods (P15) (Lin et al., 2020)).

Others envisioned better foods as eating from a chef-grade menu referencing the foods they see on the famous TV show *Masterchef* (P4), thus expanding their ingredient catalog (Kocaman et al., 2022). The machine is found helpful for accessing a wider variety of ingredients as well as ready-made foods in a fresher manner (P10, P11, P17).

One vegetarian participant shared their experience with store-bought veggie patties and their concerns about the actual nutritional quality of frozen vegetarian labeled foods. They stated that they would include more plant-based options in their diet if the machine helped make fast-food alternatives at home (e.g., veggie patty) (P18).

3DFP technology is also envisioned to increase access to one's favorite tastes, even though preparing is tedious. This view supports the utopia of having an abundance of desired foods with the help of technology (Cerpina & Stenslie, 2022).

> "It is incredibly difficult to shape the dough for profiteroles, but if I had such a technology at home (a 3DFP), I could make profiteroles much more often and eat until I get tired of it." -P15

These findings suggest an opportunity for 3DFP technologies to support users in their search for better foods (Grimes & Harper, 2008).

2.2 Theme 2: Many agents of the kitchen

The kitchen has many agents participating in food production and consumption: mother, children, father, friends, relatives, and, of course, tools and machines. Our participants often mentioned sharing the kitchen space with their families and housemates to share the labor of cooking and shopping but more importantly, participating in food-related rituals within the family, friends, and society. There was a common emphasis on cooking and eating together to strengthen social bonds (Altarriba Bertran et al., 2021). We also encountered several cases where one adapts to a roommate or significant other's food preferences (P1).

> "Nowadays, we fry veggies in the oven to reduce our oil consumption. Potatoes, eggplant, zucchini... (continues to detail the recipe). Although it does not taste the same with deep fried veggies, my wife wants to eat this way, and I adapt..." -P1

While this is the case, eating alone is also found valuable for everyday food routines. On the other hand, the non-human agents of the kitchen, 3DFP in this case, are envisioned to facilitate such rituals and create memorable eating experiences (Gayler et al., 2022). For instance, 3DFP is expected to enable the making of meals for a large number of guests. Moreover, the technology could help users increase their culinary skills and assist them in surprising guests with unexpected foods (P1, P17). These findings suggest a need to consider the various agents' preferences, habits, likes, and social dynamics when designing interactive food-making systems.

2.3 Theme 3: Joy of bodily activities

We observed a controversy about whether cooking is a pleasurable, enjoyable activity or an error-prone necessity that requires time and effort. The joyful aspects of cooking our participants mentioned were mainly related to hands-on involvement in cooking. There is an appreciation for hand-specific gestures required for making cultural foods like lokma and döner traditionally performed by a master (P8, P9).

> "I can observe everything that goes into my döner while the master prepares it. Watching makes me happy and gives me pleasure. When I compare it to watching a printer... thinking of the layers forming on top of one another... Still, it is more fun with real food..." -P8

Hands-on involvement also evokes memories; a university student mentioned mimicking their mother's movements while cooking at their lodgings (P19) to simulate their memories with their mother. Working with hands, thus being physically involved in food-making, eliminates positive feelings (e.g., being homesick), pointing to an opportunity for embodied technologies. Participants envisioned 3DFP as a solution to alleviate the unpleasant aspects of cooking, particularly regarding kitchen errors. They anticipated that 3DFP would ease food preparation and further ideated it as automated support for disliked or tedious cooking tasks such as the preparation of vegetables (e.g., peeling), minimizing waiting time (e.g., stirring a soup), and eliminating post-cooking clean-up (e.g., edible cutlery). Overall, there was a tendency to assign unpleasant tasks to the machine while the user performed the less tedious or more enjoyable ones. Our findings identify various hands-on and bodily activities that render enjoyment in cooking and eating, thus drawing future designers' attention to the tradeoff between utility and pleasure.

4. Study 2: Exploring design instances

To generate a variety of alternative 3DFP artifacts, we brought the user themes to professional designers through brainstorming workshops (Figure 3). Among the designers who participated in the sessions, 14 were practicing designers from the kitchen appliance industry, and 11 were interaction design researchers (N=25). We presented the user data in different formats at each workshop stage: presentation, keywords, food images, and user scenarios.

Figure 3 Designers working in the ideation sessions: 1st row, introductory presentation and meeting; 2nd row, individual ideation; 3rd row, group ideation; 4th row, presentation and discussion of ideas.

Introductory presentation: We started with a 20-minute presentation, providing designers with the three themes discovered in the interviews. This presentation also included a brief overview of the 3DFP technology and example product designs.

Keywords in individual ideation: Ideation started individually, where designers poured down their initial ideas without being affected by others. We placed a bowl of keywords picked from users' own words describing their food-related experiences at each work desk. Designers picked a keyword for inspiration whenever they are stuck.

Food images and scenarios in group ideation: Designers proceeded to ideate in groups of 3-4. In this phase, we provided food image cards with user stories on the back. Each user story is collected from the preceding user study. We included food stories to familiarize the designer with the users' context of the food. We collected all the ideas on the whiteboard.

Idea presentation: We concluded the workshops with a presentation of group ideas by hanging them on the whiteboard and triggering a discussion for the common points between all the ideas generated.

4.1 Analyzing designers' ideas: Generating design implications

Designers generated 73 ideas in four sessions (7 study groups). We grouped the designer sketches and design descriptions by thematic analysis. In this section, we present an annotated portfolio that we used to translate the designers' ideas into *design implications* (Gaver, 2012). Communicating design implications has been found valuable in recent research as it provides an abstraction of the rich design knowledge (Jung et al., 2021; Sas et al., 2014). To avoid simplifications, we often refer to a selection of designers' sketches along with user keywords that inspired their ideation. We named each design implication after the commonalities in the ideas nested under it. Ultimately, each design implication encompassed at least two potential design concepts. The graphic below presents the design implications referring to the designers' idea sketches (Figure 4). In the further sections, we discuss how we implemented the design implications into our ideation process by demonstrating more complete design concepts.

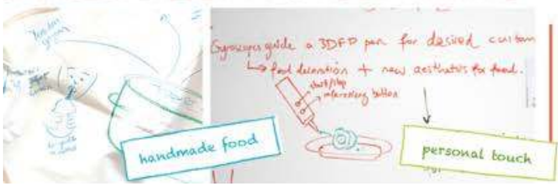
1. COMPLEMENT **MAIN DISH**

3DFP augments the main dish by making side dishes, chef-grade sauces and polishes food for presentation. Increases presentation and appetite by making daily foods look fancier.

2. CREATE **MEMORABLE EXPERIENCES**

Designed artifacts facilitate memorable eating experiences by implementing sweet, sour, and hot taste as an element of surprise within a traditional meal (e.g., beans). Ideas addressed contexts such as social gatherings to blend such surprising and memorable experiences.

3. **INCLUDE USER** INTO FOOD-MAKING



The machine actively encourages and supports user to take part in performative tasks in cooking. While doing so devices embody features such as guiding users' movements.

4. SHARE **EATING AND COOKING**

Devices can foster remote and real time sharing of cooking and eating. For cooking, the machine acts like a "director" and combines the efforts of different agents. Here, designers speculated a central positioning in the kitchen.

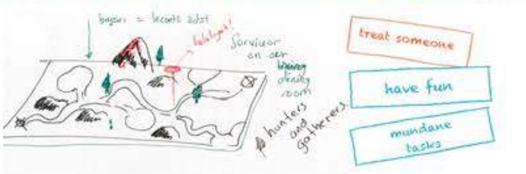
5. CREATE **COMPANIONSHIP** FOR PERSONALIZED FOOD PRODUCTION

Designers addressed producing foods based on personal data by focusing on the relationship between the machine and the user. They ideated devices that positively encourage users to adjust their food preferences based on their personal data.

6. SUGGEST **NEW USES FOR FOOD WASTE**

System designs for collection and processing of domestic food waste. Here, designers treat food waste as a new resource at home and ideated systems that fit into the infrastructure of the building to collect, process and deliver products made of food waste (e.g. either edibles or desktop objects).

7. APPROACH FOOD-MAKING AS **PLAY ACTIVITY**

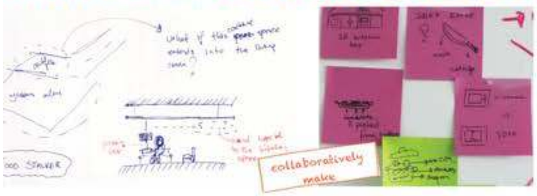


Play also has potential to transform mundane cooking tasks into fun activities by incorporating gamification. Designers ideated tabletop games where players come together and make food through following a script.

8. BREAK BOUNDARIES WITH **NEW FOODS AND EATING STYLES**

Designers aimed at transmuting diet altogether through novel foods (i.e., edible insects), and ideated devices for breeding, harvesting and processing such ingredients. It was also discussed to impact the daily schedule of eating (i.e., perpetual eating). Designers also explored restructuring the eating styles (i.e., eat spilled food from an apron).

9. INTEGRATE INTO **EVERYDAY OBJECTS**



Integrating food extrusion into current appliances in kitchen, can suggest new methods for cooking and eating (butter extruding knife, ingredient extruding pot). This integration can also be envisioned on a larger scale (i.e., 3DFP on a ceiling) to free food-making from kitchen.

10. ALLOW **EATING ANYWHERE**

Food experiencing artifacts are found to potentially free food-making and eating from designated spaces. Ideas mainly focus on portable devices which allow user to 3D print foods in unusual places (e.g., commuting on bus, at work)

Figure 4 Annotated portfolio of 10 design implications; sketches, user keywords, and descriptions.

5. Sketching concepts by combining design implications

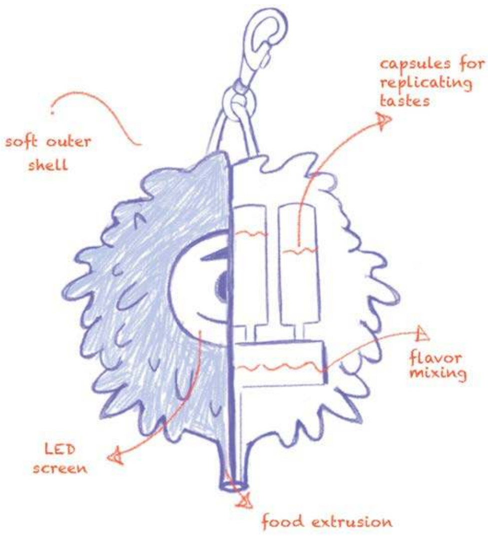
Identifying design implications helped reveal actionable guidance for 3DFP design. To focus on the relevant sequences for our case, we prioritized the most pertinent implications with our initial user data. To do so, we looked at our final mapping, which showed that three pairs of design implications were associated with the same user themes (Figure 5).

Figure 5 Relations map between user themes and design implications

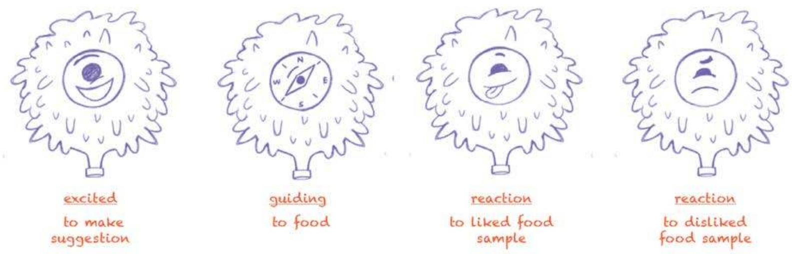
We combined the key points of the ideas under each design implication pair to develop our final concepts. The primary researcher has formed a strong familiarity with all the ideas so far in the analysis process. Thus, concepts in the non-prioritized design implications often inspired the final development process. Consequently, while the critical points of the final concepts are grounded in designers' ideas, they were further detailed with the researchers' speculations. The following sections contain the speculative scenarios of three ideas that resulted from this process.

5.1 tastebudD

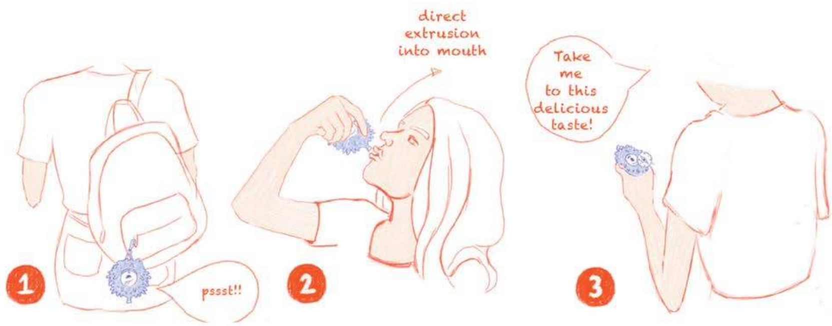
tastebudD is a mobile *food-tasting gadget* used to acquire taste samples outside the user's taste palette. The primary affordance of the tastebudD is *to introduce new foods and ingredients* to its user through sample tastes. It does not produce a complete dish, but upon sample offer, it transforms into a compass and guides the user to the location of the sampled food.



Recently, my mom gifted me a TastebudD, a culinary travel companion. Concerned about my habit of eating fast or frozen food while traveling, she hoped TastebudD would encourage me to explore local cuisine and eat healthily. I tried it for the first time during a flight. When I first opened the pack, TastebudD's soft, washable exterior and friendly eye caught my attention.



After landing, my hunger and worries about finding vegetarian options kicked in. TastebudD's real-time tracking came to the rescue. After a brief stroll, it offered me a taste sample.



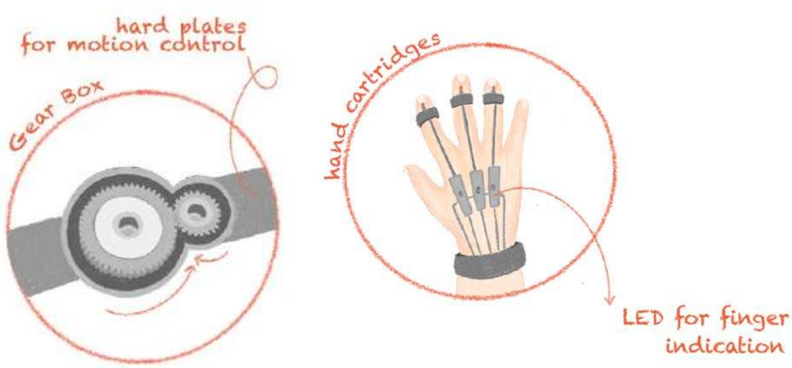
The sample it provided was intriguing. I followed its lead and ended up at a restaurant where the real version of the taste awaited. TastebudD did not disappoint, making the experience of trying new foods more exciting. As a vegetarian digital nomad, Taste-budD has become my trusted companion, helping me explore local cuisine without compromising my dietary preferences.

5.2 Motion Master (MM)

MM is a wearable food-making apron that steers the user's movements and extrudes supplementary food materials (e.g., oil, flour) based on the recipe. It mainly focuses on guiding users' moves and helps make foods that require complex hand and body gestures.

To impress my mother-in-law, I donned my Motion Master (MM) Cooking Apron, an innovative culinary assistant. Using the MM app, I selected a pizza recipe, and the apron's gear system adjusted around my elbows, a surprisingly comfortable fit.

The intuitive MM interface guided me through the entire cooking process. It provided ingredient lists and prompted me to prepare the mise en place. The apron even had finger capsules filled with flour and oil, though their purpose wasn't initially clear. As I relaxed my arms, the apron took over, directing me to mix and knead the dough while signaling when to activate the flour and oil capsules.

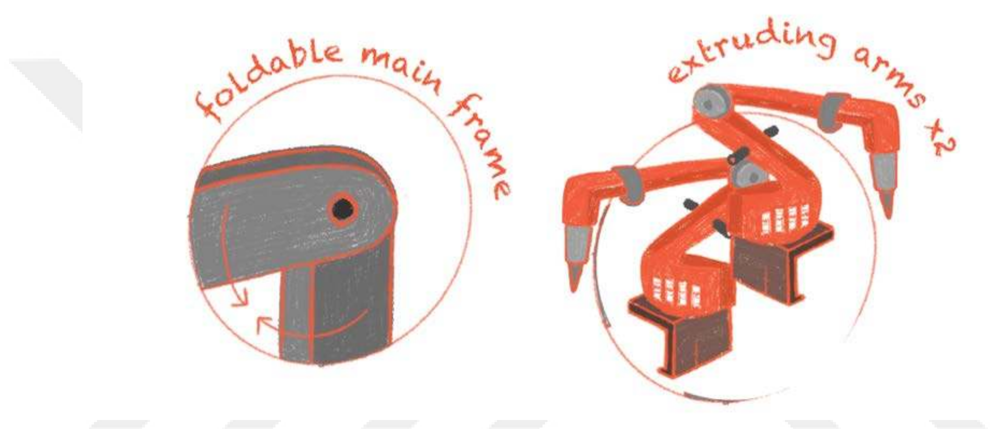


With the dough ready and toppings in place, I baked the pizza, and the delightful aroma filled the kitchen. When my mother-in-law arrived, I served her a perfectly prepared pizza, delighting her with my improved cooking skills. Savoring the meal, I felt a sense of accomplishment and gratitude for the MM apron, which helped recreate cherished memories and empowered me in the kitchen.

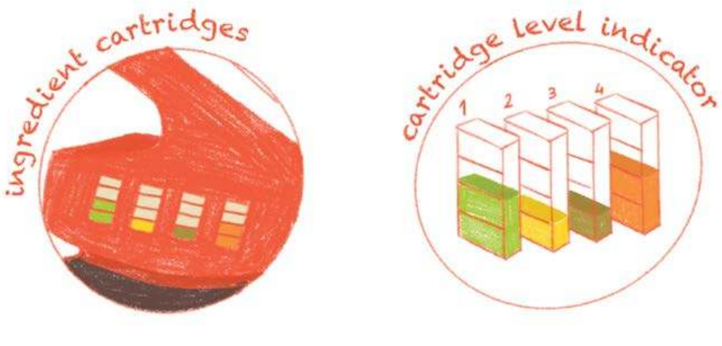
5.3 Tabletop Chef

TC is a portable food preparation game that fosters the sharing of food-making activities in social contexts. It adapts to the changing physical settings of social contexts through its responsive interface that adapts to various surfaces and multiplayer gaming modes. The game also learns users' preferences and uses this information to adjust the game for the different players (i.e., agents).

