ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL

TECHNOLOGY ACCEPTANCE OF 3D FOOD PRINTERS AND 3D PRINTED FOOD IN DOMESTIC ENVIRONMENTS

M.Sc. THESIS

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Department of Industrial Design

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ISTANBUL TEKNİK ÜNİVERSİTESİ ★ LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ

3 BOYUTLU GIDA YAZICI VE 3 BOYUTLU BASKI ALINMIŞ GIDALARIN EV ORTAMINDA TEKNOLOJİ KABULÜ

YÜKSEK LİSANS TEZİ

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Selvinaz Nesibe Kaya, a M.Sc. student of İTU Graduate School student ID 502181908, successfully defended the thesis entitled "TECHNOLOGY ACCEPTANCE OF 3D FOOD PRINTERS AND 3D PRINTED FOOD IN DOMESTIC ENVIRONMENTS", which she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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To my mom and dad,

FOREWORD

It was a long and difficult process for me to work as a professional designer and do research about thesis in the same period. I would like to thank my supervisor Koray Gelmez for his guidance in this period. I am grateful to have had the opportunity to work with him on this study.

I would also like to thank my instructors at both METU and ITU for their patience in providing feedback by lecturing, commenting, criticizing and contributing their ideas about projects during my undergraduate and master years.

During this process, I felt the warm support of my dear family, my mother, Gonca Kaya, and my siblings: Melek Kaya Badem, Sümeyye Kaya, Abdulkerim Kaya. I am especially grateful to my mother for staying strong and not giving up, teaching us to be hardworking. I would like to thank my father, Mustafa Kaya, who supported me throughout my life, did his best, always made me feel his love and set an example for me with his life, for the values he added to me and every point he touched in my life. It made me feel very lucky that my friends Burak İnce, Fatma Gönüllü, Esma Eser, Berkay Beyazgül, Elif Ayhan, Aslı Hazal Akaltun who motivated me during my studies were by my side with their support, friendship and patience. I would like to thank the interview participants who took the time me after my survey study and afterwards. Their participation and contribution was invaluable to this work.

Another thanks to my colleagues and mentors who have contributed directly or indirectly to this thesis and my professional life: Özgür Mutlu Öz, Serdal Korkut Avcı, Gizem Ünaler, Gürkan Kurtbay, Nur Fındık Önal, Muhammet Ramoğlu and Burak Bozok and Ece Çınar.

Finally, I would like to thank all my relatives who supported me on this journey with their beautiful energy and motivating words, and my classmates: Elif Gökaltay, Miray Hamarat, Beril Coşkun for sharing and supporting each other in this journey.

At the beginning of my M.Sc., I was working on 3D printer program design in my professional life and curious about this topic. I am happy to reveal a work on this topic. I hope this study will be a base for designers to work on this technology and researchers to search new relations between technology acceptance and food design.

January 2022

Selvinaz Nesibe KAYA
(Industrial Designer)

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ABBREVIATIONS

3D : 3 Dimensional
4D : 4 Dimensional
3DFP : 3 Dimensional Food Printing
BI : Behavioral Intention
DIY : Do It Yourself
EE : Effort Expectancy
FAO : Food and Agriculture Organization
FC : Facilitating Conditions
FDM : Fused Deposition Modeling
HM : Hedonistic Motivation
NASA : The National Aeronautics and Space Administration
NGO : Non-Governmental Organization
OECD : Organization for Economic Co-operation Development
P [#Number] : Participant [#Number]
PE : Performance Expectancy
PEU : Perceived Ease of Use
PU : Perceived Usefulness
SI : Social Influence
SXSW : South by Southwest
R&D : Research and Development
T : Trust
TAM : Technology Acceptance Model
TPB : Theory of Planned Behavior
TRA : Theory of Reasoned Action
UTAUT : Unified Theory of Acceptance and Use of Technology

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TECHNOLOGY ACCEPTANCE OF 3D FOOD PRINTERS AND 3D PRINTED FOOD IN DOMESTIC ENVIRONMENTS

SUMMARY

The acceptability of new technologies and new products by users is a popular research topic. In this research, technology acceptance of food printing will be investigated in food and appliance dimensions. Unlike the existing studies on this technology, it also looks at 3D food printing technology from a design perspective and examines the relationship between food design and 3D food printing under two main dimensions: design of food and appliance. This technology makes possible to produce food in designs that are difficult to achieve by using traditional methods. Studies show that the appearance and texture of the food has an impact on the user's decision to consume a food. In 3d food printer design, there are many factors that will affect the expectations of the users and the decision of use for a appliance that will be placed in the kitchen and to be used in producing food.

Under the headings of food and appliance design, the design of the service required to present this technology to the user and the design of the interfaces where the users will make the necessary settings and modeling to get output from this product are also included in this relationship. Food printing requires some digital platforms and systems that require human interaction. It is necessary to select the dish, define the recipe and design if necessary, and adapt the data to the printer or obtain the model and print settings from online platforms. Another issue is service design, which is an important part of the usability and accessibility of a food print. The user's ability to install, use and access the hardware and software should be considered as an experience design. Work should be done on the provision of content and the provision of reliable content.