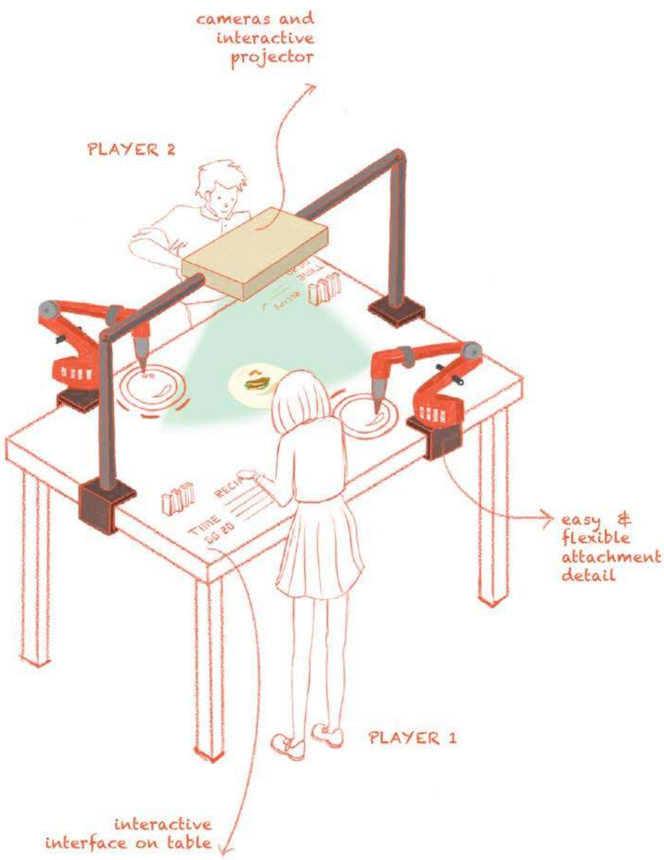
I visited my best friend to challenge him in TC, seeking revenge for his prior victory in a watermelon pit-picking contest. We quickly set up the game on his new dining table, and I was pleased to find it adaptable to any surface.



The TC game came in two main parts: extruding arms (x2) and a main frame housing a projector and motion-sensitive camera. After setup, we waited for the camera to scan the table and customize the gaming interface. Opting for desserts, we chose our favorites, with the game remembering our preferences from user profiles, adding a personal touch to the experience.



The first round, "Fill in the box," began. We competed to load our food cartridges from the extruding arms, and my friend claimed victory. I vowed to do better in the next round. In the second round, we switched places, manually controlling the extruding arms to prepare each other's plates. Projected images showcased our selected desserts, and I managed to win this round.



In the final round, we returned to our original positions for a timed challenge, adding finishing touches to our plates. Despite my friend's simpler dessert, I prevailed. The TC experience was a unique and enjoyable way to prepare desserts, strengthening our friendship with each sweet challenge. We parted ways, looking forward to the next TC adventure.

6. Discussion

Overall, this work reports our explorative journey into the design space of food experiencing artifacts, stemming from a novel technology, 3D Food Printing (3DFP). We explored user perspectives and combined them with designers' and generated design implications. The design implications we present in this study influenced our final concepts, thus, were fruitful and guiding for ideation. Moreover, the design implications represent a speculative portion of the design space of food experiencing artifacts that reveal how activities, emotions, and social relations embedded in everyday kitchens may influence their design. In the following sections, we reflect on our journey and share our learnings.

6.1 Meaning-making through naming: Food experiencing artifacts

During the workshops, designers often asked what defines a 3D Food Printer or how closely their designs should resemble conventional 3DFP devices. These questions stemmed from the recognition that the current limitations of 3DFP may not cover all food-related tasks, considering the diverse landscape of everyday kitchens. Consequently, the designers extended their understanding of 3DFP and made their definitions. In essence, the definition shifted from adherence to Additive Manufacturing methods to *food extrusion with any kind of a nozzle not requiring a 3D geometry*. In line with recent research trajectory, which agrees on the potential of 3DFP to revolutionize food experiences (i.e., a magical technology (Dolejšová, 2019)), the designers' approach addressed various aspects in everyday kitchens. By shifting the definition of the technology across concepts, we were able to ideate more alternative scenarios. Consequently, we preferred to label the final ideas based on the key features they represent (i.e., food-making apron) rather than labeling them strictly as 3DFP products.

We initially utilized 3DFP as a case to stimulate ideas for future applications, yet the scope of the design space we articulate in this paper addresses *food experiencing artifacts* in a broader sense. For this reason, we take designers' attempt to rename 3DFP one step further and suggest calling these technologies *food experiencing artifacts, for* which we speculatively mapped a design space. The *food experiencing artifacts design space* encompasses a wide range of devices that potentially facilitate the processes of sourcing, eating, preparing, disposing, and cleaning foodstuffs (e.g., mobile gadgets, add-ons to everyday objects, wearables, gaming platforms, and smartphone apps). By suggesting this new name, we help develop meaning for designers, support them in understanding the challenges in the design space better, and catalyze their ideation processes. Moreover, this initiative has the potential to enhance communication among stakeholders.

6.2 A fresh look at the limits of the technology

Another ongoing tendency during the workshops was to continuously extend the current limitations of the given technology (i.e., 3DFP). Instead of forcing Additive Manufacturing and singling out issues beyond its current capacity, the designers' approach focused on prioritizing the user data in the design process. With this lens, they conceived devices that integrate into the kitchen infrastructure or adapted food extrusion into other tools available in the kitchen inventory (e.g., knife, pot), as well as portable objects (e.g., edible newspaper printer). They even challenged how the machines operate and explored alternative scenarios to obtain foods embedded in users' everyday eating routines (e.g., vertical printer challenges the layer-by-layer working principle to create sushi or sarma).

We interpret this approach of designers as an attempt to shift away from the current trajectory of HFI technology design, which is often criticized as being techno-centric, alienating the user from the social and pleasurable dynamics (Deng, Altarriba Bertran, et al., 2022). Instead of asking, "What can the technology offer to the user?" designers asked, "How might we design the technology to respond to the current issues and create innovative device forms that enhance various aspects of users' daily food experiences?". Drawing inspiration from this approach, we made sure to employ a similar stance while ideating the final concepts and framing the design implications, as they were the main outcome of the designers' ideation sessions. This strategy helped us to think freely when ideating device forms and even encouraged us to explore the potential new forms the devices may embody.

6.3 An opportunity to bridge HFI with other technology domains

Upon reflecting on the final concepts, we discovered that the design implications inspired us to draw from external technology domains during the ideation of two concepts. Although HFI is practically framed as a sub-discipline of HCI, it often draws on the knowledge base of larger disciplines such as media studies, anthropology, and psychology (Khot et al., 2019). Our reflection hinted at extending the boundaries of food experiencing artifacts design space by steering the gaze to non-food-related technology domains.

The friendly looks of tastebudD builds on one of the earliest and most influential examples of mobile devices, Tamagotchi, while creating a companionship relationship with the user. It aims to provoke positive emotions to overcome the instances where the user is pursuing new foods beyond their palatal boundaries and potentially unpleasant experiences (Lawton, 2017). This approach helped extend the contexts (i.e., traveling or relocating) that can be addressed by designing food experiencing artifacts.

The Motion Master (MM) concept gathers insights from the exoskeleton literature, which mainly targets augmenting the physical capabilities of humans (Pedersen & Mirrlees, 2017). It includes users as active agents in creating the main dish and boosts their cooking skills (Kocaman et al., 2022), while food extrusion serves as a supportive agent. By leveraging an extrusion mechanism for ingredients that complete the cooking, this concept works around the concerns about how satisfactory 3D-printed food would be compared to a full meal (Lupton & Turner, 2018).

Overall, grounding the design implications with other technology domains helped us freely ideate new device forms outside of the norms of Additive Manufacturing. This outlook on designing food experiencing artifacts invigorated us to explore more technology domains from which HFI may draw on.

6.4 Learnings for future food experiencing technology designs

The design implications have shown a potential to provide input for interaction design research and trigger the emergence of new product ranges in the kitchen appliance industry. The design implications we present in this study highlight two paths for future research. First, in our approach, we identified the relation between the design implications and our user-related themes to prioritize and ideate further. However, this was only one of the approaches. Future studies may undertake these design implications with different motivations and user insights and produce other concepts. For instance, we believe it is possible to focus on each design implication singularly and generate more targeted ideas. The second path lies under their potential to be expanded. Further studies may expand the scope of design implications even further by increasing user-related themes and design ideas. This path would provide a more comprehensive foresight into designing food experiencing artifacts.

7. Conclusions

This study illustrates our journey in developing design implications for everyday food experiencing artifacts. We hope to guide future HFI researchers in discovering new paths following our research. Our results shed light on future studies by reconsidering definitions, limitations, and resource domains. First, we noted that to achieve novel affordances, the definition of 3DFP should shift from Additive Manufacturing to "*any nozzle-based food extrusion.*" This strategy helped us gain a broader perspective on designing food-experiencing artifacts. Following this, a shift in the device design trajectory from technology-centered to user-centered encouraged the ideation of new device forms, initially but not limited to portable and wearable devices. Finally, our reflections on the ideation process showed that sourcing inspiration only from food-related domains is limiting, and looking at external technology domains (e.g., exoskeletons and mobile devices) offers fresh perspectives for extending the HFI design space. The final three concepts demonstrate how we employed what we learned from the designers' approaches. The concepts can be prototyped, and their relevance to user needs can be explored further.

In its essence, our results underline the fruitful potential of *focusing on device design* in addition to food design to achieve alternative food futures. We inform future HFI device designs by demonstrating the potential new forms and affordances the devices might embody if oriented to everyday food experiences. We believe these results contribute valuable design knowledge for technologies at the intersection of HFI and HCI fields.

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Paper 3 – HFI Design Space Extension

Extending the Human-Food Interaction Taxonomy through Design Speculations (in-submission)

[Kocaman, Y., & Özcan, O. ***Extending the Human-Food Interaction Taxonomy through Design Speculations***. -.]

Extending the Human-Food Interaction Taxonomy through Design Speculations

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By mapping the design space of the Human-Food Interaction (HFI) field, researchers have built a knowledge base that categorizes the field's current state. Inspired by the fruitful futures that speculative work opens for the HFI field, we aim to extend this mapping by adopting a speculative approach. In this inquiry, we worked with designers (N=25) and generated 3D food printing (3DFP) speculations. We analyzed designers' speculations compared to the previous taxonomy and revealed six new categories for HFI design space to extend, which contribute to characterizing the future of the field. Our results pave the way for future research to better navigate this vast design space by showing an extensive foresight into the future of the field. Moreover, our approach blends HFI theory and speculative design and encourages future work to expand the field even more by exploring the influence of other technologies.

CCS CONCEPTS • Human-centered computing • Human-Computer Interaction (HCI) • HCI theory, concepts, and models

Additional Keywords and Phrases: Human-Food Interaction; design space; taxonomy extension; speculative design

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First Author's Name, Initials, and Last Name, Second Author's Name, Initials, and Last Name, and Third Author's Name, Initials, and Last Name. 2018. The Title of the Paper: ACM Conference Proceedings Manuscript Submission Template: This is the subtitle of the paper, this document both explains and embodies the submission format for authors using Word. In Woodstock '18: ACM Symposium on Neural Gaze Detection, June 03–05, 2018, Woodstock, NY. ACM, New York, NY, USA, 10 pages. NOTE: This block will be automatically generated when manuscripts are processed after acceptance.

1 INTRODUCTION

The Human-Food Interaction (HFI) field is growing with numerous research focusing on developing artifacts, experiences and services. More research and design work in this field leads to the emergence of new technologies that respond to new user needs of future communities. This abundance of user requirements and technologies showcases the need to map current issues, challenges, and opportunities to shed light on future research and better navigate this vast domain. Researchers have previously mapped the past and present state of the HFI by analyzing the existing research publications and artifacts carried out by designers, engineers, and food scientists [1, 10, 25, 28]. These attempts have successfully created a taxonomy for the existing research highlighting the most prominent issues and tendencies in the field's current state.

There is also potential for HFI research to explore possible food futures through speculative methodologies. Speculative design is a commonly used method among HFI scholars to ideate possible food futures. For instance, researchers ideated audio-interactive artifacts where the users could make music with their food as they eat [50] or communicate with their food to check their freshness [18]. These speculative concepts set the ground for future research by showing the positive potentials speculatively approaching food futures entails. However, they only reveal singular instances in the future. An example of speculatively uncovering a wider part of the possible food futures is Food Tarot Cards [14]. It is an excellent example of how future food personas could trigger new ideas grounded in today's trends.

Using these cards, researchers were able to sketch multiple instances into possible food futures, proving its fruitful potential for mapping the HFI.

Inspired by the fruitful potential of speculatively designing food futures, we aim to draw an initial glance at the HFI design space with a speculative gaze through design activities [23]. Although speculative making is a common practice in HFI research, our study responds to the absence of mapping that layers the past, present, and *future* to reveal a broader depiction of the future.

Thus, we asked if we could speculatively extend the taxonomy to obtain a foresight into the future of the HFI field. By doing so, we aim to contribute to the HFI and design research in the following ways:

1. First is a set of speculative future directions for HFI taxonomy [1] to extend into. This extension will help researchers aiming to develop food experiencing artifacts to better navigate their work in the past and present literature and the future.
2. Second, the extension we suggest here encourages more speculative research to be conducted and creates curiosity for how these other technology domains would shape the future of the field.

To approach this inquiry, we focused on 3D food printing (3DFP) technology as it is a technology in the early development phases, and we expect its influence to be significant on the future of HFI [10, 28]. We speculated future concepts grounded in 3DFP technology with 25 designers actively working in academia and the kitchen appliance industry. We reached 73 speculative concepts that will potentially take place in the future HFI design space. In line with the collaborative and cumulative nature of scholarly knowledge, we layered our speculative concepts with the current HFI taxonomy to better envisage how our speculative concepts may fit in and extend the HFI design space. Our results showed that the designers' speculations extend the three HFI lenses (Agency, Domain, and Focus) with six new categories: share, plan, play, temporality, spatial experience, and fluid agency. We anticipate these results will help future researchers and technology designers foresee the near future of the HFI field and better navigate the field.

2 RELATED WORKS

2.1 Boundaries of a Speculative Design Space

The term "design space" is widely used and has various meanings in a range of design-related disciplines. Here, we aim to review the most prominent works that coin this terminology and eventually make our definition for a speculative design space.

We encountered two main approaches to using the term "design space" by reviewing 23 research papers that use the term. In the first approach, a design space is often coined as a physical environment and setting in which designed objects are located and expected to have their lifetimes [19]. In the physical design space, the spatial elements of an environment are defined, and constraints can be prescribed as design directions [19].

The other most common coin of the term is in design and HCI research. In these fields, design space is often referred to as a conceptual space where design instances cumulate to form a systematized well of knowledge [17]. Our understanding of the term design space is rooted in this perspective, referring to a conceptual space that constitutes a set of alternative designs [24, 47] explored through design activities [16].

There are two possible approaches to map a conceptual design space. The first is to lay the existing literature onto a taxonomy by examining it empirically and quantitatively. Some studies in the field of HFI achieved this mapping, although only one suggested a quantitative taxonomy [1, 10, 25, 28]. While the first approach follows the traces of the existing literature, the second approach concentrates on revealing possible futures through speculative concepts and builds a speculative map. Similar quantitative analysis methods can be applied in both approaches. Yet the main difference is that while the former portrays the past and the present (which results in a static representation), the latter draws an image of the future.

The design space we aim to sketch in this study seeks to inspire design opportunities rather than prescribe design choices, as the picture drawn of the future will always be fluid, dynamic, and blurry [43]. According to our definition, a speculative design space is far from sharp boundaries and is infinitely objected to change. However, it provides a flashlight aimed at the obscure future and helps reveal a part of the future and its links with the past and present.

2.2 Designing the Future of Human-Food-Technology Interactions

Researchers have explored possible food futures by developing speculative food concepts singularly. 3DFP research has focused on developing speculative futures by advancing the technology for shape-changing foods [40, 48], Cyber-foods [8], slit-injection printing [36], edible tags [37], and logic bonbon [9]. These examples from HFI research serve as inspiration and catalysts for further exploration, encouraging designers and researchers to think beyond traditional boundaries and consider new possibilities for the future of human-food interaction. They play a crucial role in pushing the boundaries of the field. However, they only shed light on singular instances in the future.

Other speculative works in the HFI focused on developing multiple scenarios to imagine possible food futures. An intriguing example is the More-than-human Futures (MTHF) cookbook [13]. They propose twelve provocations triggered by experimental food design co-creation activities they developed. Each of their proposals point to an alternate dimension of the future. Through design proposals, they invite future researchers to commit material, social, legislative, socio-technical, or ecological aspects of possible food futures. In another HCI workshop, researchers collected proposals for HFI explorations, which enabled future research to emerge in three distinct design directions [11]. These works successfully brought together multiple instances of the possible future of HFI. Despite being inspirational for future research, navigating through their outputs is challenging.

2.3 Design Space Navigation Tools

To help navigate designers in this vast design space, researchers have employed varying methods from food design cards, tables, or maps. Researchers developed Food Design Cards, which aim to guide the design process in the initial stages of design [30]. They provide an overview of the aspects that need consideration, such as storage and waste issues, recipes, and the type of food tech used [30]. Food Tarot Cards, on the other hand, suggest 22 speculative future personas and open up multiple futures through a gamified approach in an immersive and valuable method [14]. Through many workshop applications, researchers successfully obtained multiple future food scenarios that tackle the major issues in the food research domain. They were one of the main ideation tools utilized in the MTHF cookbook development [13].

Researchers also developed maps and tables as navigation tools for future research. One attempt at mapping the HFI design space suggests forming a Special Interest Group (SIG) named “foodHCIfutures” [10]. They propose an indicative map of the potential map they intend to create with the community. There are also empirical studies that map the current issues in the HFI by systematically reviewing research publications and proposing a taxonomy made of three lenses: Domain, Focus, and Agency. In this study, researchers developed an online tool –HFI lit review app– that allows open access to their results [1]. It was functional, but not a permanent tool, and its format was limited to research publications. From our experience of browsing the HFI literature through this app in our research activities, we believe this tool could benefit from community input that would make it timeless.

Nevertheless, their approach successfully proposes a comparable and quantitative account of the taxonomy of publications in HFI that could practically be followed by future research. Another mapping extends the HFI field from the lens of eating experiences [25]. Their results delve deep into eating experiences and propose several tables showing empirically grounded key aspects of future eating experiences. Their results serve as an inspiration and generative tool for ideation and co-design, but they only extend the design space under one category of HFI taxonomy [1].

2.4 Extending the HFI Design Space with the Influence of One Technology: 3D Food Printing (3DFP)

Our research questions how to extend all lenses of the HFI taxonomy by focusing on a single technology [1]. In this case, we focus on 3D Food Printing (3DFP), as its place in the HFI field is vaguely described in previous attempts. 3DFP is a revolutionary method for creating edible materials using Additive Manufacturing. These machines are utilized in a variety of domains, such as high-end and pop-up restaurants [22, 38]. There are also concepts where 3DFP devices promote provoking ways of futuristic eating. In the Tiger Penis Project, 3DFP devices help critique a traditional way of eating and staying healthy [46]. The machines also operate at a more personal level, tailoring foods to one's nutritional needs and developing healthier eating habits. Researchers empirically tested these machines to modify the internal filling of foods that prolong the chewing time of foods that induce satiety earlier [32]. Due to its wide application areas, 3DFP, as a singular technology, scans a portion of the HFI space [10]. Because of its potential for changing food practices from many levels, from personal to industrial, it is expected to revolutionize the future of food and human-food interactions [7, 33]. For this reason, we expect the influence of 3DFP on the future of the HFI field to be significant and worth exploring.

3 METHODS & MATERIALS

3.1 Study Settings

To discover a large number of possibilities for potential speculative artifacts, we conducted brainstorming sessions with professional designers from the kitchen appliance industry and interaction design researchers (N=25). The designers who participated in the sessions were design practitioners (UI, UX, product, and graphic designers working in the kitchen appliance industry) (N=14) and interaction design (IXD) researchers (N=11). We invited the designers through our professional network of our research lab. For the brainstorming, we used several materials to trigger ideation: an introductory presentation about 3D Food Printing and its state-of-the-art (3DFP), food-related keywords, food images, and recipes. These materials were constructed based on the user insights from a previous study [citation anonymized for review]. Each brainstorming session started with the introductory presentation (20 mins), which is followed by individual ideation (20 mins) and then group ideation (90 mins). Designers were instructed to use the provided materials in brainstorming to acquire user-centered inspiration. Designers were divided into seven study groups and generated 73 ideas in four sessions (Table 1).

Table 1: Participant distribution in the brainstorming sessions and the number of ideas produced in each session.

Session no	No. of ideas produced	No. of designers	Group	Designer specialties
#1	34	6	A, B	IXD researchers
#2	17	3	C	IXD researchers
#3	15	8	D, E	design practitioners
#4	7	8	F, G	IXD researchers & design practitioners
Total	73	25		

Except for session 2, all brainstorming sessions were completed with two groups, and a design critique session between groups followed each session (Figure 1).

Figure 1: (left) Designers working in two study groups; (middle) designers sketching in group brainstorming; (right) design critique session. (images are blurred for review)

All the design critique sessions were video recorded, and all the drawings designers generated during the brainstorming sessions were collected and digitized by photographs. We collected six hours of video containing the designers' design descriptions, following design critique sessions, and designers' sketches for all 73 concepts.

3.2 Data Analysis

We analyzed the speculative concepts designers created with the current HFI mappings previously reported to help draw visible links between today and future speculations. From this analysis, we also aim to understand how design speculations might extend the current design space. Although there are several mappings of the HFI design space [10, 28], we chose to pursue Altarriba Bertran et al.'s framework because it proposes a comparable and quantitative account of categorizing the HFI literature [1]. In our analysis, we base our approach to this framework by coding each design concept with the 11 HFI dimensions reported (Figure 1) [1].

To prepare our dataset for analysis, we transcribed each design presentation recording (a total of five hours). Then, we created a data sheet in MS Excel and created rows for each idea. All the designers' sketches were linked with their design descriptions to ease browsing. We conducted data coding using the same software. Apart from the main researcher, a junior researcher who majored in psychology was involved in coding ideas. She is invited to the analysis to refrain the main researcher from her potential biases and provide a perspective of human psychology. Both researchers coded the dataset blindly, and after each was done, the codes were compared to make a final decision. While coding the ideas, the researchers were tasked to suggest any new domains that would extend the taxonomy at hand. After the coding was completed, the main researcher moved on to draw graphs and make meaning out of the analysis. Overall, we looked at several descriptive statistics and compared the frequency of ideas under each dimension.

Apart from coding the designers' ideas with 11 HFI domains, we also conducted an open coding session with two junior design researchers, followed by a thematic analysis [4] to identify potential patterns forming in the dataset. This analysis delved deeper into the unique themes that emerged from the patterns of design concepts and revealed potential paths for future HFI artifacts. In a recent work, we presented ten design directions resulting from this analysis [citation anonymized for review].

4 RESULTS

The HFI taxonomy [1] categorizes HFI publications under three lenses: Domain, Focus, and Agency. The categories under the HFI lenses propose a conceptual model of HFI research by reflecting on the diversity of approaches and contemporary issues they tackle. While coding the dataset with the existing lenses, we encountered new categories emerging from the designers' speculations. We observed that concepts were coded with these emerging domains as frequently as some existing categories. Thus, following Altarriba Bertran et al.'s evolutionary approach to their dataset coding, we allowed new domains to emerge as we coded the dataset. Our coding of design concepts resulted in six new categories that extend the current lenses of HFI taxonomy with the influence of 3DFP technology (Figure 2).

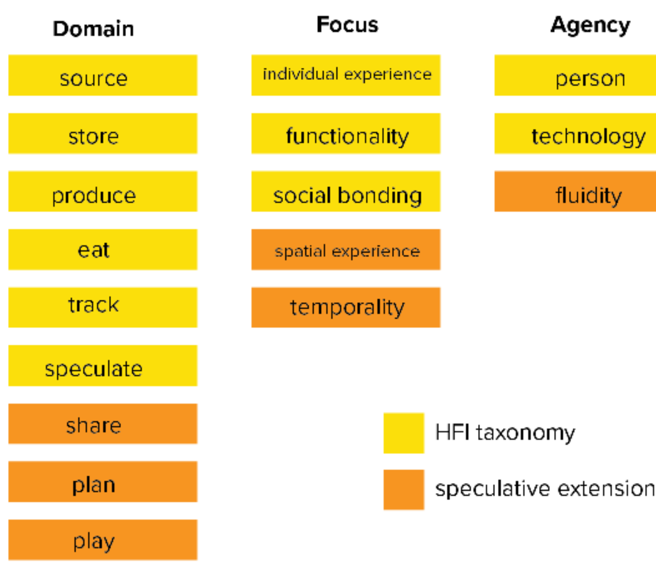

Figure 2: HFI design space taxonomy [1] and the speculative extension suggested in this study

4.1 Emerging Human-Food Interaction Domains

Previously listed HFI taxonomy suggested six unique categories of domains where each contribution responds to the diverse nature of the human-food web [1]. Each domain represents the portion of HFI literature followingly [1]: **Source**: foraging or buying food (e.g. [5, 34]), **Store**: practices of both storing and disposing of food (e.g. [21, 42]). **Produce**: growing foods, as well as manipulating them to create more complex combinations, such as dishes or meals (e.g. [49, 52]). **Track**: identifying and measuring food and related practices (e.g. [32, 35, 39]). **Eat**: food consumption (e.g. [36, 44, 45]). **Speculate**: contributions that explore alternative food futures or conduct meta-reflections on HFI as a research field (e.g. [3, 15]).

Supporting the perception of 3DFP technology as a food fabrication device, results show most of the ideas to be cumulated under the produce category. We observed in the dataset that 34,7% of design concepts have incorporated food creation in some way. The second most attributed category was eating, where almost 16,2% of the ideas involved eating foods prepared by or with the artifact designers speculated (Figure 3). Store domain was the least attributed in our dataset. Our coding of design concepts resulted in three new categories that extend the domain lens with the influence of 3DFP technology: share, play, and plan.

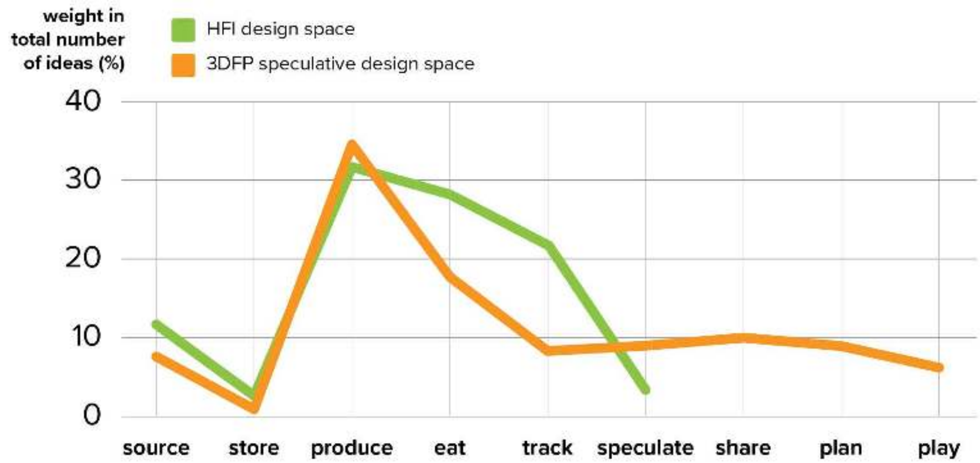

Figure 3: Comparison between speculative 3DFP dataset and HFI publications based on the weight in number of ideas in each domain category.

Share: Designers ideated concepts that involved three different types of sharing practices. First, several concepts involved sharing images and recipes of foods on online platforms directly through an interaction with the food experiencing artifact. Designers discussed building open-source recipe-sharing platforms where users could share their personal recipes, browse recipes to download directly to their 3DFP and read community and celebrity recommendations. The second sharing practice involves making and presenting food for guests and loved ones, which entails emotional experiences. Some designs touch upon artifacts that help users make elaborate foods for eating routines and anniversaries shared with family members, partners, and roommates. Finally, designers discussed concepts where the technology mediates eating together in social settings.

Play: Designers developed several playful eating scenarios, ideated food-making and eating toys for kids, commensality games for adults, and playful interactions with the technology. They ideated toy guns for children that let them print food on various surfaces at home and eating, with a connotation to how children paint walls. Another idea, again, was a toy concept that fostered social interaction between children, in which they fed each other by directly printing foods in each other's mouths. The commensality games for adults were imagined in contexts such as pubs or dining dates, either romantic or friendly. Most concepts involved achieving a goal (e.g., building a bridge between tables using French fries) or completing a story (e.g., role-playing hunter-gatherer personas and foraging food as if they were in a tabletop terrain). Other ideas considered playful interaction with the machines, where they imagined a companionship relationship with the machine. In one of the ideas, the user becomes a dancing partner with the machine. In this scenario, users dance with the machine following a particular choreography to make foods such as shredded pastry (i.e., kadayıf), which require specific body movements for their creation. All the scenarios in the play domain mainly incorporate fun and entertainment as a core element, where food-related practices mediate this experience.

Plan: In designers' concepts, we observed several planning works practiced by the users, either with food, daily meal scheduling, ingredient preparation, matching, and gathering, or deciding the primary agent of cooking. In each idea, a common goal was to plan the upcoming food-making or eating activity. For instance, there were critical scenarios where planning was crucial and made possible by artifacts they designed, such as planning a child's medication and giving it through food. Other instances involved devices that guide the user to make use of the ingredients that they already have at hand without buying anything new or suggesting new uses for fruits and vegetables in their pantry that are about to rot. These scenarios highlighted the importance of reducing household food waste and promoted digital food technologies as a potential help to guide users consume food more sustainably.

In our dataset, we observed relationships between domain categories. Almost all the concepts were coded with at least two HFI domains, with seven exceptions. In line with this observation, previous studies show that future digital food technologies should support users' food practices in more than one aspect [29]. In our dataset, the patterns of these relationships between domain categories could be viewed as a map (Table 2).

Table 2: Cross relationships between domain categories.

Source	**Store**	**Produce**	**Eat**	**Track**	**Speculate**	**Share**	**Plan**	**Play**	
12	3	9	1	1	2	1	2	0	**Source**
	3	3	0	0	1	0	0	0	**Store**
		60	20	11	11	13	15	8	**Produce**
			28	1	8	8	4	5	**Eat**
				12	2	0	3	2	**Track**
					15	1	1	3	**Speculate**
						18	1	1	**Share**
							16	1	**Plan**
								9	**Play**

While most domain categories relate to the production of foods, storing foods is rarely associated with other categories. The second most matched category was found to be the eat category. Clearly, the designers mainly related the 3DFP technology with the produce domain. However, they did not treat this technology only to produce edibles but combined its productive capacity with other HFI dimensions to elevate its potential.

4.2 Extending Focus with Spatial and Temporal Dimensions

The focus of studies in HFI taxonomy is attributed to a continuum between functionality and experience [1]. The latter is divided into two parts: individual experience and social bonding. Although this taxonomy helps to develop an initial understanding of the focus of HFI research, it does not delve into much detail about how the continuum between the function and experience formed while also leaving out where to position social bonding on this spectrum. For this reason, we treated this lens as a categorical variable with distinct clusters, where it is insignificant to define a hierarchical relationship within. In addition to previously reported dimensions of functionality, individual experience, and social bonding, our speculative extension into the HFI lens focus suggests two new dimensions: spatial experience and temporality.

Spatial Experience: Designers ideated concepts where food experiencing technologies affect how they experience the space. For instance, one scenario particularly focused on feeling like they are in another country, which is mediated by atmospheric elements such as food smells (e.g., coffee or baked bread smell in breakfast reminds them of their time in Italy). They also considered the changing lifestyles in today's world, such as nomadic and mobile living arrangements. There were several instances where designers focused on food-making devices that prepare food on the go while highlighting that there might be no kitchen space in future homes. This discussion led to another idea where the digital food-making device is integrated into the interior infrastructure of the living space. Designers also questioned how one experiences a city through food. Concepts focused on kindling a bond with the town they live in or travel to by helping them experience foods from history. They discussed concepts that allow them to "time travel" in history through exploring and reviving lost recipes from the local history.

Temporality: In our dataset, we've encountered many concepts that focus on the time efficiency of food experiencing artifacts. Designers ideated concepts where the new artifact elevates the food experience into a more practical fashion (e.g., quickly cooking for unplanned events, making weekly schedules, timing food-making with other daily activities). They also generated concepts in which they consciously approach the time spent cooking (in these scenarios, 3+ hours) and focused on creating foods worth the time spent (e.g., functional foods). They defined these foods in their concepts as foods they could not achieve using conventional cooking methods. They questioned the food-time relation on a larger scale, focusing on recreating cultural food history creating food experiences for special occasions like national holidays or anniversaries. Lastly, designers focused their speculative concepts on the shifts in food requirements and preferences throughout one's lifetime.

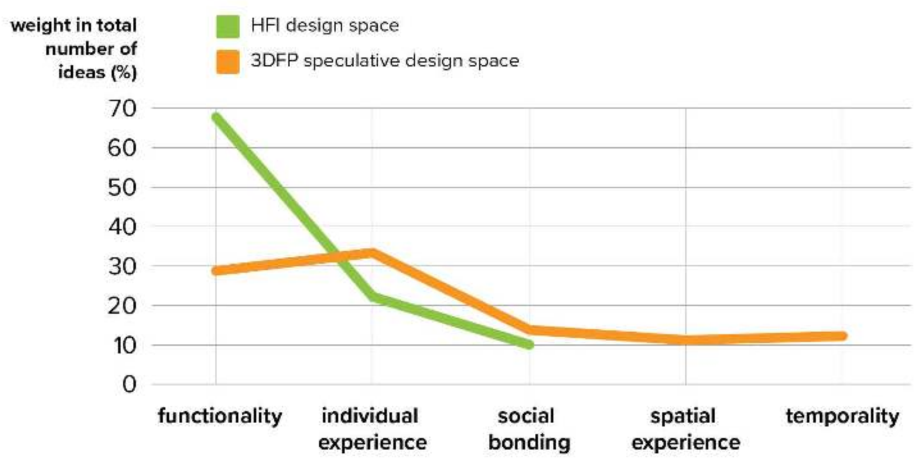

Figure 4: Distribution of Focus lens compared to the results in the HFI literature dataset.

In contrast with the HFI literature, designers' speculative concepts mainly focused on functionality and the individual experience (Figure 4). However, the individual experience focus is slightly more attributed in our dataset. Designers interpreted functionality as a concept that leans towards practicality, while they the concepts they generated highly focused on developing better eating and food-making habits associating new artifacts as personal or shared devices. Another significant finding that Figure 4 illustrates is that the spatial experience and temporality categories were attributed in the concepts as frequently as social bonding, which verifies their existence as new focal points for future HFI concepts.

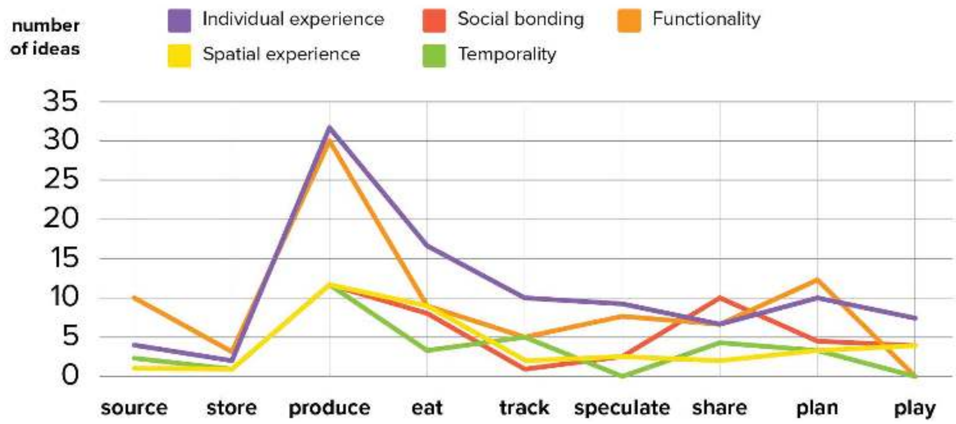

Figure 5: Distribution of Focus under HFI domain categories.

When broken into the focus dimensions, we found that designers mainly focused on the eat and track categories when designing individual experiences (Figure 5). In most domain categories, individual experience and functionality were attributed more frequently than the other HFI focuses. Although there is a tendency to focus on individual experience and functionality, none of the concepts that fall into the play domain focused on temporality or functionality. We also observed a duality in concepts that fall into the produce domain. As this is the domain where most of the speculative 3DFP concepts were accumulated in the dataset, we found that these results may be interpreted more broadly. Here, our results show that while functionality and individual experience are highly focused on speculative concepts, another direction focuses on spatial experience, social bonding, and temporality.