3D food printers offer a new food production method for use both at home and in food companies or small businesses, thanks to the developments in today's 3D printing technology. It allows consumers to produce personalized products at home. 3D printing can bring culinary arts and non-professional food manufacturers closer together. In the future, this technology will enable everyone to access every recipe and easily produce that dish at home whenever they want. In addition, the user can reach the food that is free from harmful ingredients and has the nutritional values they need.

3D food printers in their current form have barriers such as shelf life, lack of official regulations, constraints of usable materials and the need for processes such as cooking and freezing after printing process. Although it is frequently used in areas such as chocolate printing and cake decoration to create presentation and interesting forms, it is thought that it will change food production methods and become widespread in the future with its potential benefits such as personalized food and new food sources. Vegan meat production will be a solution to problems such as carbon footprint, depletion of natural resources and quality of life of animals. Alternative protein sources such as insects and algae are thought to offer a solution for users with limited access to food. In addition, it provides both ease of chewing and interesting

presentation opportunities for patients and children with eating difficulties. Finally, it is studied to meet the nutritional value needs of the body by customizing the ingredients with personalized foods. The impact of this technology on people and whether humanity is ready to use this technology at home is an issue that needs to be discussed.

Various models have been put forward to investigate the degree of impact of factors on behavioral intention of users in the adoption phase of new technologies. This study, was carried out on the acceptability of 3D food printing technology in the home kitchen environment by making use of the Unified Technology Acceptance and Use Theory (UTAUT), which is one of the technology acceptance research methods and frequently used. In this research, the quantitative research carried out with a survey using the mixed method was supported by the interview with the volunteers of the survey participants. For this research, the dimensions of model were chosen as facilitating conditions, social influence, effort expectancy, performance expectancy, hedonistic motivation, trust, behavioral intention. With the video prepared, brief information was given about the potential benefits of technology, the food production process and the food produced. The relationships between dimensions on method were examined and analyzed. An online interview was conducted with participants who voluntarily shared their e-mail addresses in the survey, both their current habits, where they saw this technology in the future, their expectations and opinions were learned.

In the analysis phase, data was transcript and categorized under the determined dimensions. The graphs in the survey results and the interview outputs were compared and the hypotheses and research questions were evaluated with the findings. Participants stated that their social circles may express different views on the use of this appliance and the consumption of printed foods. It was stated that although they will receive both positive and negative feedback, neither situation will affect the participant's decision to purchase and use this product. Regarding the efficiency expectation, some of the participants thought that this product would save them time. However, there is an opinion that experience will affect this view and that technological capability will be effective in terms of time and effort. Efficiency can vary depending on how technology is applied, how it is presented to the user, and the design of the product, interfaces, supply system. The participants said that the appliance should add practicality and time to their lives, but they can decide to buy it when they need and they would like to try printed food in a restaurant before buying.

Some of the users think that their budget will not be enough to buy the appliance when it is released. However, survey and interview results show that consuming a designed food and its customizability attracts attention. Another point that the participants highlighted is the importance of the taste of the food. No matter how good the form is, there were users who stated that they would not continue to use it if they did not like taste or texture of the food.

In the future, a study can be carried out by testing the food to the participants. Thus, more clear data will be obtained on the acceptability of the consumed food in terms of visual quality, taste, and form. In addition, a new study can be conducted to learn the perspectives of users on meat supply with new methods. With a study in which the acceptability of the appliance will be examined by the users, the expectations and needs of the users from this product to be placed in the kitchen can be studied. The aim of this thesis is to define the factors affecting the user acceptance of 3D food printing technology in the home environment. The results are valuable for a theoretical

scope that contributes to further research in this technology rather than the design practice of a device. A product and service design can be studied based on the outputs of this study by conducting new research on this technology with designers. However, 3D food printer design requires a multidisciplinary study. It's not just about designing a 3D food printer, it's more about designing the system in which people buy and enjoy this technology and food, considering the environment, human interactions, tangible factors, and output.

3 BOYUTLU GIDA YAZICI VE 3 BOYUTLU BASKI ALINMIŞ GIDALARIN EV ORTAMINDA TEKNOLOJİ KABULÜ

ÖZET

Yeni teknolojilerin ve yeni ürünlerin kullanıcılar tarafından kabul edilebilirliği popüler bir araştırma konusudur. Bu araştırmada 3 Boyutlu (3B) baskı teknolojilerden biri olan gıda baskısının kullanıcılar tarafından ev ortamı için kabul edilebilirliğini etkileyen faktörler ve ilişkileri, potansiyel kullanıcıların bu teknoloji ve geleceği hakkında düşünceleri ele alınmıştır. Bu teknolojiyle ilgili mevcut çalışmalardan farklı olarak 3B gıda baskı teknolojisine de tasarım perspektifinden bakılmaktadır. Bu araştırma gıda tasarımı ile 3B gıda baskısının arasındaki ilişkiyi inceler. Bu teknoloji sayesinde yiyecekler geleneksel yöntemlerle üretilmesi zor olan tasarımlara sahip şekilde üretilebilir. Bu tasarım üretici kişinin el yeteneği ve deneyiminden bağımsız olduğu ve hata payı düşük olduğu için aynı şekilde birçok ürün çıkarılmasını mümkün kılar. Gıdanın görünümü ve dokusu kullanıcının tüketme kararı üzerinde etkilidir. Ürün tasarımı konusunda ise mutfakta yerleşecek bir ürün için kullanıcıların beklentileri ve kullanma kararını etkileyecek birçok faktör vardır. Bu nedenle tasarım bakış açısıyla yazıcının ve gıdanın kabul edilebilirliği bu araştırma için iki ana kesişim noktası olarak belirlenmiştir.

Gıda ve cihazın tasarımı başlıkları altında bu teknolojinin kullanıcıya sunulması için gerekli olan servisin tasarımı ve kullanıcıların bu üründen çıktı almak için gerekli ayarları ve modellemeyi yapacakları arayüzlerin tasarımı da bu ilişkiye dahil edilmiştir. Gıda baskısı, insan bilgisayar etkileşimi için iyi bir örnektir. Gıda baskısı, insan etkileşimi gerektiren bazı dijital platformlar ve sistemler gerektirir. Yemeğin seçilmesi, gerekirse tarif ve tasarımın tanımlanması ve verilerin yazıcıya uygun hale getirilmesi gerekmektedir. Bir diğer yöntem olarak çevrimiçi platformlardan model ve baskı ayarları temin edilmeli ve bu bilgiler istenildiği zaman yazıcıya aktarılmalıdır. Bir diğer konu da bu sistemi tasarlamaktır. Servis tasarımı, bir gıda baskısının kullanılabilirliğinin ve erişilebilirliğinin önemli bir parçasıdır. Kullanıcının donanım ve yazılımı kurabilmesi, kullanabilmesi, içeriklere ulaşabilmesi gibi pek çok konu, teknolojinin gelişiminden bağımsız olarak deneyim tasarımı olarak ele alınmalıdır. İçeriklerin hazırlanması veya temin edilmesi gerekmektedir. Belirli bir akışkanlığa sahip olması gereken bu içeriklerin evde hazırlanması kullanıcıları zorlayabilir. Bunların temini konusunda hem iyi işleyen bir zincir hem de güvenilir ve sağlıklı içeriklerin sağlanması konusunda çalışılmalıdır.

20. yüzyılın sonunda tasarımcılar, gerekli başarılı çözümler üretmek için davranışları incelemenin ve insanları sürece dahil etmenin önemini anladılar. Bu bakış açısıyla oluşturulan kullanıcı merkezli tasarım, daha çok insan ve nesne arasındaki etkileşimle ilgili olmaya başladı. Bu bakış açısıyla, gereken yalnızca 3B gıda yazıcısı tasarlamak değil, daha çok insanların bu teknolojiyi ve yemeği satın aldığı ve zevk aldığı durumu çevresi, insan etkileşimleri, somut faktörler ve çıktı göz önünde bulundurarak tasarlamaktır.

3B gıda yazıcıları, günümüz 3B baskı teknolojisindeki gelişmeler sayesinde hem evde hem de gıda firmaları veya küçük işletmelerde kullanmak için yeni bir gıda üretim yöntemi sunmaktadır. Kullanıcıları üretici-tüketiciler olarak tanımlayan "prosumer" terimi kullanıcıların kamera, yazıcı ve tarayıcı gibi teknolojileri kullanmaya başlamasıyla daha da değerli ve popüler hale gelmiştir. Örneğin, 3B yazıcılara yatırım yapmak, tüketicilerin evde kişiselleştirilmiş, ihtiyacına yönelik ürünler elde etmesine olanak tanır. 3B gıda baskısı da, mutfak sanatları ile profesyonel olmayan gıda üreticilerini birbirine yaklaştırabilir. Gelecekte bu teknoloji herkesin her tarife ulaşmasını ve dilediği zaman evinde o yemeğin çıktısını alarak kolaylıkla üretebilmesini sağlayabilir. Ayrıca kullanıcı, zararlı içeriklerden arındırılmış, ihtiyacı olan besin değerlerine sahip yiyeceğe istediği şekilde ve yerde ulaşabilir.

Bu teknolojinin gelecekte gıda üretimiyle birlikte gerekli besinlere ulaşım yolları, pişirme alışkanlıkları ve gıda tüketimi üzerine yeni deneyimler getirmesi bekleniyor. 3B gıda yazıcılarının şu anki haliyle içeriğin raf ömrü, resmi düzenlemelerde eksiklik, kullanılabilir malzemelerin kısıtları ve yazıcıdan çıktıktan sonra pişirme, dondurma gibi işlemlere gerek duyulması gibi bariyerleri vardır. Ancak yapılan çalışmalarla bu teknoloji her geçen gün daha da gelişmektedir. Günümüzde sıkça sunum ve ilgi çekici formlar oluşturmak için çikolata baskısı ve pasta süsleme gibi alanlarda kullanılsa da kişiselleştirilmiş gıda, yeni besin kaynakları gibi potansiyel faydalarıyla gelecekte gıda üretim yöntemlerini oldukça değiştireceği ve yaygınlaşacağı düşünülmektedir. Vegan et üretimi, biyobaskı teknikleriyle et sektörünün yol açtığı karbon ayak izi, doğal kaynakların tükenmesi gibi problemlere ve hayvanların yaşam kalitesi sorunlarına çözüm olabilecektir. Böcekler, algler gibi alternatif protein kaynakları besinlere ulaşımı kısıtlı olan kullanıcılar için ve belki de gelecekte doğal kaynak sorunlarının artmasıyla tüm insanlar için bir çözüm sunabileceği düşünülmektedir. Ayrıca yeme güçlüğü yaşayan hastalar ve çocuklar için hem çiğneme kolaylığı hem ilgi çekici sunum olanakları sağlar. Kişiselleştirilmiş gıdalarla içeriklerin özelleştirilmesiyle vücudun besin değeri ihtiyaçlarının kişiye özel karşılanması üzerine çalışılmaktadır. Bu teknolojinin insanlar üzerindeki etkisi ve insanlığın evde bu teknolojiyi kullanmaya hazır olup olmadığı ise tartışılması gereken bir konudur.