4.3 Another Type of Agency in Human-Food Interactions

In HFI taxonomy, agency refers to the interplay between humans and technology when dealing with foods [1]. Previous work attributed agency to a continuum between Person and Technology, in which the latter end represents a higher autonomy of devices in food-making. Compared to the HFI literature, our dataset showed a more equal distribution of the agency of ideas between person and technology dimensions (Figure 6).

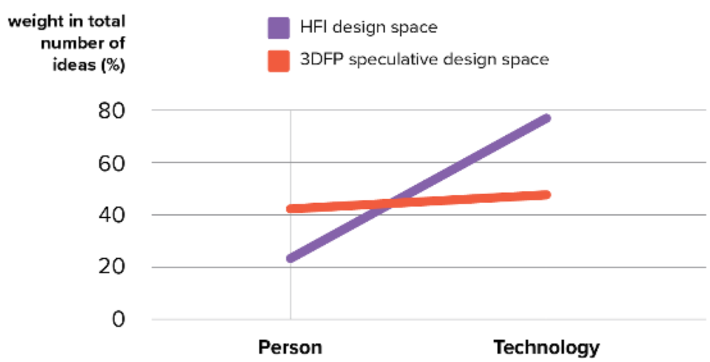

Figure 6: Comparison of 3DFP speculative dataset and HFI literature under the Agency lens.

Designers' speculations in each HFI domain category almost equally considered person and technology agencies. This may be caused by the narrative shift we employed where we initially instructed participants about building 3DFP artifacts; however, we did not limit them to stick to the technology in its conventional sense. Due to this shift, designers could play with the level of agency between the user and the technology more freely, where the artifact may sometimes drift from being a complex machine that overrides the human agency.

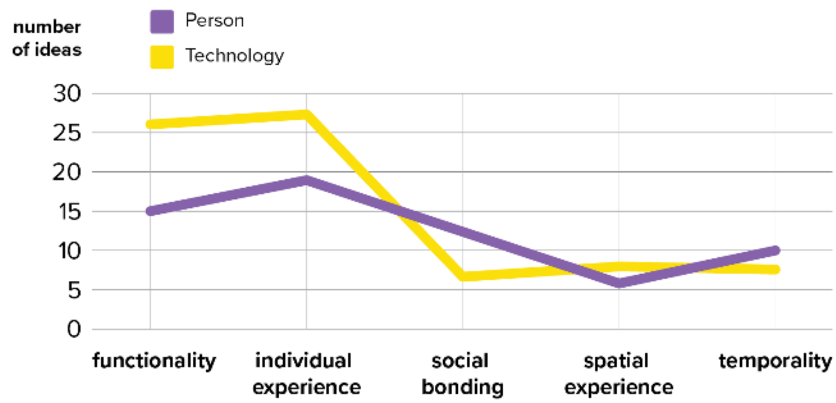

Figure 7: Distribution of speculative 3DFP concepts (Agency vs. Focus).

While speculations that focus on functionality and individual experience prioritized the agency of technology over the person's, those focused on social bonding prioritized the agency of the person (Figure 7). They ideated making functional foods and making food waste useful by keeping the technology in charge. In this scenario, designers kept only a sense of agency in the user while helping them achieve foods that are impossible to obtain using conventional cooking methods (e.g., lab-grown proteins).

In the remaining focus categories, we observed design instances that involve tasks operated by both the user and the machine. For example, designers ideated social bonding scenarios where artifacts only serve for task delegation during co-cooking, surprise dining guests with sweet and sour flavors, and help diners fairly share a meal based on personal favorites. However, designers often questioned who the end-users of the future food-experiencing artifacts are. They speculated scenarios where control is interchangeable between potential agents such as children, animals, and devices. For instance, designers imagined a unique scenario where the machine is the companion to the user with its sense of self and vital requirements. In this concept, users co-exist in a *fluid* agency with the food-making device. The fluid agency is represented in the concept as a mutual feeding relationship. The device takes care of its users' gut health while requiring care from them to operate at a healthy level. We observed the fluid agency in other design instances as well. Designers ideated artifact concepts designed to fluctuate behavior based on the users' momentary motivation shifts towards food practices. Designers discussed the importance of this temporal shift in eating and cooking motivations as they change by the hour.

5 DISCUSSIONS

5.1 Peeking into the Future of Human-Food-Technology Interactions

Due to the increasing number of studies in the HFI field, there is a need to produce navigation tools for the studies to be carried out in this field. In this sense, design space studies can be guiding, and our approach unlocks multiple pinholes into a possible future space by proposing a speculative direction for mapping the HFI design space. In this study, we generated an initial idea of the potential areas where future studies might fall into. We also draw links to this proposed future rooting in the current state of the research field. Notably, this future is blurry and will most likely change with more research and design work to come. Yet, we believe drawing these links through HFI taxonomy helped generate discussions for the future of the field. Our results revealed how speculative concepts can extend the research field of Human-Food Interactions (HFI), and under the six domains we suggested, several design opportunities emerged.

5.1.1Uncovering Fluidity in Agency

How designers approached the relationship between the various participants of future food experiences triggered discussions about the fluidity of agency. This scenario relates to a recent work, Data Hungry Home, which suggests redefining the relationship between humans and more-than-human agents at home [31]. In this concept, the human in the domestic environment feeds the digital artifacts with data, a phenomena defined as their food. She contributes to the well-being of their non-human agent at home by providing it vital resources. Our results showed that this relationship could be designed in a changeable manner for human-food interactions. Designers were inspired by the users' perception of cooking as an enjoyable activity, and they avoided generating concepts that automate cooking altogether, thus alienating them from the process while keeping technology ready to help when needed [12]. They sketched food futures where the users could unlock new foods, eating habits, and cooking skills with the help of digital technologies [29].

The studies in HFI literature mainly prioritize the agency of technology. This approach exemplifies the tendency towards a techno-solutionist approach, which undermines users' values, practices, and experiences, a common critique for technology research in HFI [7, 10]. Specifically, for 3DFP research, there is a prominent perception that it is a magical solution that automates food production and reduces all tedious tasks in the kitchen [2, 33]. This perception completely neglects the fact that food making is a recreational activity that relates to relaxation, creativity, and intimacy and even has the potential to improve one's mental well-being [20, 26]. For this reason, it is crucial for HFI research to adjust the level of agency to refrain from neutralizing the user and keep food-related activities enjoyable.

5.1.2Space and Time in Food Experiences

While food-making and eating could be interpreted at a human-machine relationship level, there are also spatial and temporal dimensions. Our extension of the focus lens of HFI taxonomy is meaningful as we frequently observed the focus of space and time in the designers' ideas. Although spatial exploration is a new focus for the HFI field, speculatively adding this category to the taxonomy encourages future researchers to think deeply about this notion and incorporate the spatial element in their research. The spatial experience of digital food artifacts is only discussed in the context of space missions where the end-users (i.e., space travelers or astronauts) operate in an extremely small space and without gravity [41]. Researchers developed the Memory Bites concept to overcome physical constraints such as the aforementioned limited space. This concept highlights the healing power of food-memory matching and points to the issue of being physically away from a place that could affect one's emotional well-being. Thus, the Memory Bites design concept contributes to astronauts' or future travelers' potential challenges by transferring a place's memory through foods. In fact, our results highlight the changing lifestyles of future communities, such as migration, nomadic living, and communal living. These instances together show that novel food experiencing technologies could support well-being in future communities by place-making through food and creating meaningful experiences.

5.1.3Plurality of Domain Categories

Although HFI domains are diverse, we argue that interrelationships of HFI domains could lead to critical discussions within the field. For instance, future research could work by looking at the domain relation map we provided and identifying current trends in which different domains are matched. It is also possible to reveal more neglected matches and domains with this map. We believe it is possible for future researchers to develop their speculative concept database and develop the same map using the same method. This way, they could identify the trends in their dataset and domain categories that receive less attention.

In this study, we focused on a technology that is mainly perceived as a food production technology, which our results verify. However, our results also show that a technology positioned in the produce domain in the HFI can trigger extending the field from a broader perspective, resulting in extensions in all the other HFI lenses. This finding verifies our initial motivation for selecting 3DFP technology for its wide impact potential area on the future of the field.

5.2 Footsteps of a Living Design Space

The analysis we made in this study helped us realize that the future is inspired by today. Today's technologies are highly influenced by the speculative vision put forth by sci-fi literature of the past, such as Star Trek [51]. Inspired by such work, our study takes an initial step toward picturing multiple instances of possible food futures. However, all the design instances we propose in this study belong to a different alternate world and are not necessarily linked. Thus, their illuminative strength is limited. Still, in our analysis, we observed that they illustrate links between the past, present, and tomorrow's food experiences. For instance, in the spatial experience category under the focus lens, we observed how the food culture, customs, rituals, palates, and recipes are shaped continuously and cumulatively. In fact, many speculations in this category relied on local and cultural inputs and draw ties that are impossible to neglect when designing future food experiencing artifacts. This observation highlights the importance of incorporating the spatial, cultural, and societal realities of the past when creating the future of food.

We also believe there is potential in discovering phenomena in close proximity to a design instance of the future for mapping possible and plausible futures. In fact, it is a pressing matter to develop convincing design strategies for building tools and methods for mapping the multiple perspectives and related controversies of the future [27]. Thus, this creates an opportunity for future research to employ more speculative methods and continue expanding the HFI field. We believe our approach is open for improvement if other design fiction methods (e.g., worldbuilding [6]) are employed in a more grounded manner. This would diversify the multiple perspectives we present here.

Although our results revealed several opportunities for possible food futures, they present a still image of a possible future. Yet, earlier in the article, we explained that the speculative design space is a dynamic phenomenon that changes with new design instances. This pushed us to question how we could advance this research more dynamically. We highlight the value of the approach taken in HFI taxonomy to build a living tool for the community to actively engage with [1]. As one of their most appreciated contributions, the HFI Lit Review App became a handy tool that we used quite frequently in our research activities. Therefore, we offer an opportunity for future studies to build a dynamic online platform for this speculative database with open-source access and community contribution. This platform could serve as a digital design studio for HFI researchers as well as design researchers in which they come together, share their speculative food future ideas, and give it life. If such a tool existed, it would serve as a common ground for a global and fruitful dataset to form, which could be used by design and HFI scholars for taking inspiration, observing how the field tends to grow, and browsing future trends.

6 CONCLUSIONS

In this work, we attempted to speculatively map a design space for the future of the Human-Food Interaction (HFI) field. We reached six new categories where 3D Food Printing (3DFP) technology may extend the HFI taxonomy. Overall, our approach successfully shows that it is possible to speculatively sketch a design space rather than generating design speculations for an instance in the future. This way, we were able to gain a foresight into the future from a broader perspective. We believe this work inspires both HFI researchers and HCI researchers to broaden their gaze and look into the future speculatively.

Although this work marks a significant contribution by providing a speculative direction for extending HFI design space, our collected cases mainly were inspired by the influence of one technology, 3DFP. Focusing only on this technology limits our results regarding the possible extensions it could influence. We acknowledge that the HFI interaction design field is concerned with technologies in a broader spectrum, from laser cookers to robotic servers. We invite future research to intentionally extend the HFI design space by focusing on the possible food futures each technology may facilitate.

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Paper 4 – MFP in Restaurants

Mobile Food Printing in Professional Kitchens: A design inquiry of potential applications.

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Mobile Food Printing in Professional Kitchens: A design inquiry of potential applications

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ABSTRACT: The knowledge transfer from 3D printing technology paved the way for unlocking the innovative potential of 3D Food Printing (3DFP) technology. However, this technology-oriented approach neglects user-derived issues that 3DFP technology could address. To explore potential new features and application areas for 3DFP technology, we created the Mobile Food Printer (MFP) prototype. We collected insights from novice chefs for MFP in the restaurant context through four online focus group sessions (N=12). Our results revealed how MFP can be applied in kitchen routines (preparation, serving, and eating) and introduce novel dining experiences. We discovered two main themes and four learnings for HFI designs, and using these learnings, we generated eight design ideas in an iterative design workshop with designers and engineers (N=6). We conclude this work by discussing four potential design considerations for future HFI artifact designs. Our findings create a baseline for future research to investigate mobility in 3DFP and explore new features.

1 INTRODUCTION

The evolution of 3D Food Printing (3DFP) technology can be traced back to 3D printing, which established its foundational design principles. We anticipate that this influence will continue considering the shared design features between 3DFP and 3D printing devices, such as device proportions, nozzle diameters, chassis-based bodies, and axial constraints. Although this knowledge transfer paved the way for unlocking the innovative potential of 3DFP technology, recent research asserts the importance of considering users' current practices, knowledge base, habits, and values when designing Human-Food Interaction (HFI) technologies given the food's unique nature as a production material (Dolejšová et al., 2020).

The current trajectory of the 3DFP development primarily focuses on implementing features from 3D printing. For instance, several studies work on advancing the food formulation and printing process to increase the usable ingredients and achieve the best textures at the end of the printing (Pereira et al., 2022). While this approach advances the mechanical capabilities of the technology, it reduces the food experience to the variety of ingredients and recipe precision. Such studies mainly focus on the applicability of 3DFP to the food service sector; however, they neglect the user-derived issues in the kitchen that the technology could address (Deng et al., 2021, 2022).

The competitive landscape forces restaurants to constantly seek innovative solutions to address critical issues such as reducing food waste, menu limitations, and labor costs. 3DFP technology is found to have the potential to help overcome such challenges by automating tasks, especially laborious ones (Pereira et al., 2022). Moreover, digital fabrication tools elevate chefs' creativity by allowing a medium for new recipes (Mizrahi et al., 2016). These factors together influence hospitality managers to implement robotic technologies based on competitive pressure and relative advantage (Pizam et al., 2022). Despite its potential, 3DFP is still a technology that needs new features and capabilities to fully adapt to everyday settings (J. Y. Zhang et al., 2022).

Overall, explorative research is needed to seek new features and application areas for 3DFP technology with a user-oriented lens. To respond to this inquiry, we aim to uncover opportunities for 3DFP technology rooted in the situated practices in professional kitchens. We adopted the Research through Design (RtD) methodology and created the Mobile Food Printer (MFP) prototype. MFP prototype implements *mobility* as a novel feature for 3DFP. In a two-step study, we explored application areas in the restaurant context that mobility enables.

First, we used the MFP prototype as a research object in four online focus group sessions (N=12). We collected novice chefs' insights on using MFP in the current routines of professional kitchens (preparation, serving, and eating). By doing so, we uncovered ideas for how such a novel technology might improve food service and offer novel experiences for diners. We extracted four learnings from this study.

In the second step, we brought the insights from novice chefs to interaction designers and engineers (N=6). In an ideation workshop, participants ideated eight concepts that would appropriate MFPs in the professional kitchen and dining room spaces. By doing so, they transformed the insights from novice chefs into design knowledge, which we present as four design considerations. With these findings, the current study aims to contribute to the HFI in the two following ways:

- We exemplify a case that creates a baseline for adapting mobility to 3DFP technology in the restaurant context
- We present design considerations to inspire potential HFI concepts that future research may build upon.

Our inquiry showed that MFP may help address conventional practices and has the potential to streamline food preparation and serving in the kitchen. MFP also showed the possible futures of enhancing diners' experience by facilitating playful eating. This transformation is uncovered by the user-centered approach we adopted while implementing mobility from 3D printing. By doing so, we were able to delve deep into the features of mobility and propose design considerations for future HFI innovations specialized to the restaurant context.

2 RELATED WORKS

2.1 *Mobility in 3D printing*

Innovative applications in 3D printing have helped to unlock new possibilities for the technology. For instance, swarm printing concepts, often operated with materials such as plastic and concrete (Hunt et al., 2014; Oxman et al., 2014), opened up opportunities for building larger structures using this manufacturing method. In those examples, the outcome is built in collaboration with many synchronized small robots. With the advantage of free movement, the outcomes reach great sizes. In construction, it is emphasized that mobility increases the maneuver capability of the printer rather than stationary robotic examples. Increased maneuver capability is considered a novel advantage in small construction sites. Especially when mobility is combined with a robotic arm that enables the system to handle large load capacities while allowing it to work accurately (Keating et al., 2014). Even though some examples tested mobility with robotic construction (Hunt et al., 2014; Keating et al., 2014; X. Zhang et al., 2018), we have not encountered a study that deeply explored mobility in digital food fabrication.

2.2 *Adapting Mobility to Food Printing*

Previous research and commercial product examples show that most food printers were derived from existing 3D printing devices that are stationary and have limited printing plates. Similar to most conventional types of 3D printers, most food printers are not mobile or portable devices that can be carried around. Only one product on the market offers portable use (*byFlow*, 2015). Portability allows this device to be used in novel dining concepts such as FOOD INK's pop-up dining concept (*3DFP Ventures Ltd.*, 2016). At FOOD INK, food is prepared by 3DFP devices at the sight of the diners. Although a portable food printer is commercially available (*byFlow*, 2015), mobility in food printing is still an underworked area. Since portability extended the usage areas of the food printers, we speculate that if being mobile, contrary to being stationary, is possible in food fabrication, such devices could extend the potential use cases of 3DFPs.

As exemplified in recent work on different materials, mobility offers manifold opportunities for digital fabrication. However, we believe studying mobility in edible materials is crucial as the unfolded opportunities are welded specific to the context. For instance, overcoming size limitations is vital for architectural construction (Oxman et al., 2014), while such an affordance does not have a reflection on the food domain. For food production, parameters such as precision, consistency, health, and safety are the challenges that need to be addressed. In fact, when the dynamic nature of the kitchen and the dining room contexts are considered, mobility may entail more unique use cases situated in the kitchen and the dining room. For this reason, studying mobility in the context of digital food fabrication needs further studies.

2.3 *Designing for the Restaurant Context*

In this research, we divide the restaurant notion into two main spaces: kitchen and dining room. In the kitchen, food preparation occurs, while in the dining room, there is food service where service staff interact with the diners.

The complexity of the kitchen space ignited a large body of literature on developing ergonomic and safety standards for designing this space. Previous research worked immensely on developing standards for achieving the most efficient workflows in the kitchen (Knott, 2010). The design field is also advanced in designing singular kitchen items, such as kitchen counters, to work in the best posture and put ergonomic considerations at the front (Patil & Rajhans, 2018). Ergonomics is considered at the intersection of work environment and human task performance, informing the field on the most effective, efficient, and safe cooking practices without compromising kitchen functionality (Chen et al., 2024).