Yeni teknolojileri kabullenme aşamasında kullanıcılar için bariyerlerin ve destekleyici faktörlerin etki derecelerini araştırmak için çeşitli modeller ortaya konmuştur. Teknoloji kabul modelleri; amaç, kapsam gibi özelleşmelerle geliştirilmiş ve araştırmacılar tarafından versiyonlar üretilerek yıllardır kullanılmıştır. Teknoloji kabullenme araştırma yöntemlerinden biri olan ve sıklıkla başvurulan Birleşik Teknoloji Kabul ve Kullanım Teorisi (UTAUT) modelinden faydalanılarak bu araştırmada 3B gıda baskısı teknolojisinin ev mutfağı ortamında kabul edilebilirliği üzerine bir çalışma gerçekleştirildi. Bu araştırmada karma metod kullanılarak anket ile gerçekleştirilen kantitatif araştırma, anket katılımcılarından gönüllü olanlarla gerçekleştirilen röportaj ile desteklenmiştir. Her iki yöntem de online olarak yürütülmüştür. Bu araştırma için kategoriler kolaylaştırıcı koşullar, sosyal etki, efor beklentisi, performans beklentisi, duygusal motivasyon, güven, davranışsal niyet olarak seçilmiştir. Bu kategorilere göre hazırlanmış sorularla önce online yürütülen bir ankette katılımcıların ileriye yönelik görüşleri alınmış, bakış açıları incelenmiştir. 129 katılımcıya ulaşılan bu araştırmada açık uçlu ve çoktan seçmeli sorularla katılımcıların demografik bilgileri, teknolojiyle ilişkileri ve mutfak deneyimlerine dair bilgiler edinilmiştir. Hazırlanan video ile teknolojinin potansiyel faydaları, gıda üretim süreci ve baskı alınan gıda ile ilgili kısaca bilgilendirme yapılmıştır. Ardından Likert ölçeği kullanılarak belirlenen faktörlere göre gruplandırılmış sorularla derinlemesine

görüşme gerçekleştirilmiştir. Bu faktörler arasındaki ilişkiler incelenerek analiz edilmiştir. Bu teknoloji hakkında tasarım açısından yazılmış geniş bir literatür bulunmamaktadır. Bu nedenle, konu bir tasarımcı gözüyle ele alınarak, tasarım sürecindeki gereksinimleri belirlemek için teknolojinin kabul edilebilirliği üzerine araştırma modellerinin kullanımı incelenmiştir. Anket çalışmasında gönüllü olarak e-posta adresini paylaşan 10 katılımcıyla çevrimiçi bir derinlemesine görüşme yapılmış daha detaylı şekilde hem şu anki alışkanlıkları üzerine görüşülmüş hem de bu teknolojiyi gelecekte nerede gördükleri, beklentileri ve görüşleri öğrenilmiştir.

Analiz aşamasında da belirlenen kategoriler altında gruplama yapılmıştır. Anket sonuçlarındaki grafiklerle Excel dokümanına aktarılan röportaj çıktıları karşılaştırılmış ve hipotezler ve araştırma soruları bulgularla değerlendirilmiştir. Katılımcılar, bu cihazın kullanımı ve basılı gıdaların tüketimi konusunda sosyal çevrelerinin farklı görüşler ifade edebileceğini belirtmişlerdir. Hem olumlu hem de olumsuz geri bildirim alacak olsalar da her iki durumun da katılımcının bu ürünü satın alma ve kullanma kararını etkilemeyeceği belirtildi. Verimlilik beklentisi ile ilgili olarak, katılımcıların bir kısmı bu ürünün kendilerine zaman kazandıracağını düşündüler. Ancak tecrübenin bu görüşü etkileyeceği, teknolojik kabiliyetin zaman ve emek açısından etkili olacağı yönünde bir görüş hakimdir. Verimlilik, teknolojinin nasıl uygulandığına, kullanıcıya nasıl sunulduğuna ve ürünün tasarımına, arayüzlere, tedarik sistemine bağlı olarak değişebilir. Katılımcılar cihazın hayatlarına pratiklik ve zaman kazandırması gerektiğini, ancak ihtiyaç duyduklarında bu cihazı satın almaya karar verebileceklerini ve evlerine almadan önce bir restoranda denemek isteyeceklerini söyledi. Bazı kullanıcılar bir başkasının evinde denemenin ya da kullanan birinden olumlu yorumlar duymanın etkili olacağını ifade ettiler. Bazı kullanıcılar ise yemek yapma deneyimini terapi olarak tanımlayıp rahatlatıcı ve severek yaptıkları bir aktivite olduğunu belirtti. Ancak bu teknolojik ürünü yardımcı bir mutfak aleti olarak kullanabileceklerini ve tüm süreci onun gerçekleştirmesini istemeyeceklerini söylediler. Kullanıcıların bir kısmı cihazın piyasaya çıktığında bütçelerinin satın almaya yetmeyeceğini düşünerek ancak yaygınlaşıp fiyatı düştüğünde edinebileceğini söyledi. Profesyonel bakış açısınından değerlendiren bir diyetisyen katılımcı ise bu teknolojinin kendisi için ev kullanımını süsleme amaçlı görürken hastane gibi ortamlarda hasta ve özel ihtiyacı olan kullanıcılar için faydalı olacağını ifade etti. Kişiselleştirilmiş gıda katılımcıların dikkatini çektiği ve bu özelliği eğlence aracı olarak gördükleri söylenebilir. Anket ve röportaj sonuçları gösteriyor ki tasarlanmış bir gıdayı tüketmek ve özelleştirilebilir olması ilgi çekici bulunuyor. Katılımcıların özellikler belirttiği bir diğer nokta ise gıdanın tadının önemi. Formu ne kadar iyi olursa olsun tadını sevmediğinde kullanmaya devam etmeyeceğini belirten kullanıcılar oldu. Katılımcıların söylemlerinde bu cihazla üretilen gıdanın tadı ve formuna dair endişeleri ön plandaydı. Güven konusunda katılımcılar bu cihazın hata yapmadan doğru çalışacağını ve tasarlanmış yiyeceği basmak konusunda güçlü olacağını düşünse de içeriklerin yapıldığı malzemeler, üretim şekli, saklama koşulları ve onlara ulaşmak gibi kaygıları vardır. Ambalajlı gıdaların tüketiminin artması, doğal ürünlere ulaşımın zorlaşması ve bilginin yayılmasının kolaylaşmasıyla kullanıcıların yediklerinin kalitesiyle ilgili farkındalıkları artmıştır. Güvenilir ve sağlıklı gıdaya olan talep bu ürünün kullanıcıları için de önemli olacaktır.

İleride 3B gıda baskısı yöntemiyle üretilen yiyecekler katılımcılara denetilerek bir çalışma gerçekleştirilebilir. Böylece tüketilen gıdanın görsel kalite, tat ve form açısından kabul edilebilirliği konusunda daha net veriler elde edilecektir. Ayrıca et basımı ve alternatif protein kaynakları başlı başına incelenmesi gereken yeniliklerdir

ve kullanıcıların yeni yöntemlerle et temini konusunda bakış açılarını öğrenmek için çalışmalar yapılabilir.

Bu araştırmadaki iki ana araştırma alanından biri olan cihazın kullanıcılar tarafından kabul edilebilirliğinin inceleneceği bir çalışma ile de mutfakta yer alacak bu üründen kullanıcıların beklentileri ve ihtiyaçları üzerine çalışılabilir. Bu tez çalışmasının amacı, ev ortamında 3D gıda baskı teknolojisinin kullanıcı kabulünü etkileyen faktörleri tanımlamaktır. Sonuçlar, bu teknolojide bir cihazın tasarım pratiğinden ziyade daha fazla araştırmaya katkıda bulunan teorik bir kapsam açısından değerlidir. Bu teknoloji üzerine tasarımcılarla yeni araştırmalar yapılarak bu çalışmanın çıktılarına dayalı olarak bir ürün ve hizmet tasarımı çalışılabilir. Ancak 3B gıda yazıcısı tasarımı çok disiplinli bir çalışma gerektirmektedir.

1. INTRODUCTION

This chapter explains the background of the study, purpose of the thesis, scope of the thesis and finally the structure of the thesis. These will be clarified step by step in the following sections.

1.1 Background of the Thesis

This thesis focuses on the acceptance of technology in two aspects, the acceptability of the appliance and the acceptability of consumption of the food produced in the appliance. Although there are studies investigating 3D food printing (3DFP) in terms of marketing, mechanical, technological and food engineering, there are limited studies in the design domain. When we associate this technology with food design, it overlaps in appliance design and food design. 3D food printing technology has the potential to bring users together with the design experience as it allows the user to design their own food. In addition, although printing designs shared with open sources is a common method for the environment using 3D printers, it will provide a new experience for many users who are familiar with 3D food printers. Food is an item that is specialized in many cultures with traditional flavors and materials used, and passed down from generation to generation together with cooking, preparation and presentation methods. In addition, in many cultures food is valued as a socializing medium. It can be difficult for users to accept the changes that will come into their lives in an area that has such a place in the culture and where the habits are settled fast. However, needs and changes continue to trigger developments in the field of food. For example, although the microwave oven has not been accepted by some people for a long time because people believed that it emits radiation, it is widely used today.

3D printer technology started with research and development (R&D) studies and became widespread with the development of technology and the increase in usage areas. There are 3D printing hubs where the model sent from plastic parts is output. In addition, it has started to gain a place in the home and office of many end users. Students, workshop workers, prototype makers, designers and users with special

interests in many different fields print at their homes. This situation both introduced the open kitchen to the users who use the model library and contributed to the development of this sector, and also brought together the relevant computer applications and modeling programs with various users. One of the usage areas, building/construction technology, is developing gradually and it is thought that new cities will be built with this technology in the future.