The kitchen is a complex space operating in collaboration with many agents who take part in the food preparation and service (McBride & Flore, 2019). One of the prospective agents that will be a collaborator in the kitchen is undoubtedly robots. There are numerous robotic applications developed for food service, helping cooking practices in a number of ways enough to form a taxonomy (Pereira et al., 2022). Studies show that the adoption of robotics, artificial intelligence, and service automation positively influences customers' intent to revisit and recommend a restaurant (Santiago et al., 2024).

Evidence shows that innovations help restaurants improve quality, cut costs, and increase sales and profits (Ottenbacher & Gnoth, 2005). As a key component of innovations, it is critical for entrepreneurs to develop new products, open up new markets, and bring novelty to the sector, thus generating a competitive advantage in the market (C. Lee et al., 2016).

3 DESIGN AND IMPLEMENTATION OF MOBILE FOOD PRINTING (MFP) PROTOTYPE

We initially intended to design a robot to print edible materials by moving on varying surfaces. We further aimed to open up possibilities for mobility to pave the way for 3DFP technology. While building this prototype, we primarily targeted free movement, which ultimately relates to responding to the current context in professional kitchens. In principle, we made a design proposal for a digital food fabrication device that prints edible materials on an indefinite surface (Fig. 1).

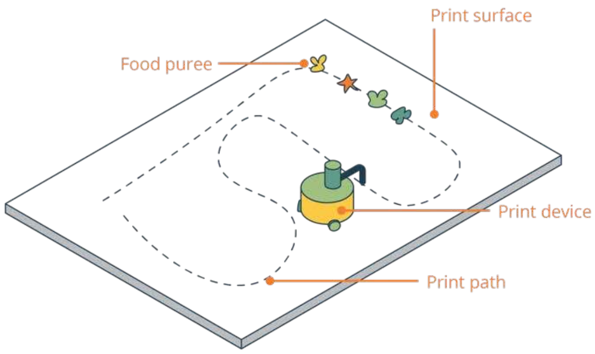

Figure 1. Initial drawing defining the basic principles of the Mobile Food Printer (MFP) prototype

As this prototype aims to facilitate the exploration of new use cases and the design is prone to revisions, we built a low-fidelity prototype without depending heavily on resources. Instead, we collected available components online and designed parts necessary for the assembly and basic operations. We divided the MFP system into three main components: 1) Effector, 2) Arm, and 3) Extruder. (Fig. 2)

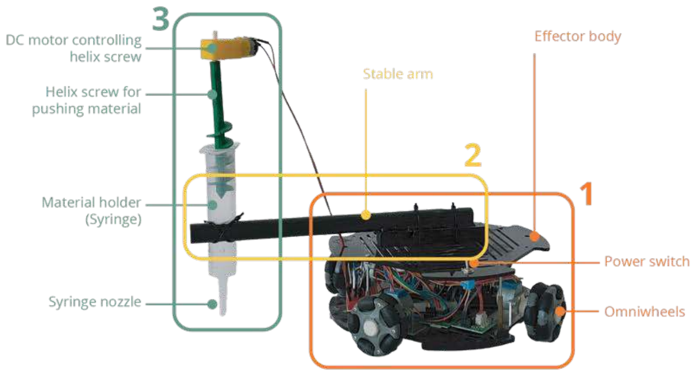

Figure 2. Components of Mobile Food Printer (MFP) conceptual prototype.

Effector: This component is primarily responsible for the movement of the printer. Thus, it required actuator motors and wheels that allow free movement on varying surface types and sizes. Additionally, this component highlighted the necessity for sensors to assist in navigating the printer on the printing surface. To achieve these functions, we used a premade robotic platform with four Omni wheels capable of moving freely on the x and y axes. The platform is controlled by an Arduino UNO processor, and each omni-wheel is driven by 28 BYJ-48 Geared Stepper Motor and ULN2003A Stepper Motor Driver circuit.

Arm: This component positions the extruder away from the platform to prevent overlaps during printing. In the initial design, we used a stable stick with future aims to allow it to move on the z-axis. We fixed the arm to the body with zip ties.

Extruder: In this part, we used 60 ml medical syringes as accessible food-safe parts that could be quickly supplied and replaced. We designed a 3D-printed helix screw to push the material from the syringe nozzle using Polylactic Acid (PLA). We attached a DC motor to the tip of the helix screw.

After we designed and assembled the prototype's components, we made trials for printing basic geometrical shapes and complex models using our prototype. We first generated the G-code representation of a digital model by using the slicer software Inkscape and transferred the code to the Arduino UNO through a USB cable. Then, we prepared whipped cream and filled the syringe. After activating the code, the system succeeded in printing the geometries we intended to (Fig. 3).

The current degree of movement in the Z axis did not enable MFP to print complex 3D models. Thus, in line with our aims, we decided to pause the prototype development when we reached a lo-fi representation of our concept (Rudd et al., 1996). At this point, we continued to collect insights on this speculative artifact before spending any more effort advancing it.

At this developmental stage of the MFP prototype, we defined three cases that differentiate MFP from other 3DFP devices: 1) Printing on a large piece of food on a rectangular surface; 2) printing multiple small foods on a large rectangular surface; 3) printing food on different plates located on a table. We created video sketches illustrating how MFP operates to complete the tasks in these cases. (Fig. 3)

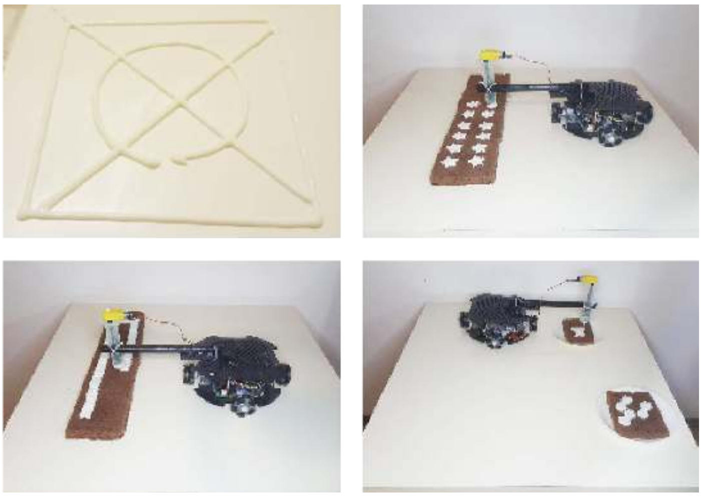

Figure 3. Screenshots from prototype demonstration videos. Top left: Initial test shape generated with MFP prototype; Bottom left: Printing on a large piece of food on a surface; Top right: printing multiple small foods on a large surface; Bottom right: printing food on different plates.

4 STUDY 1: EVALUATION OF MFP: THE CASE OF NOVICE CHEFS

To explore potential discussions mediated by a 3DFP device design, we adopted the Research through Design (RtD) methodology and created the Mobile Food Printer (MFP) prototype (see section 3). With this prototype, we aim to trigger meaningful discussions about what the future of 3DFP could and should be (Olson & Kellogg, 2014, p. 169). Therefore, the knowledge we aim to produce within the scope of this study functions as proposals for the future, not predictions (Zimmerman et al., 2010).

4.1 *Participants*

A common practice in the Human-Food Interaction field is to collect experienced chefs' views while developing interactive kitchen technologies due to their advanced knowledge and experience working and managing professional kitchens (Genç et al., 2021; Mizrahi et al., 2016). However, a recent study highlights the significant difference in opinions on kitchen design among kitchen workers with changing experience levels (Teyin & Seçim, 2023). Thus, we focused on a relatively underexplored community of kitchen workers and collected ideas from novice chefs currently in or fresh out of culinary school. We anticipate that novice chefs potentially present an open mindset to the practices in professional kitchens. We reached twelve novice chefs through word-of-mouth in our professional circles and snowballing (Coskun et al., 2023). All our participants have experience working in professional kitchens as sous-chefs or interns between four months and sixty months ($M_{experience}$=21.75 months). (See Table 1 for details on participant characteristics). Two participants were professional food photographers trained in culinary arts (P8, P9). Three participants were pursuing double majors in nutrition and dietetics (P7, P10, P11).

Table 1. Novice chefs' participant characteristics.

Session	Participant	Grade*	Work experience (months)
1	P1	FG	4
	P2	FG	24
	P3	Senior	12
2	P4	FG	14
	P5	FG	35
	P6	Senior	60
3	P7	Senior	6
	P8	FG	14
	P9	FG	14
4	P10	FG	12
	P11	FG	60
	P12	Senior	6

* FG: fresh graduate.

4.2 *Study Procedure*

In four online focus group sessions, we collected novice chefs' ideas on using MFP in their kitchen routines (preparation, serving, and eating) and how it might enhance their diners' overall experience.

The sessions started with a brief presentation about the state-of-the-art of 3DFP technology and the current industry trends. We proceeded to introduce the MFP prototype and briefly explained how it works. After an initial exchange of perspectives on the prototype, we showed three cases that we speculated as potential competencies of MFP: 1) Printing on a large piece of food on a rectangular surface; 2) printing multiple small foods on a large rectangular surface; 3) printing food on different plates located on a table. (Fig. 3)

4.3 *Data Collection and Analysis*

Each session lasted approximately one hour and was video recorded on Zoom. We then transcribed these recordings into text for analysis. We conducted reflexive thematic analysis (Braun & Clarke, 2006) on these transcriptions to reveal potential themes emerging from the dataset that could hint at future uses for MFP in professional kitchens.

The analysis started with reading through and familiarizing with the focus group transcriptions. Then, we coded each transcription with direct meanings using an online document tagging platform for qualitative research, Taguette (Rampin & Rampin, 2021). Following the coding process, we transferred each code on a Miro board to visually group them and generate themes emerging from the dataset. After creating the initial themes, we convened with two other interaction design researchers to discuss and finalize the thematic map (Fig. 4).

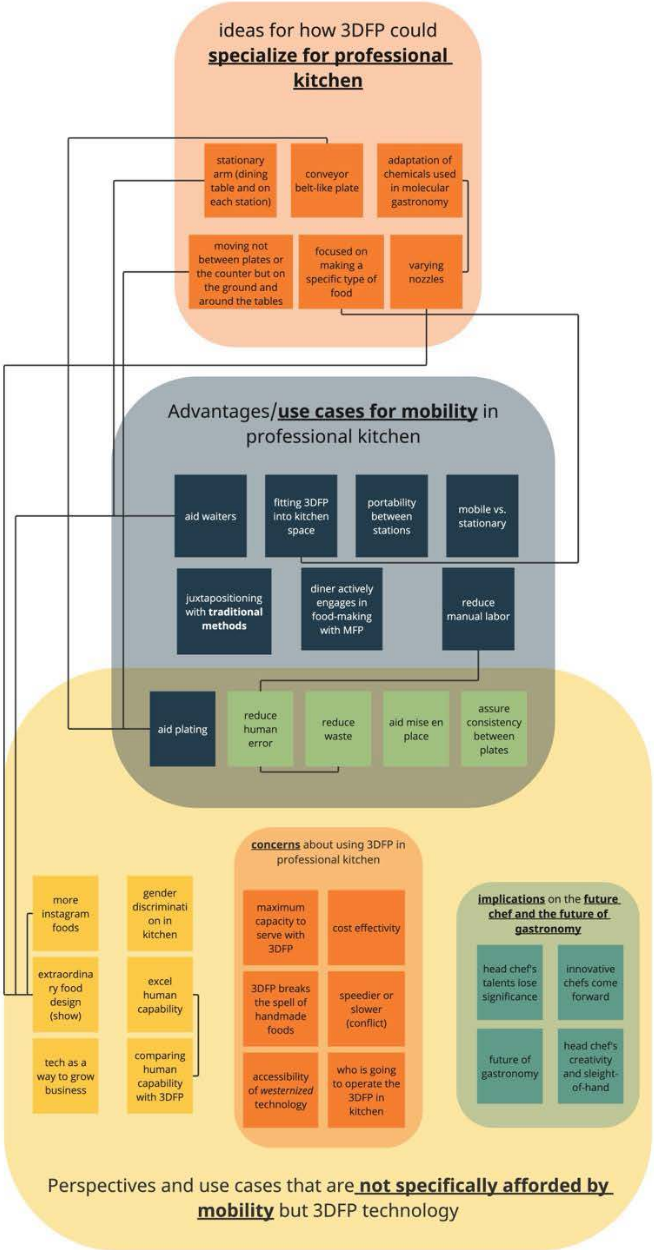

Figure 4. Thematic map of research findings

5 RESULTS

We discovered potential advantages and relevant use cases for a Mobile Food Printer (MFP) to adapt to the commercial kitchen. Our results highlighted some aspects in particular to mobility, thus, could inspire specializing MFP to the commercial kitchen.

Overall, we extracted four learnings from the analysis and presented them under three themes, highlighting intersecting topics for MFP and the restaurant context.

5.1 *Placing MFP in the dining room*

Our respondents frequently mentioned concepts that use technology to enhance the dining experience. In addition to the applications in the kitchen (i.e., backstage), the dining room (i.e., front stage) was found appropriate for elevating the presentation of tastes, visuals, and interactivity. Participants suggested extraordinary food presentations enabled by the potential competencies of working with a mobile device.

"I imagine roasting a whole turkey and putting some tiny garnish that would be almost impossible to do by hand. I think the contrast created could generate interest. (P1)"

Here, they imagined a scenario where they prepared a huge spit roast in front of the diners and added tiny details using the MFP. Participants discussed how juxtaposing a piece of high-tech equipment (i.e., MFP) with ancient cooking techniques to capture diners' interest. They explained adding such a technological contrast to the dish design (a high-tech addition to a traditional recipe) would engage diners even more with the food they designed. They also discussed that adding sauces or decorations using state-of-the-art technology would render traditional recipes more captivating.

Learning 1: Using MFP as a presentation tool for food could foster novel dining experiences and ignite novel interactions between chefs and diners. Highlighting the technology and the new culinary capabilities it provides could be used as a strategy to create such experiences.

In the dining room, they also envisioned utilitarian concepts where MFP enables overcoming size limitations. One participant suggested reducing the size of the MFP even more so that it could be attached to the corner of the dining table at the service of the diners. Just like in a Korean Barbecue, diners are envisioned to act as the primary agents operating the machine right at the dining table. By using this device, they would be able to add extra sauces and personalize their dish designs.

"The device is located in the corner. When the customer runs out of sauce on their plate, they can add extra sauce using this bot. (P3)"

They discussed such a device would help keep track of the side dish consumption by the diners digitally. Such an application is mentioned to ease the tracking of the cost of foods by digitalizing the serving process. Our participants also envisioned a restaurant setting similar to an automated sushi bar, where food is delivered by a conveyor belt upon ordering. They envisioned that the device could help servers with the presentation of certain foods right at the table (e.g., serving foam right at the table). They further ideated future restaurant concepts that the MFP devices are the central agents that serve food. In such settings, participants noted that the menu of the restaurant needs to be adapted for that particular serving style.

Learning 2: The dining experience could be enhanced right at the front stage as much as the backstage of the restaurant. Diners and food service staff are the potential agents of the device.

5.2 *Dealing with the kitchen rush*

How MFP could be efficiently used by the kitchen staff to reduce their overall workload was the most frequent discussion point that arose during the sessions. Our participants found MFP helpful in carrying out repetitive, time-consuming, and precision-intense tasks. They found the concept to aid the mise en place of the bakery station, which is often quite monotonous. However, the technology is found to be most beneficial for the plating. Here, participants elaborately described how the head chef needs to assign several kitchen staff to prepare plates for a dinner service of 100+ guests. In the current settings, participants noted that the kitchen staff who are assigned such monotonous tasks get bored quickly and may end up doing a sloppy job. They highlighted that a technology such as MFP could help reduce human error in such scenarios.

"If we are preparing a meal for five hundred people, all the plates come out at the same time. Let's say there are five people working there. One of them puts the meat, and the other squeezes the sauce. Someone else puts the decor next to it. There is a system that works like this. Using a mobile device that roams on the counter can be logical for that setting. (P9)"

While a convenient 3DFP could aid the plating routine, mobility enriches this task with its ability to print on separate plates and move on the kitchen counter. It acts as a moving agent of cooking, just as any other kitchen staff operating monotonous tasks.

Learning 3: Mobility could help reduce manual labor and human error in the plating routines. Mobility also augments the role of the equipment as an agent of cooking.

5.3 *Fitting a new machine into the kitchen space*

Participants pressingly discussed that the kitchen space in restaurants must be used in the most efficient way possible, especially during the dinner service hustle. An additional device would require spare space, which is often not preferred as the current settings in *a la carte* kitchens already operate in small spaces. Participants offered several perspectives on how to reduce the space that MFP would occupy in the kitchen. First, they suggested that this device needs to be adaptable to different food preparation stations (e.g., bakery and grill). This would help reduce the machine's storage need by scheduling the operation hours between stations.

"The device should not be exclusive to stations. Since it is a portable device, every station can benefit from it. For example, it can also be used by the patisserie station for astonishing visuals and by a saucier to prepare thick sauces. (P1)"

Second, they suggested transferring the device to move on the floor, thus not occupying counter space during plating. Lastly, they suggested designing the device to be able to be attached to a corner of the counter, therefore reducing the extra space it occupies on the counter. They further suggested adding a conveyor belt-like plating surface for extra space efficiency. Participants' first two suggestions assigned mobility to the device, while in the third suggestion, they fixed the device on the counter and assigned mobility to the remaining kitchen equipment (e.g., plates).

Learning 4: Mobility can be an advantage in improving space efficiency, especially counter space, when used at different food preparation stations. However, the objects to which mobility is assigned affect how the technology supports food preparation in the professional kitchen.

6 STUDY 2: ITERATING MOBILE FOOD PRINTING (MFP) ARTIFACT

After collecting insights from novice chefs for potential use cases in professional kitchens and the dining room, we convened with interaction designers and engineers to generate solid design ideas for future HFI innovation that focuses on mobile food printing in the restaurant context. To do so, we primarily used the four learnings we collected in Study 1.

6.1 *Study materials and procedures*

We invited interaction design researchers and engineers through our research circles to contribute to an iteration ideation session (Fig. 5).

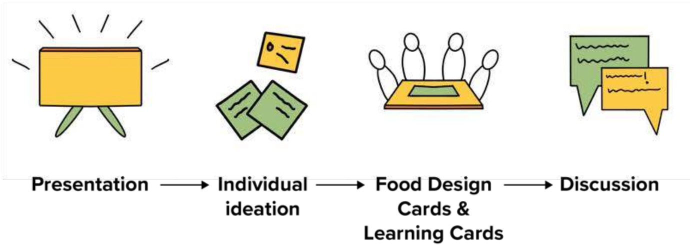

Figure 5. MFP iteration ideation study procedure.