Its use in the food industry is not common today. It is seen to be used in very few restaurants and in the future works of some companies such as Barilla which makes pasta in various designs. In addition, it is used in chocolate and decoration areas for reasons such as cake decoration, brand promotion at fairs and events. It also appears at technology fairs. The 3D food printer conference, which will be held for the 9th time in 2022, attended by specialists/founders of leading brands from this sector and also university members who study on related topics. It is an international event where talks and conversations are held on topics such as the developments in technology, contents, business model, customization/ co-creation, on-demand and on-the-go production, flexibility, patent / legal and regulatory issues, investment opportunities. In the website of the conference they (3D food printing conference n.d.) state that much research is required to change the hype into reality. They are searching for the answer to these questions: "Which industries will be influenced by technology? Which food components can be printed in the near future? And which aspects should be taken into account to ensure safety and maintainability of 3D printed food?"

While 3D food printing technology is developing on the one hand, there is a growing need for meat production and consuming meat without killing animals and harming nature. Awareness on this issue has increased in recent years.As environmental problems such as global warming progress, the answer to the question of how to protect nature is sought. Different methods are being studied to reduce the consumption of animal foods and meat. It is aimed to reproduce meat tissue from animal cells in the laboratory environment and to produce meat with loyal ingredients or to reduce the breeding and consumption of cattle and small cattle with a high carbon footprint and high incidence of water consumption by directing them to different protein sources such as insects. Vegan hamburgers from big brands such as McDonalds have hit the market in many countries. The 3D food printer is a candidate to become one of the products that will become widespread following these developments.

3D food printers are going through a period of comparison with various kitchen tools and trying to position them in the market. For example, a piping bag and 3D food printer were compared. It is said that they are used in similar functions in areas such as chocolate and cookie decoration, but if they are made by hand, they require a serious skill. In addition, the printer can ensure that all these cookie decorations are the same. In this case, the possibility of human error is reduced.

1.2 Purpose of the Thesis

The aim of this study is to contribute to the relationship between 3D food printer technology and design by defining a framework by analyzing the factors affecting the acceptance of new products in the home environment. To achieve this, customers' perspectives on new technologies and new foods are examined here. In addition, the effect of its relationship with food design on acceptability will be investigated. In conclusion, the main research question of this study is as follows:

• What are the factors affecting the acceptance of 3DFP technology (printer and food) by the user in the domestic environment?

With this study, it is aimed to examine the effects of potential users' performance and effort expectation regarding this technology, social impact, facilitating conditions, trust and hedonic motivation on individuals' behavioral intentions to use 3D food printers in their home environment by utilizing the dimensions of the UTAUT2 research model. The relationships between these factors will be examined and analyzed. There is not a large literature on this technology written from a design point of view. For this reason, the use of research models on the acceptability of technology will be examined to determine the requirements in the design process for a new technology, by considering the issue from a designer's point of view.

Understanding and predicting how new technologies will be received by potential users is an important issue for designers and other stakeholders of the process, such as product managers, during product development, during the planning of processes and during the design activity. In order to be involved in users' lives, it is essential to understand both the users' mindsets and the context of their activity. Various methods have been developed to understand users' needs, with techniques drawn, for example, from ethnography (Beyer & Holtzblatt, 1999), dramaturgy and theater (Svanæs &

Seland, 2004), and survey-based quantitative research. TAM is one of these research methods. Although these methods are not suitable for use in the design process without any adaptation, the designer makes use of these methods and adapts them according to their own processes. Although research methods regarding the acceptability of technology are not used to create a brief for the designer, the results can be used as support for a designer. Davis et al. (1989, p. 1000) originally envisioned that TAM could be used in the early stages of product design, it was eventually found that the concepts presented could not guide the design but could only be used to justify it.

1.3 Structure of the Thesis

There are five main chapters in this thesis. Figure 1.1 shows the diagram of the thesis structure. Chapter 1 consists of the background of this study which explains the current situation and aim of the study.

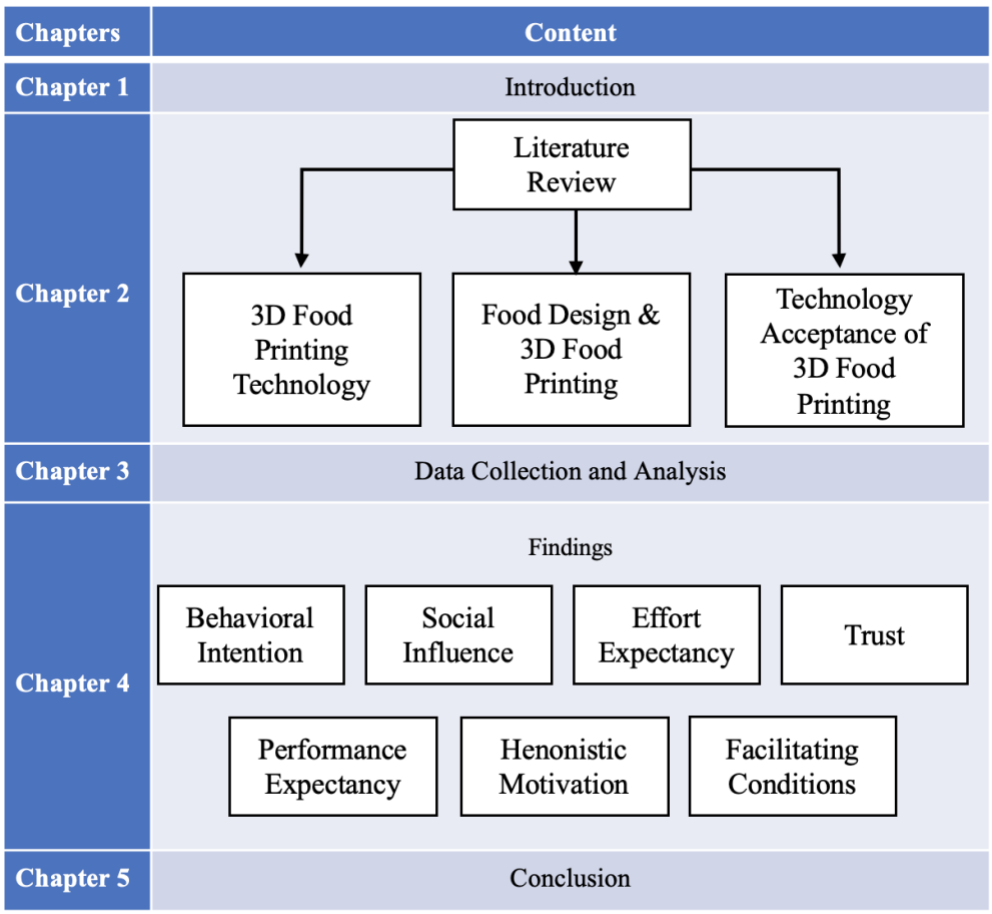


Figure 1.1 : Diagram of the thesis structure.

Chapter 2 is a review of related literature. It is focused on three literatures: 3D food printing technology, food design and 3D food printing and lastly technology acceptance of 3D food printing.

In the first part, 3D food printing technology will be defined and connection of 3D printing and 3d food printing will be explained. In the second part, 3D food printing will be associated with food design. In the third part, technology acceptance models in literature will be revealed.

As Chapter 3 data collection method and analysis of the results will be presented. Chapter 4 reveals the findings in categories.

In the last chapter, findings will be evaluated and conclusion of the study will presented. It also consists of the limitations of this study and recommendations for further studies.

2. LITERATURE REVIEW

There are three sections to address 3DFP in the literature review part. The first section focuses on technological features of 3DFP. It is correlated and compared with 3D printing. How and why it emerged is explained. Then its advantages and potential value of this technology on users' lives will be explained with examples of studies. In addition, limitations of this technology in current time, potential frictions are mentioned. For 3D printing and food printing material is a significant factor which determines the quality of printing and more importantly the printing method. For this reason material requirements of 3DFP are revealed in general terms. Then, predictions on the future way of 3DFP technology is revealed. The second section is on food design and food printing relationship. It is figured out in two perspectives which are design of food and design of printer. The last section is about technology acceptance methods which are practiced carrying through this research.

2.1 3D Food Printing Technology

According to Derossi et al. (2021) the bibliography of 3DFP is getting large and the reviews which delineate the features of 3DFP. Although it is seen that in their analysis the majority of the papers have been published under ‘engineering’, ‘agricultural and biological science’, 'computer science' areas. Categories which studies concentrate on in the last years can be listed as effects of variables to print (Derossi, Caporizzi, Ricci, & Severini, 2018; Perez, Nykvist, Brogger, Larsen, & Falkeborg, 2019), the printability of food (Liu, Zhang, Bhandari, & Yang, 2018; Tian et al., 2021) printing behavior of food materials (Kuo, Qin, Cheng, Jiang, & Shi, 2021; Gholamipour-Shirazi, Norton, & Mills, 2019), 3D structures to get texture properties (Derossi, Caporizzi, Paolillo, & Severini, 2021) and 4D printing (Phuhongsung, Zhang, & Bhandari, 2020; He, Zhang, & Fang, 2020).

Computer science studies on 3DFP is that some current models of 3D food printers have ready to print recipes and models in their software and present a modeling program which allows the user to design their own models on their smart devices (e.g.,

phones, computers). The most common models in the market today have FDM technology. In these types of printers, the content is held in syringes and transferred layer by layer onto a surface by flowing through a nozzle, to form the food as designed. In this way, a variety of dishes of different shapes and colors can be obtained by processing the food content on top of each other. In the next parts, detailed information about 3DFP techniques and features.

2.1.1 3D printing & 3D food printing

The potential of designing complex structures with customized properties such as desired shape and dimension of 3D printers is seen as the main reason for success in industrial sectors and growing interest in many scientific fields. As Derossi et al. (2021) explained, while the first application of 3D printing has been rapid prototyping, its usage currently occurs in pharmaceutical, regenerative medicine, biomedical implants, bioengineering, construction, etc. Moreover, after the implementation with thermoplastic materials, the printing of metal, clothing, glass, concrete, etc., have become popular (Derossi et al., 2021).