The ideation workshops began with an introduction by the principal researcher about the innovations from the 3D printing world that inspired the design of the Mobile Food Printing (MFP) concept and finished with a brief on the agenda of the workshop. Then, the participants were asked to participate in individual ideation for 10 minutes and to pour down their initial ideas on post-its (Fig. 6). In this session, we asked participants to write down or sketch the first ideas that came to their minds right after the presentation.

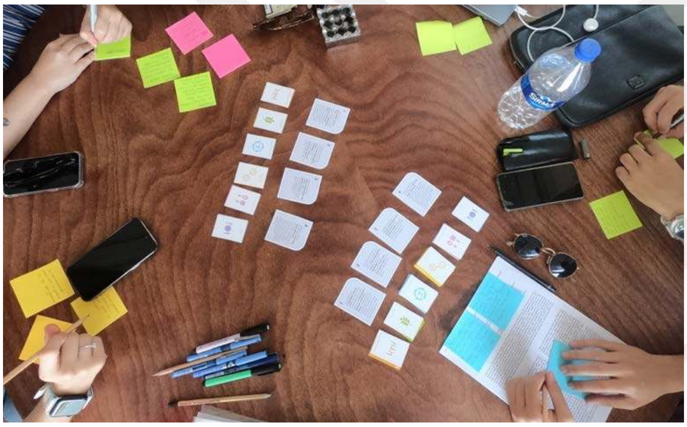

Figure 6. Study setting during individual ideation session.

Following the initial ideation, we divided participants into two groups and introduced the Food Design Cards (Y. Lee et al., 2020). We chose to utilize this tool to iterate the MFP concept and help designers become more aware of the possible perspectives on food during ideation (Y. Lee et al., 2020). Among the seven topics covered in the original card set (agriculture, industrial processing, distribution & marketing, kitchen management, eater, consumption situation, and policy & legislation), we discarded the *policy & legislation* category as it is a near-future trend that relates more to later iterations. To iterate the MFP concept, we utilized card-based tools to potentially inspire designers in the design process. Hence, in line with this methodology, we presented the learnings from chefs in the same format. For the workshops, we transformed the learnings we gathered from novice chefs into Learning Cards (LC). On the front face of each LC, a learning from the novice chefs was written (see section 5), while on the back, a participant quote related to that learning was printed (Fig. 7).

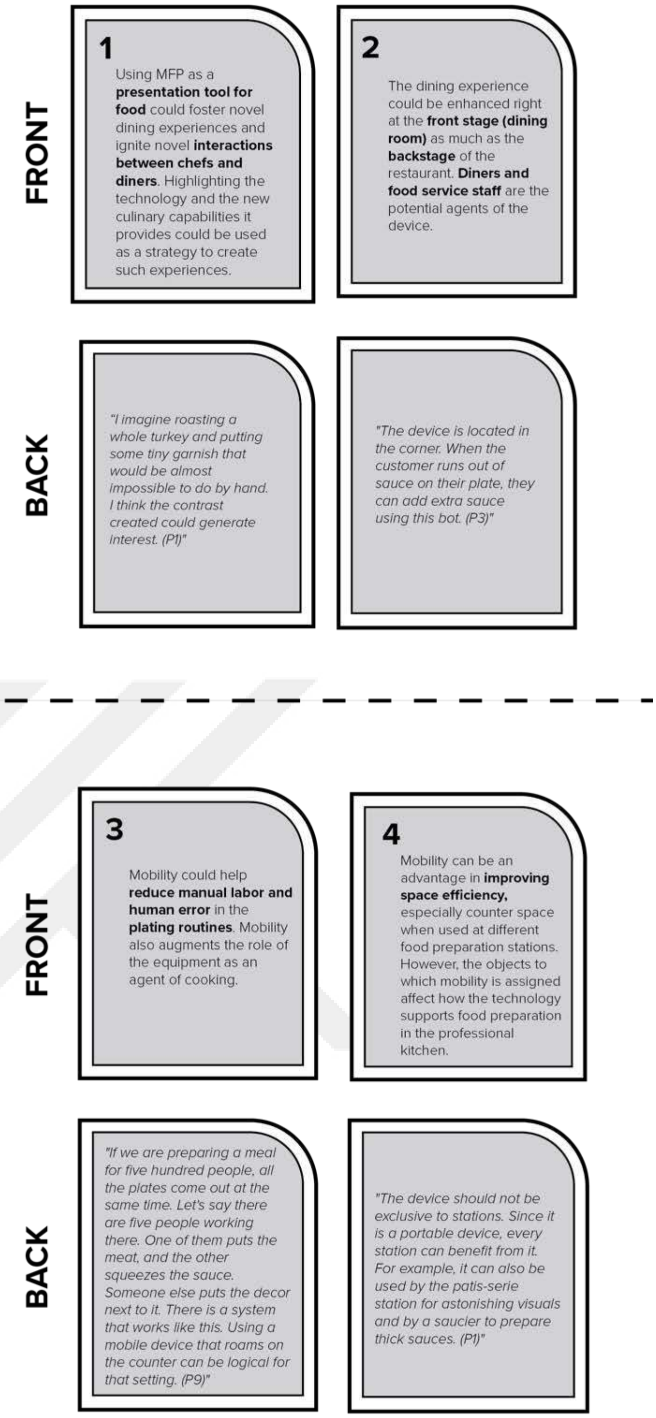

Figure 7. All four Learning Cards (LC).

To use the Food Design Cards, participants were asked to randomly pick two cards from different categories and match them with each LC (Fig. 7).

Afterward, they iterated the MFP concept for each LC, gaining inspiration from the Food Design Cards they matched. We asked them to illustrate their ideas using pen and paper and also post-its. In the end, participants sketched the artifacts they were conceptualizing for each LC.

This session lasted for 60 minutes. After each group had finished detailing their ideas, they presented them to the other group and discussed potential implications for design (30 mins).

Figure 8. G1 matched each LC with a randomly selected Food Design Card.

6.2 *Participants*

We invited interaction designers and engineers to weave the learnings from novice chefs into tangible design knowledge for building on the MFP concept. We find their input valuable at this stage of prototype development. Three interaction designers, one UI/UX designer, one mechanical engineer, and one software engineer attended the ideation session (Table 2).

Table 2. Interaction Designer and Engineers' participant characteristics.

Group	Participant	Expertise
G1	P1	Interaction Designer
	P2	Interaction Designer
	P3	Mechanical Engineer
G2	P4	Interaction Designer
	P5	Software Engineer
	P6	UI/UX Designer

6.3 *Data collection*

In the ideation session with Learning Cards and Food Design Cards, participants worked in two study groups and generated a total of eight ideas (two for each LC). The presentation and discussion session lasted 33 minutes and was voice-recorded. After the workshop, the primary researcher collected participant sketches and digitized by photographing them. In the following section, we will present each idea presented by the designers referring to their own words in the discussion session between the study groups.

7 DESIGNING CONCEPTS FOR MOBILE FOOD PRINTING IN RESTAURANTS

In the ideation session, participants generated concepts that address the issues in each Learning Card (LC). Although we asked participants to match two Food Design Cards with each LC, participants in group 2 picked three cards for LC 1 and 2.

7.1 *Learning Card 1: Performative interactions between chefs and diners*

G1: picked physical processing and beliefs and values
G2: picked social situation, branding, and prepared meal

For this LC, each group interpreted the interaction between the diner and chef as communication and both built concepts that focused on transferring the diner's personal information to the chef. To address the need to increase communication between the diner and the chef, both groups proposed a mobile food printing robot roaming around the dining room that collects personal information from the diner. While G1 ideated that the robot could collect information regarding the diners' background (e.g., hometown, beliefs, or occasion), the other group's idea would collect only health-related information (e.g., allergies, intolerances). The robot in G2's idea adjusts its height based on its user's height and physically shuttles between the dining room and the kitchen to transfer information (Fig. 9). This framing helped the group name the concept as *Apprentice*, referring to the apprenticeship between the chef and their assistants.

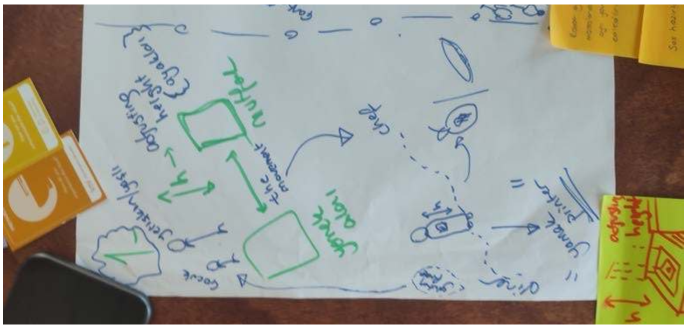

Figure 9. Participant sketch of MFP shuttling between the kitchen and the dining room.

In both groups' ideas, information collected from the diners is then used by the chef to personalize the ingredients to their own preferences. To personalize the dish to the user, G1 focused on making visually appealing custom garnishes inspired by their authentic background, while G2 focused on tailoring meals for diners' health data. In participants' definition, these robots act as a mediator between the diner and chef (P4) and help restaurants serve the same meal but a personalized version without compromising quality (P5).

7.2 *Learning Card 2: Front-stage interactions between diners and service staff*

G1: picked physical occasion and Branding
G2: picked cooking tech, place, and food additive

For this learning card, the idea of mobility was mainly challenged by designers. G1 developed a roaming robot that playfully makes final touches on food served at the table, such as pouring croutons on soups or grating parmesan on pasta. Inspired by the learning card, this scenario focuses on bantering with the robot while it makes the final touches. While presenting this idea, participants referred to the serving shows made at the table by chefs such as Salt Bae. Inspired by this example, this robot embodies some physical properties of a garçon (i.e., mustache (P1)), taking attention to the similarity of the two in their scenario (Fig. 10).

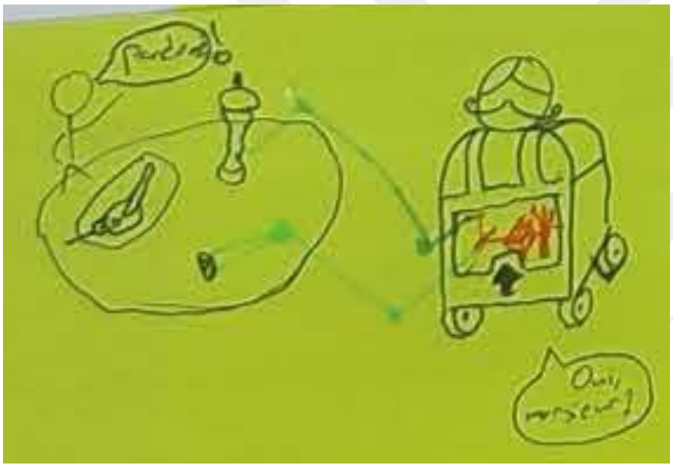

Figure 10. (left) G1 sketch picturing the physical resemblance to the garçon.

To call the robot, the diner waves at it as if they do with a garçon. Designers commented that they used this resemblance as a strategy to make the interaction more inviting (P1). The participants commented that the interaction with the robot would be playful when they imitate the usual interaction with the garçon.

In G2's idea, they focused on mobility and designed mobile food printing devices in the form of clothing (e.g., jackets, hats, necklaces, rings). In their proposal, diners pick up these fashionable wearables from the cloakroom at the restaurant entrance. Each diner selects clothing to their own liking and taste. Their food is served through their clothing, which is operated by the chef in the kitchen.

7.2.1 *Learning Card 3: Reduce manual labor and human error in the plating routines*

G1: picked cooking tech and self-sufficient farming
G2: picked type of food service and convenience food

Referring to the LC, both ideas located their designs inside the kitchen. G1 focused on a food plating station with multiple food printing arms that are mobile within the boundaries of the station. These robotic printing arms are attached to the roof of the station and can print multiple food items for plating without interrupting other kitchen staff's workflows (Fig. 11).

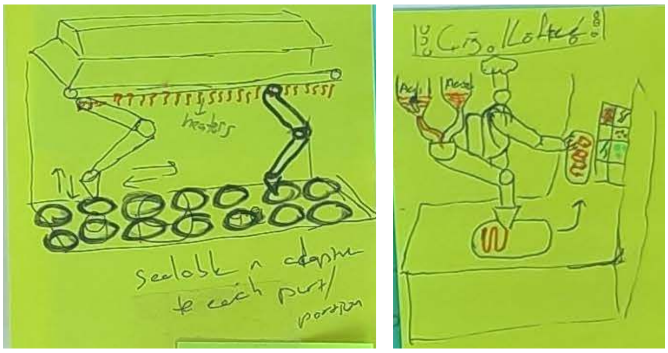

Figure 11. (left) G1 sketch illustrating the food printing station; (right); G1 sketch wearable arms

The plates are located on the counter and prepared according to the order by the robotic food printing arms. The arms automatically refill through large tanks, and only the tanks need to be replaced by the kitchen staff when they run out. The station also uses a camera and an image processing algorithm that detects when a plate is ready and rings the waitstaff to deliver the order to the diner.

For this LC, G2 focused on a robotic helper in the kitchen space with multiple tentacle-like arms. The arms are replaceable and modular, thus extending the use cases to which the concept is applicable. It is an autonomous cooking bot that is tasked to help around different stations in the professional kitchen. The robot is adjusted to each station when the relevant arm is installed by the station chef and performs tasks based on its algorithm. Inspired by the cooking technique card, participants ideated each arm to perform a different cooking technique (e.g., julienne cutting, Bain-Marie cooking). Participants commented that having multiple arms and modularity enabled this concept to address multiple occasions that take part in the kitchen.

7.3 *Learning Card 4: Ensure space efficiency by shifting the notion of mobility*

G1: picked type of food service and food additive
G2: picked food preservation and storage & waste

In this LC, the proposal of G1 addresses businesses operated by only one or two staff (e.g., çiğköfte shop) in a limited space. Building on the idea of moving with the chef, participants ideated a mobile printer with multiple arms worn like a backpack by the chef (Fig. 11). In their scenario, the chef and the device collaborate and share tasks for preparing an order. In the çiğköfte shop scenario, the machine shapes the çiğköfte as the chef picks the lettuces that will go into the roll. As the chef continues to exchange money to complete the order, the backpack continues to serve as a sterile pathway for serving food to the diner.

The other group approached ensuring space efficiency from a different perspective. Inspired by the Storage & Waste card, they focused on placing the printer out of the way of the customers and kitchen staff. To do so, they ideated a food printer embedded in the ceiling of the kitchen, offering an infrastructural integration (Fig. 12).

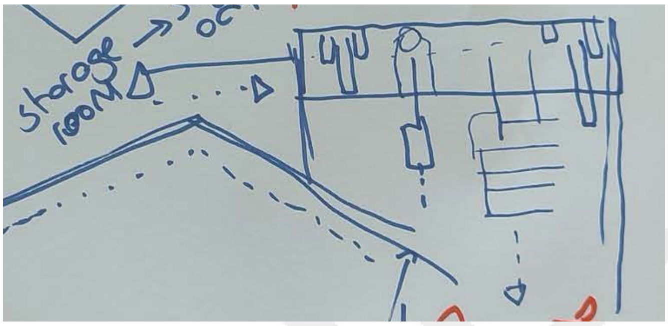

Figure 12. G2 sketch architecturally embedded mobile food printer.

This space created on an elevation holds several printing heads that are operated by gears and pulleys. Participants resembled the space they created to a catwalk, which is a narrow walkway or a bridge placed on top of stages. This space also has the capacity to store food, acting as a direct resource for refilling the print heads. G2 commented that they designed a food printer the size of a restaurant that moves freely within its limits (i.e., mobile) (P6).

8 DISCUSSION

8.1 *Reflection on the learnings from novice chefs*

We adopted a user-centered approach while implementing mobility from 3D printing for developing food-experiencing artifacts. In doing so, we were able to delve deep into how to implement the mobility feature. Our findings reveal initial insights into the design space of MFP based on culinary students' visions of collaborating with MFP in their daily work routines.

8.1.1 *Streamlining workflows in the kitchen*

The kitchen is a labor-dependent space, and the kitchen staff are the main agents who spend this labor. They are the grandmasters of the methods in the kitchen. The kitchen space in which the kitchen staff is ought to shrink in size (Ghiselli, 1998). The kitchen is a space with strict design guidelines, and when new interactive technologies enter this space, careful consideration needs to be made of how this new technology will affect the current kitchen layout (Claus Bech-Danielsen, 2012). Suggesting where the new technology will fit in the kitchen layout is a crucial point that requires recognition. In our case, we observed several design possibilities for MFP that do not require a fixed place for the device (a detachable add-on to the service counter, used between countertops). These applications were enabled by mobility and show how it may advance their current equipment by being integrated into the existing practices and routines in the kitchen (e.g., plating or presentation).

Interactive kitchen technologies developed for extreme settings such as space missions have strict design requirements. For instance, space foods have to be lightweight and easy to store (Enfield et al., 2023). In order to maximize the use of space, the design for such extreme environments prioritizes practical features. Our results show that such function and efficiency-oriented approaches to interactive kitchen technology design may also be relevant in the restaurant context. Especially by reducing human error in monotonous tasks, we showed that some of these requirements could be met by mobilizing the newly designed devices.

8.1.2 *Determining the end-user in the dining room*

In contrast to the professional kitchen, which is a highly utilitarian space, the expected user experience of a restaurant's dining room is exceptionally hedonic. Although the prototype we developed in the scope of this research is not capable of operating advanced cooking tasks, it triggered ideas for potential applications in the dining room.

Numerous applications of interactive technologies augment the dining experience using food (Bonacho et al., 2020, p. 130) or novel technologies such as AR as main mediums (Batat, 2021). The propensity of consumers to love gadgets impacts the perceived value of interactive restaurant self-service technologies (IRSST). Putting high-tech innovation at the forefront of the food presentation and dining experience might capture the interest of such user types (Ahn & Seo, 2018). Dining experiences such as the FOOD INK, a pop-up interactive dining experience, mainly target such audiences. Such concepts offer entertaining and visually captivating dining experiences by making the 3DFP technology visible (*3DFP Ventures Ltd.*, 2016). Our study participants imagined taking advantage of the positive influence the high-tech device creates and using it to elevate the attention towards traditional foods. Previous research reports no significant effect of menu descriptiveness on customers' perception of traditional or local cuisines. Our results show that chefs might have other strategies than menu design, using novel technologies such as 3DFP to positively influence their customers' perceived quality and value of traditional dishes.

Another previous study investigating the integration of Artificial Reality (AR) to positively affect customer experience suggests that restaurants should integrate novel technologies in stages depending on their customer profiles (Batat, 2021). In our case, mobility ignited proposals for adding new elements to the dining experience, such as including the user as an active agent of cooking. This finding suggests that an initial participant base needs to be identified who would be interested in using 3DFP as part of their dining out experience. There are previous attempts aiming to identify potential users of 3DFP technology (Gayler et al., 2018; Kocaman et al., 2022). One of these examples identifies characteristics of domestic users who have the potential to be interested in using 3DFP in their homes (Kocaman et al., 2022). In the study, researchers highlight common characteristics of potential 3DFP users, such as enjoying trying new foods or eating out at least a couple of times a month. We expect such a user profile would be one of the earliest customers of the dining concepts our participants imagined, where the users enjoy operating high-tech equipment in the restaurant to have their dishes.

8.2 *Reflection on the methodology*

Overall, we adopted a two-step research approach. We first gathered situated insights from novel chefs about their prospective use of a Mobile Food Printer (MFP) for preparing and serving food in a restaurant. We then used these insights to ideate concepts with experts and observed their approach to conceptualizing products, services, and experiences. In ideating concepts, we utilized the Food Design Cards to multiply the artifact designs through experts' ideation with multiple perspectives (Y. Lee et al., 2020). This process produced fruitful results, revealing how design ideas might revolve around each Learning Card (LC) considering different stakeholders' perspectives. Using the Food Design Cards helped us explore topics in close proximity to each learning gathered from novice chefs and helped us discover social, playful, authentic, experiential, and personal opportunities for designing human-food interactions.

Throughout this research, we adopted the Research through Design (RtD) methodology by implementing a design object as a research artifact (Zimmerman et al., 2007). However, we note that the artifacts (including designer ideas and the MFP prototype) presented in this paper do not propose complete solutions to the issues in the professional kitchen. They only represent the best judgment of designers about how to address each particular issue (Gaver, 2012). In that sense, all ideas presented in this paper serve as an incomplete research artifact. In fact, our observations and discussions with designers and engineers showed that patterns emerged from the ideas they produced. We present these patterns in the form of design considerations that could be considered by future design and HFI research.

8.3 *Design Considerations for Mobile Food Interactions in the Restaurant Context*

After collecting the ideas, we detailed design considerations that would pave the way for future mobile food interaction designs in the restaurant context. In this section, we present four design considerations and a critical reflection on the current study. This reflection aims to broaden the impact of the user and design insights gathered throughout both studies. By presenting these, we hope to shed light on future Human-Food Interaction innovations.

8.3.1 *Design Consideration 1: Consider the spatial movement of technology to mediate communication between the diner and chef.*

During the workshops and by looking at the concepts developed in the workshops, we observed that participants focused on redesigning the communication between the chef and the diner.

A restaurant consists of many agents that collaboratively perform food service. Among the other agents, chefs have a distinguished role as the main creators of the dish, merging their creativity with culinary skill sets (Madeira et al., 2022). Over the years, the notion of a chef's role has evolved, starting from the chef as an entrepreneur (1970s-1990s), the chef as an entertainer (1990s-2000s), and finally chef as an expert (2000s-current) (McBride & Flore, 2019). The role of the chef as an entertainer required them to perform their cooking in front of the diners or a camera and showcase their knowledge base and skills. Despite this evolutionary pattern, chefs still roam around the dining room during food service and welcome guests directly. In many restaurants, chefs are the main actors who present food at the table along with a show as a way to entertain and praise diners, fulfilling their role as chefs as entertainers (McBride & Flore, 2019). However, in the current phase, the expert role of the chef requires learning about a broader range of issues. A recent study lists the required skills of chefs that not only include culinary expertise but also conceptual and general communication abilities for increasing restaurant competency (Mahfud et al., 2019). The expert chef is a trusted personality for the public diffusion of food-related knowledge. Chefs navigate this responsibility by sharing culinary expertise on social media (K.-S. Lee & Tao, 2022).

Our results align with the timely shift in the chef's role by showing that the communication dynamic is expected to transform when a mobile food-service robot enters the restaurant context. In our case, the placement of the mobile food printing device in the dining room potentially impacts how food service staff, chefs, and diners communicate personal and food-related data. The design ideas participants produced physically separated diners and chefs and put the technology in the mediary role. Introducing the technology transferred the role of the main presenter from chef to MFP device. Thus, manifesting the object as the medium for entertainment allows the chef to stay in the background and focus on presenting more personalized, high-quality dishes.

8.3.2 *Design Consideration 2: Build on the authentic knowledge base embedded in the restaurant when designing diner interactions.*

To attract diners' interest even more, insights from both studies put forth building on authentic experiences using state-of-the-art technology.

A recent study defines the notion of authenticity in the restaurant context as *"the restaurant's ability to create, maintain, and genuinely communicate a timeless identity, construe a place of sense and meaning, and enable customers to experience a sense of self-connectedness"* (Al-Kilani & El Hedhli, 2021). Authenticity is a multifaceted notion that critically underlines the importance of considering the multidimensional nature of a whole dining experience. Recent studies demonstrate that authenticity could also be interpreted subjectively, which stands to influence the perceived value of the organization (Kovács et al., 2014).

In response to this body of knowledge, in the ideation workshops, designers addressed the authenticity of diner-chef communication by utilizing personal data that are rooted in diners' backgrounds (e.g., hometown, occasion, or hobbies). They used this data to personalize foods even more, carrying the notion of personalization beyond health-related data. Moreover, designers were inspired by the situated interactions occurring between diners and the service staff and weaved this knowledge into their designs. The design proposals reenact the authentic forms of communication (e.g., waving to call the waiter) as a way of building an inviting interaction. Focusing on such situated knowledge embedded in the restaurant context allowed the concepts to foster inviting social and playful experiences.

It is found that a restaurant's perceived authenticity during a gastronomic experience builds the foundation of brand equity, affecting the business's eventual success (Rodríguez-López et al., 2020). The insights from both studies show that there is potential in focusing on authentic cuisine as well as authentic interactions. While novice chefs proposed juxtaposing authentic recipes with high-tech equipment to attract diners' interest, the designers' take on authentic focus was local daily food stops (e.g., çiğköfte shop). Supporting this claim, recent research asserts that the perceived dining experience does not only rely on food quality but also other tangible and intangible elements such as the atmosphere, food service, or authenticity (Horng & Hsu, 2020). These findings suggest that there are two main ways that could be focused from the lens of authentic experiences facilitated by mobile food experiencing artifacts: authentic foods and authentic experiences. In our observations, we assert that both perspectives offer novel dining concepts that mobile food printing could facilitate.

8.3.3 *Design Consideration 3: Clearly divide the placement of hedonic and utilitarian experiences.*

The motivations that resulted in the modern-age diet are far from the pre-industrial era's undernourished style of eating. Today, humans do not only eat to nourish themselves but, at the same time, please themselves through food-related experiences (Freedman, 2007). In the modern age, food cannot be considered only from a nutrition-oriented perspective or a pleasure-oriented perspective. Research supports this perspective by showing both utilitarian and hedonic values significantly increase customer satisfaction in the food service industry (Ryu et al., 2010).

Throughout the ideation sessions, guided by the learning cards, there were several designs that focused on the same food experience but from the lens of these two distinct aspects. Our observations on design concepts show that while functionality-oriented kitchen equipment could improve the workflows in the kitchen, novelty-oriented food serving agents could improve the dining experience. In this example, the main agents of the two scenarios differ between the diner and the food service staff.

On the other hand, as mostly apparent in the two ideas developed for LC1, while one group focused on the pleasurable aspects of eating, the other group focused on the functionality of the kitchen equipment. In this example, designers clearly set where each design is placed on the restaurant layout, whether in the dining room or the kitchen, to proceed with designing the hedonic and utilitarian values and how it operates. Their approach shows that the value of hedonic and utilitarian affordances of technologies are designed differently based on their placement on the restaurant layout. For mobile technologies, defining where the technology will move in the restaurant layout is extremely critical, as movement makes up its most prominent affordance.

8.3.4 *Design Consideration 4: When conceptualizing mobility, assign objects and play with boundaries, paths, or device proportions.*

Conceptualizing mobility for the restaurant context is one of the main aims of this study. During the focus group sessions and the ideation workshops, we observed that participants tended to assign mobility to various objects located in the restaurant space (e.g., counter, clothing, food service staff). During the discussions in the ideation sessions, four participants stated that they thought of wearables on top of their heads when they started to conceptualize mobility.

After picking an object and assigning mobility to it, they then ideated on three main parameters to conceptualize the usage scenario: boundaries, paths, and proportions.

From several designer ideas, we observed that after selecting their mobile object, they defined a boundary for that object to be mobile in. For LC3, G1 ideated a food printing station that could aid the plating. In their example, the boundary of mobility is defined by the proportions of the counter. Likewise, for LC4, G2 ideated a mobile printing station in the size of a restaurant, which could move inside the limits of that space. These two examples together demonstrate that mobility could be designed by playing with the boundaries of movement.

On the other hand, for LC1, G1 designed a communication bot that shuttles between the dining room and the kitchen. This shuttling movement they defined proposes a path that requires careful consideration when designing the interactions between the agents and the space. As designers put it, the movements of the robot should not block the food-service staff but also should be visible to the diners. These findings suggest that identifying the surrounding objects and assigning their mobility is a primary step in starting the ideation of mobile HFI artifacts. This identification is followed by designing the movement and the interrelations between the objects of inquiry.

9 CONCLUSION

In conclusion, this study delves into the design of Mobile Food Printer (MFP) technology, seeking to explore new features and application areas for 3D Food Printing (3DFP) technology. We specifically investigated the implementation of the mobility feature and discovered that MFP might digitize food serving and foster increased interactivity between diners, chefs, and the kitchen staff. To our knowledge, this is the first study that underlines these potentials, particularly enabled by the feature of mobility. Uncovering these potentials helps foresee alternative futures with 3DFP technology.

We further brought design insights to interaction designers and ideated eight concepts that could appropriate the MFP concept even further to professional kitchens. These concepts showcased an example of designing mobile food interactions and revealed four design considerations. The design considerations we present in this study aim to serve as inspiration for future HFI designs that aim to innovate mobile food interactions in the fields of professional kitchens and the dining room.

Utilizing the design considerations points to several future research opportunities. First, we suggest that each design consideration could be addressed singularly, and novel concepts could be developed inspired by them. Moreover, studying the design considerations holds potential for HFI and design research as each also creates curiosities and questions for future human-food-machine interactions.

This study also had limitations that point to fruitful future work. We studied with a limited number of participants. The number of ideation workshops could be multiplied; thus, design considerations could be multiplied by working with more design teams, bringing together several other actors (diners and professional chefs).

Overall, we demonstrated that MFP has the potential to enhance users' eating experiences in the restaurant context. Moreover, we found that MFP could swarm the kitchen appliance industry by increasing the demand of enterprise customers. Our results form a basis for future research to dig deeper into the feature of mobility and its potential and create curiosity for other potential features that might be explored in the food printing domain (e.g., drone printing). The set of proposals we present in this study acts as a starting point for HCI and HFI researchers and encourages them to investigate the concept of mobility in other contexts further.

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Paper 5 – FB in Travel

Pick your Foodiebuddy: Travelers' Reflection on a Personal Taste Exploration Gadget.

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Pick your Foodiebuddy: Travelers' Reflection on a Personal Taste Exploration Gadget

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Designing artifacts and interactions to influence everyday food-interactions positively is gaining attention in Human-Food Interaction (HFI) field. Prior HFI research has not yet deeply investigated the impacts of personal food-experiencing gadgets in the context of eating while traveling, limiting the design knowledge on the complex interactions among travelers, their practices, and contextual factors affecting food-choice in those settings. In response, our paper shifts the perspective towards the travel context and design interactions through a study in cooperation with interaction designers and travelers. We utilized "Foodiebuddy" as a research artifact – a personal mobile gadget that facilitates exploring new tastes – in eight walk, talk and eat tours to help investigate the concept of "taste exploration journey" and experiential dynamics of eating while traveling. Our study resulted in three themes concerning travel food experiences. Our work aspires to leverage the social and individual potentials of designing artifacts for food exploration, paving the way for future HFI innovations.

CCS CONCEPTS • Insert your first CCS term here • Insert your second CCS term here • Insert your third CCS term here

Additional Keywords and Phrases: food-experiencing artifacts, prototypes as probes, traveling food futures

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1 INTRODUCTION

Exploring new foods and tastes while traveling has been gaining traction among modern societies [8]. Despite the extended scope of Human-Food Interaction artifacts that target to improve life in social, physical, nutritional, or playful ways, no prior study has focused on how to design artifact for improving eating experiences while traveling. There is a vast knowledge base considering social interactions among travelers, their practices, and factors affecting their food-choice, there is a scarcity of focus among prior HFI research for designing artifacts for eating while traveling.

However, prior HFI research has not yet substantively investigated the impacts of personal food-experiencing gadgets in eating while traveling, limiting the understanding of the complex interactions among travelers, their

* Place the footnote text for the author (if applicable) here.

practices, and factors affecting food-choice in those settings. The context of travel is a complex setting, which differs than the domestic settings in social, individual and experiential parameters.

Addressing this need we set out to understand the context of traveling from the lens of eating experiences. Within the scope of this research, we consider domestic and international traveling as potential cases that could inform our inquiry. We examine the following research questions: 1) how do users' eating while traveling relate to a personal food exploration gadget? and 2) how would such a device impact the travel experience?

To investigate these questions, we bring into attention the knowledge base embedded in the travel context by taking interaction designers and travelers through an explorative taste journey. We designed Foodiebuddy (FB), a personal mobile gadget that facilitates exploring new tastes for users when they visit a new place. We deployed FB as a research artifact in eight walk, talk and eat tours with travelers to help investigate the concept of "taste exploration journey" and unravel the experiential dynamics of eating while traveling.

Our initial investigation resulted in five design considerations targeted at future HFI artifact and interaction designs. Our work aspires to leverage the social and individual potentials of designing artifacts for food exploration, paving the way for future HFI innovations in various other contexts. Starting by deepening the exploration of the travel context by designing other artifacts, future research holds the opportunity to extend our approach to other contexts where food is essential in defining the overall experience.

1.1 Designing for Improving Everyday Food-Interactions while Traveling

The field of Human-Food Interactions (HFI) have been gaining traction in recent years. There are numerous studies that focus on different aspects of food-related experiences. A recent study created a taxonomy of works in HFI based on their domains and listed five: source, store, produce, eat, track and speculate [1]. This taxonomy is made up of studies on social food-experiencing robots [11], personal eating assistants [9], novel dining experiences [5] and many others. All of these examples cover a different aspect of human-food relationship in everyday life, and a common point of them is that each propose a novelty whether it is a new food, technology, practice or habit. However, the design space of artifacts in this field is vast and contribute to this body of knowledge. Although the taxonomy of HFI maps the field initially, the design space is broader and the potential design directions are variegated. A recent study maps ten potential design directions that HFI artifacts could use to set out from, and design new artifacts [10]. They suggest that for designing HFI artifacts, looking at the knowledge base in the adjacent domains could result in fruitful applications [10]. Despite the variety of topics covered by previous HFI research, we have not come across a study that focus on the eating experience in the travel context.

Traveling in its essence is an activity of self-expression [17] which contributes to forming an identity of an individual and shaping their ideas [2]. It is a mobile context, which relies on limited temporal and financial resources, however, is an explorative journey. There are systems, that augment reality by bringing together and digital food worlds [3]. The user characteristics of travelers vary based on the purpose of travel, and traveling for food is a prominent trend of modern day traveling [2]. These users are defined in the literature as foodies, food enthusiasts or food tourists, who seek new eating experiences as their main goal of traveling. Studying such users have helped recent research to discover how their food preferences differ from leisure travelers. There are various elements that affect the overall travel experience.

2 FOODIEBUDDY AS A RESEARCH ARTIFACT

We designed Foodiebuddy (FB) as a research artifact that would help participants enact a usage scenario of a travel food tasting gadget [7]. FB is a food exploration gadget where users take it on their travels. It guides the user for picking a food item based on their personal diets, eating and travel preferences and expectations. It mainly affords exploring new tastes in new places; however, it adapts its selection of foods to the users' changing food-related needs and decisions while traveling. The design of FB device is comprised of two main parts: The main body and the taste buds (Figure 1).

Figure 1: (left) Parts of FB; (top right) rear view of an assembled FB and the elastic attachment piece; (bottom right) inserting tastebuds in the mounts located on the main body.

All parts except the attachment piece is 3D modeled using Rhinoceros 7 and 3D printed using Prusa MK3S and Ultimaker S5. The main body and spinning middle parts are printed with Polylactic acid (PLA) and the taste buds are printed with Polyethylene terephthalate glycol (PETG) because both materials are safe to get into contact with skin and mouth. The taste buds are the parts responsible of providing taste samples or previews to the user and are placed on the main body. The two parts of the main body are attached to each other. The spinning middle and the elastic band were then assembled and affixed on the middle. There are three identical tastebuds in each FB package and each one is inserted in the mounts located on the main body. We designed an instruction manual for Foodiebuddy (FB) that folds into its packaging, as a compact method to present it.

2.1 Technical Platforms Validating Foddiebuddy

During the development of the probe kit and the following deployment studies, designers' feedback continuously questioned whether the taste generation mechanism is technically possible and how accurate the taste samples would replicate the actual flavors of foods. To respond, we surveyed literature for possible technical platforms to convey flavors artificially. This search resulted in three studies that possibly generates flavors digitally. The most recent study builds a technical platform for delivering in-mouth flavors for leveraging advances in electronics and molecular gastronomy [15]. In Füpop, edible pouches are placed inside the cheek which are then programmatically "popped" through an ultrasound transducer from outside the cheek [15]. Authors note Füpop is not limited in terms of the flavors it can produce, as the pouches can hold edibles. The Norimaki Synthesizer offers electro-tactile prototyping that uses ion electrophoresis in five gels containing electrolytes for delivering basic tastes to user [12]. Each gel contains a controlled amount of each five basic taste and apply taste to user's tongue arbitrarily. Finally, the TactTongue prototyping platform, that also uses electricity to convey taste previews. This platform offers a flexible PCB design with an electrode array engraved on. The PCB generates pulses that stimulate the tongue based on variances in sensitivity across tongue to induce taste sensation [13]. Both Norimaki Synthesizer and TactTongue systems are limited to five basic tastes. However, with its array-based, flexible and light design, we find TactTongue the most appropriate for assuring the technical validity of the FB concept.

2.2 The Scenario: Out on a trip with FB

"The first thing the user sees upon opening the FB package is the user manual. After quickly skimming through the manual, the user inserts the taste buds on the mounts and spins the device twice, triggering it to start a taste journey. As FB activates, the user starts walking in the streets as per planned in their itinerary. As they walk, FB spins freely in their hand, offering a playful distraction as they explore the city. As they approach a promising restaurant fit for their palate, the FB locks spinning abruptly signaling a culinary experience nearby. The user then picks of the tastebuds and places it in their tongue. Upon putting it on their tongue, they suddenly sense a flood of spice and exclaim: "Arghh! What's that?". They immediately hit the dislike button and pick up another tastebud. This time, they a rich, creamy flavor infests their mouth, a flavor that spark their curiosity. Then they hit the like button, and FB immediately turns into a compass, guiding the way to the restaurant. The user then follows the FB and enters the restaurant and savor the much-anticipated meal."

3 METHODS

We organized walk, talk and eat tours carried out with FB prototype inspired from recent research in HCI and HFI [6, 16]. While walking and talking has been part of ethnographic research for many years, it recently was recognized as a method in its own right [14]. Walking and talking method typically combines field observations and interviews in a semi-structured manner and have been frequently used by HCI researchers along with other digital design prompts and digital augmentations [14]. Researchers integrated NFC-tagged prompt cards to facilitate access further archival material related to places along the walk while others prompted participants to indicate their place-based feelings [16]. Overall, research have aligned the walking methods in aid for their research context. In HFI research, walking tours were facilitated to collect insights on challenges and issues in the HFI [6]. Building on this methodological ground in our research, we designed walking tours to initiate discussions through the experience of FB prototype. We named these enactment journeys as walk, talk and eat tours are conducted in two-steps: 1) Handing out the kit and introduction to concept (20 mins), 2) Foodiebuddy experience (approximately 60 mins) and 3) Data collection.

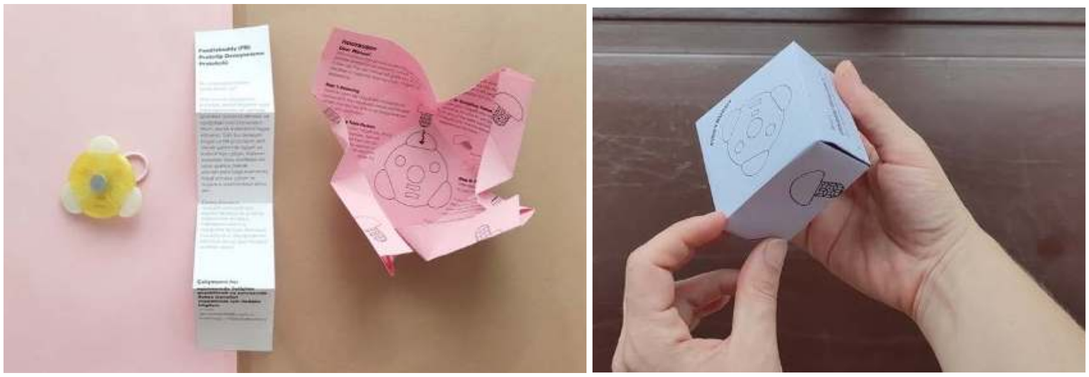

Figure 2: (left) Foodiebuddy (FB) probe kit: FB gadget, prototype experiencing protocol, and instruction manual; (right) FB probe kit as folded and handed out to participants

We prepared a prototype experiencing protocol, printed it on a sheet of paper and put it inside the FB packaging (Figure 2). Except two participants who preferred to answer the protocol questions in written format, all experiences were voice recorded along with photos taken by the participants and the primary researcher. Due to participants' hesitations regarding the hygiene and plastic safety of the tastebuds, we left putting the pieces in their mouth to their judgements. However, this did not limit our findings as the prototype is only conceptual and is enacted by the participants' imaginations.

4 STUDY

4.1 Participants and Study Procedure

One of the main challenges for this study was to find participants who were traveling. This limitation led us to navigate to our professional circles to find participants. For this reason, we adopted convenience snowballing for finding participants for this study. The only criteria we set for joining the study was to have a travel plan either domestic or international. All participants attended this study was individuals who reside in City A and have traveled international or domestic between March 2024 and June 2024. We handed out the Foodiebuddy (FB) kits to participants before they started enacting their travel exploration journey. Upon handing the kits, each participant was informed briefly of how they should proceed with the protocol along with an explanation of the FB's usage scenario. After, each participant enacted the scenario in their own time and sent their voice recordings and photos through WhatsApp.

4.2 Data Collection and Analysis

The dataset we collected included voice and video recordings along with photos sent by participants and taken by the main researcher in the tours she participated. The voice recordings were recorded by participants as they enacted a food exploration trip with FoodieBuddy (FB) and answered the questions prompted to them (See supplementary material). We conducted a total of eight walk, talk and eat tours with 21 domestic and international tourists residing in City A. The settings of each tour were in nature unique as the travel cases differed and we made sure that each tour would include at least one interaction designer and one traveler. Due to the study settings' dependency on interaction designers, some participated more than one tour. This was the case for P8, who participated in session 2 as a user and then they acted as the interaction designer in session 3. To clarify the participant details, we present each session with its unique identity (Figure 3).

Figure 3: All Walk, Talk and Eat sessions and attending participants.

After collecting this multifaceted dataset, we conducted thematic analysis [4]. We proceeded to the analysis by first transcribing the voice and video recordings which helped the researchers familiarize with the data. We took memos and notes on quotes we found interesting or related to our research questions. After, the main researcher went through each transcription and generated summary sentences for each chunk of text that she found related to the research question. Following the summary creation on MAXQDA, the summaries are then moved to a Miro board where each summary would be placed on a single post it. We then clustered each summary based on their relevance to each other. After the initial clusters were created, before completing the clustering, we started naming the clusters. These names made up the codes which eventually were clustered again to generate insights.

5 RESULTS

5.1 Expected Affordances from a Personal Food-Exploration Gadget

5.1.1 Insight 1: Exchange complex information (e.g., giving feedback on the food or initiating the exploration journey) through voice-based interaction.

While interacting with FB, most participants were inclined to talking with it as if they were talking to a friend. They made up voice-based prompts for initiating certain tasks. To find FB, “Hey, FB!” (P3), or to guide the recommendation “FB, I want to lose X kilos!” (P13) or “Suggest me carbohydrates.” (P22). On the other hand, giving feedback on the taste preview and food after eating required a more detailed communication. The initial design of FB only allowed binary feedback on the taste preview (like-dislike), participants extended this feedback stating that they neither liked nor disliked the sample and picked something in-between on the FB interface (P4). In another session, P14 specified this interaction as FB understanding their reaction to food and sampled phrases to say after taste sampling “Ah, yoghurt? not bad!” or “Hmmm, nice!”. They highlighted that giving detailed feedback is especially crucial for disliked foods (P12, P15) and details include taste elements of food (e.g., spiciness, serving temperature, heaviness or just the taste).

5.1.2 Insight 2: While eating with a group of friends, users are in a co-exploration mode. In co-exploration, the social dynamics of the group should be reflected on the taste recommendation.

Participants often questioned how FB fosters consensus among group members (P1) and stated that they would evaluate its suggestions based on the foods’ appropriateness to all group members (P8). To avoid selecting a mediocre place to satisfy everyone at the same level (P14), participants offered either building a complex algorithm for avoiding mundane suggestions (P13) or picking a lead user (P1, P4, P14). Picking a lead user prioritizes their preferences among other group members and respects the social dynamics of the group. These social dynamics was exemplified in two cases. P1 mentioned that picking a lead user aligns with their familial routines when they go out to eat in a meyhane. Currently, they assign the women in the family (i.e., mother and sister) to pick the mezes, letting them choose food for the rest of the family. In another case P4 mentioned leaving map reading to P5 in their travel routine as a coupled, selecting their partner as the lead user from a practical perspective. In this respect, when they use FB together, P4 stated that they would follow P5's device together by putting their own device in idle position by attaching FB on their phone strap. In session 5, participants discussed having an introvert person in a friend group who abstains to express their preferences (P14). Participants suggested prioritizing introvert users’ preferences and helping them to feel more included in the group through food. In cases where picking a lead user is not applicable, for making a food choice as a group, participants stated that the temporal and taste expectations would vary, and FB recommendations should adapt to this catalogue of preferences. Especially while traveling, some users are in a mood of cultural omnivorousness, where they try to taste as many new and authentic foods as possible. To do so, they share meals with their partners (P1, P6) or they have a bite from a friends’ food (P1). In some sessions, participants performed a specific interaction with their FB devices, by bumping them to each other, that enable them to pass on taste samples with each other (P4, P5, P6, P8, P9).

5.1.3 Insight 3: Keeping record of users' changing preferences and letting them guide their taste exploration journeys could help build trust.

In some sessions, participants compared using FB to their current food selection methods such as browsing community suggestions in Google Reviews (P5, P20, P21, P22). Some stated that they wanted to sync their FB records with Google reviews (P3, P10) and see their taste history (P8, P10, P12). This suggests that FB could build trust by building on current methods while keeping a record of users' previous taste journey logs. One participant stated that they would like to keep a record of the foods they encountered and tasted during their trip even if it is just a bite (P1). An appropriate method suggested by participants for tracking the log of previous meals was through an app (P8). They stressed that such an app would help them browse through their previous explorations (P10, P22), and support FB to adjust recommendations based on their personal taste history (P3). By doing so, FB would get to know the user and users' previous choices and personal preferences would guide its recommendation. Guiding FB suggestions could go further by making a two-step recommendation while making the taste preview. One participant pictured a scenario where they first filter down their options after the first taste preview sample (P5). They then have another taste sample and make the final call for their choice. While FB suggestions could be improved over time by keeping record of users' choices, it was also found trustworthy when compared to suggestion from a local resident (P14) or their familiar places (P12). The reason is that they tended to find local knowledge unreliable, and even said that they would cross-check a local suggestion with FB (P14). Although the unanticipated interactions with locals were found unreliable, they also hold potential for fostering unique experiences (P14).

5.2 Food-Related Dynamics in the Different Modes of Travel

5.2.1 Insight 4: While traveling, trying local food is prioritized and options are filtered out based on users' diet. The authentic taste experiences are to be shared with others traveling to the same destination.

Most participants prioritized trying local cuisine and new foods while traveling. Some stressed that eating Greek food in Dubai for example, would not make sense to them (P1, P9). However, we also observed occasions where some user types might not prefer trying local options. For instance, when traveling to certain destinations with a very different type of cuisine to travelers' own palate, such as Asia, they would hesitate to be open to try everything (P8). For such cases, participants suggested that this option should be turned on and off. However, one participant underlined their approach to trying local foods as a core definer of their overall travel experience, and if they do not have opportunity to try out local foods, they would have the anxiety of missing out the best local experience (P14). To overcome such risks, FB could only show tourist-friendly options for keeping user journeying on taste (P8). Participants often approached making the food choice by filtering out the unwanted options instead of adding foods to their glossary (P8). They envisioned filtering out disliked tastes for future taste recommendations (P3). Some also mentioned that FB should filter out foods that are off diet for some of some user types. Foods that contain certain ingredients should be automatically eliminated by FB based on users' special diet. For instance, for users who have allergies, foods that contain certain ingredients should never be suggested (P10, P17), while meat tastes should never be offered for vegans and vegetarians (P8, P10). Some participants also had personal preferences for how they want their food. For instance, one participant stated that they would filter out oily foods (P1), while another participant wanted to filter out their options based on ingredients that they are familiar with (P14). Participants were also motivated to share their explorative journeys with their friends and family traveling to the same destination (P1, P3, P10). In this discussion, participants highlighted that FB should be informed of the travel itinerary and prioritize foods based on the length of the trip and the stops included (P3).

5.2.2 Insight 5: Food is experienced in varying contexts such as traveling alone, group dinner and many others. Different types of users would relate to FB differently.

The discussions about the different types of users also related to the discussion about when or when not to use FB. For instance, participants envisioned several modes that FB would operate in, such as the different types of travel modes. The varying travel modes include resting while eating, budget friendly street food exploration (P8). Participants also envisioned some contexts where they find the use of FB as the most appropriate. The most prominent one is expectedly trying new foods in various different settings. Participants discussed that FB could be a permanent item that would have its place in their travel kit or bag (P2, P16) and found it to offer convenience for exploring budget friendly street food (P8). FB was found helpful for trying foods for the first time (P15) and while also giving courage to do so (P4). They also found it to be useful in scenarios where they have limited access to food. For instance, one participant stated that their hotel had no restaurants in close proximity, so they would make use of FB suggestions because they could not have access to explore (P14). Some other accessibility issues were the crowdedness of the place due to popularity (P4). The situations where FB would not be useful was found as when participants wanted to eat only to nourish themselves with food, and in that case, they stated that they do not take any risks (P3) and just want to eat comfortably when exhausted from walking in the city (P8).

5.3 The Effect of Taste Sampling on Human-Food Relation

5.3.1 Insight 6: Taste samples foster curiosity to try more tastes. Participants wanted to continue the taste trying action while ordering. Not giving an instantaneous cue but helping and guiding the user through the taste exploration journey.

Participants were motivated to continue their taste exploration journey after making the first taste sample trial. Some were curious of the other tastes that they wouldn't select if they liked the first sample they've tried (P5, P8) and stressed that they would like to taste all three suggestions just out of curiosity. Another participant mentioned that they would use FB and sample tastes in different occasions, just for fun not only when going out to eat (P21). On the other hand, other participants also mentioned continuing the taste sampling action for ordering their foods. Some wanted to continue tasting while walking to (P4) and after arriving at the restaurant (P9, P10, P12, P13, P21, P22). They wanted FB to continue informing the user about the different parameters of food, such as the portion size (P15) and spiciness level (P12, P13) before making the final order. They also enacted a scenario where they spin the FB while holding it above the menu, to make a new taste sample roll from the menu (P9). If they are not in a playful mood, they would scan the menu items with the FB and pick new taste samples from the menu.

They stated that this would be an enjoyable way to interact with the menu even if they made a call on their liked taste sample. Two participants mentioned that they would enjoy keeping slurping on taste buds while walking to the restaurant (P4) or waiting for their order to arrive (P22). Another use of FB while waiting for food to arrive was to get additional information on food about its best drink, spice or sauce matches of the food that they just ordered (P12). They also mentioned that they would be interested in getting additional info about their foods, such as where it comes from, how was it produced (P4, P22).

Some participants related the taste sampling action with their satiety level (P5, P13, P15, P16). They questioned whether the taste samples would make a user full or tame their hunger and prepare them for food. Some participants, speculated that continuing to sample tastes would increase their appetite, make them hungry (P5) and foster anticipation (P13).

5.3.2Insight 7: Factors that affect overall food experience are not limited to taste but include users' expectations about the restaurants' spatial qualities such as the seating availability, estimated wait time, price range and overall ambiance.

During the tours we observed that there are multisensory elements that would improve the taste preview of FB, such as the freshness of food (P15), the smell (P16) and the visual of food (P3, P10). These are all properties related to foods current unique state.

There were also other factors that would affect their overall satisfaction from the food they eat related to the properties of the physical space. Participants specifically valued the view, the visual elements (P16), ambiance, traveling distance (P8). They would also want to be informed about the restaurants', food service quality and their sustainability level such as the carbon footprint (P4) or price performance balance (P21), estimated arrival time (P5), the crowdedness of the place (P16). Some factors were related to not just the physical space, but the social interaction with others in that space. For instance, one participant specifically mentioned that social interaction with the sellers at the food market is valuable and initiates them to make a decision on the food. Lastly, the emotions were found related to their satisfaction from the food. One participant mentioned that they would be satisfied if the FB suggestion would meet their expectation (P21), while another mentioned that they cannot forget the ice cream they had in Dresden which relates to the setting and their overall emotional attachment to that memory (P16).

6 DISCUSSION

By looking at the insights we gathered throughout the walk, talk and eat sessions, we derived five design considerations (DC). We present them in the list format which do not only inform the design of FB, but also travel taste exploration artifacts in a broader sense.

Table 1: Design considerations for taste exploration artifacts.

Design consideration	**Description**
DC 1 Consider the details of shared information with the gadget (feedback on food, social dynamics and travel itinerary) and share them seamlessly.	During the FB enactments, participants shared information related to various aspects of their experience. Some shared detailed feedback on food with FB, some on the taste sample, and others focused on reviewing the final meal. Some also discussed sharing the travel itinerary with FB so that they would guide the journey.
DC 2 Match local food recommendations with users' diet.	One of the most prominent food items that travelers seek in new places are local foods. Accordingly, our participants stress the importance of trying local tastes using FB. However, they highlighted the differences of diets and preferences while making local food selection.

DC 3 Adapt taste recommendation to user types and travel modes.	Traveler personas differ and are various. Likewise, the travel modes are also various. The recommendation systems developed for such functions are to be adapted to these varying modes of travel and personas.
DC 4 Design a continuing taste exploration journey.	We initially designed the taste preview as an instantaneous experience which occurs during the walking stage of the experience. However, in different occasions participants stated how they want to continue previewing tastes.
DC 5 Incorporate spatial, atmospheric, occasional and social elements into the exploration journey.	While food is a main element of a taste exploration journey, users' choice does not only depend on the quality, authenticity or taste of food. We observed that various other elements could contribute to improving users' overall experience. Including such elements in the restaurant selection is crucial especially for the travel case, because users mostly want to experience multiple novelties in each activity they practice during their travels.

7 CONCLUSIONS

In this study, we investigated the dynamics of eating while traveling through a research artifact Foodiebuddy (FB). We also derive design considerations for future devices that will be designed for this context. Overall, our findings indicate that such a personal food-exploration gadget would entice users to try out new foods and improve their overall journey. Our findings contribute to the HFI artifact designs in two perspectives. First, we introduced the field of HFI about social, psychological and practical dimensions of eating while traveling context. Although some were already uncovered by other fields, to our knowledge, this is the first study that brings together in-the-wild data for HCI field. Second, we contribute five design considerations for designing eating artifacts for the traveling case. These considerations serve as tools to inspire future HFI innovations by forming a basis for the basics.

Although we were able to extract meaningful design considerations for eating while traveling, our study had some limitations. First and foremost, as we deeply discussed in the methods section, finding traveling participants who were willing to join this study was challenging. This challenge underlines the accessibility issues of traveling case which is restricted by financial, time and mobility constraints. Studying the accessibility of the travel case in presence of digital food experiencing artifacts could be a fruitful and promising future path for research. Second, we found that the researchers' presence affects participants' motivation and the results during the studies. For this reason, any future endeavor that replicate the walk, talk and eat sessions would consider making an autoethnographic journey separate from the study participants.

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