The idea of adapting 3D printing technology to food production has emerged with the use of foodstuffs which can be used as raw material after the emergence of 3D printer technology in the field of materials science, which can provide the required flowability to print (Godoi et al., 2016). The first experiments in this area were made with 2-dimensional food such as biscuit and cake decorations. In these experiments, sugar, water, and chocolate were used because of their structural advantages and modeled on the surface of the food (Sun et al., 2015; Pallottino et al., 2016). The first 3D food printer prototype, which can be developed in terms of modeling and simulation, was introduced in 2007 by Cornell University under the name of Fab@Home Model 1 (Malone ve Lipson, 2007). Later on, other studies have been conducted with the inclusion of big companies in the food industry, R&D activities in the universities and the adaptation of 3D printers working in different concepts to food processing systems has been realized. NASA founded a study on the possibility to print food on deep space missions using a 3D printer (Pallottino et al.,2016). Systems and Materials Research Consultancy conducted the study with the aim to develop a 3D-printed food system for long-duration space missions. In a study published Sept. 1, 2021, by Science of Food at Columbia University, the team explored various modalities of cooking by

exposing blue light and infrared light to chicken, which they used as a model food system. About the vegan meat production field day by day new startup companies occur and improvements go on. An Israeli company, which produces burgers, kababs, and sausages, called Redefine Meat, rather than culturing animal cells, is producing fully plant-based “beef” products that are 3D printed at 10kg an hour. At a food truck blind taste test held in 2020, over 90% of the meat-eating tasters agreed that the flavor and texture were a success. (https://www.redefinemeat.com/news-media/) According to a news article published in Turkey in December 2021 functional food was produced at Ankara University using 3D food printers for individuals with dysphagia.

Some 3D printing techniques are applied to 3D food printing. These techniques can be classified according to the type of material used: liquid, powder and cell culture. The deposition of liquid-based materials can be printed via extrusion and inkjet processes, while the powder-based structures are suitable for deposition followed by application of a heat source (laser or hot air) or particle binder. Bio-printing is expected to widely be used in the future and used to print meat that is thought to destroy problems caused by animal food consumption. At present, except bioprinting, four types of 3D printing methods can be applied to food printing: selective laser sintering, extrusion-based printing, binder injection, and inkjet printing (Sun et al. 2015), among which extrusion-based food printing is the most established. According to Wang et al. (2021) studies have led to the development of many extrusion-based food printing materials, including chocolate, dough, mashed potatoes, powdered sugar, cheese, insect-enriched snacks, and fruits and vegetables. In Table 2.1, which is adapted from the study of Dankar et al. (2018), 3DFP techniques are explained. It is explained that which kind of material can be used in the technique and what are the advantages and disadvantages. Moreover, the company studies on the technique are exemplified. After printing, additional processing, cooking, may be required depending on the nature of the material and the recipe used. Again, pressing on a platform with a PancakeBot heater also performs the cooking process during printing. However, it is necessary to rotate the pancake manually. In pizza printing, after dough, tomato sauce is created with the printer, it is necessary to place the ingredients manually and then bake the pizza in the oven. This makes the process far from practicality. There is a study which integrates laser cooking to 3D food printing in California University, Creative

Table 2.1 : Comparison of 3D food printing technologies. Adapted from "3D printing technology: The new era for food customization and elaboration" (Dankar et al., 2018).

Printing technology	Technique	Fabricated materials	Advantages	Disadvantages	Company
Direct printing through extrusion	Extrusion and deposition from a nozzle	Chocolate, cheese, mashed potato, pizza, hummus, cookie dough, hydrocolloids, peanut butter	Support wide array of foods Can be coupled with more than one syringe allowing infinite combinations and degree of freedom for food	Appearance of seam line between layers, long fabrication time	NASA, Foodini Fab@Home 3D systems
Inkjet Printing	Drop-on demand printing from a syringe nozzle	Confectionary fabrications, decorations on cookies, biscuits, drops on pizza bases	Innovative shapes of decoration Easy method	From a 2D and half dimensional image Restricted more on decoration	FoodJet
Selective sintering technology	Powder binding and heat source that melts and fuses desired regions of the powder together	Sugar, Nesquik powder	Recycled powder More freedom to build food with complex design in short time	Applicable to restricted materials with low melting point	CandyFab Cornucopia
Binder Jetting	Apply binding agent to powder according to a predefined 3D shape	Sugar sculptures from sugar powders, flour, starch, caster	Precise Complex structures formation	Fragile end products, Better to be used at a close point of consumption like home and restaurants	3D Systems

Machines Lab (Blutinger et al., 2019). It seems that technological developments can overcome these barriers in the future. Therefore, the design of the product and the system plays an important role in the acceptance of this technology by the user.

From the perspective of the business sector, 3D food printing is considered in 5 clusters. The first cluster, the home and domestic kitchen, where 3D food printers could serve individuals for producing personalized meals in their home. The second cluster is small enterprises such as chocolate cafes, bakeries and restaurants. Third cluster represents large enterprises like food brands such as Barilla, and sports/fitness centers. Airline industry is also considered a market under this cluster. NGOs including nursing homes and disaster relief centers identified in the fourth cluster, whereas conferences, festivals and other events are in the final cluster. Each of them needs to be considered separately and needs a system and service design to be faced with the user.

In the first, domestic, cluster users become prosumers. The term prosumption was introduced in the early eighties. This concept, which was limited to cooking with DIY projects, became more valuable and popular with users starting to use cameras, printers, and scanners. For example, investing in 3D printers allows consumers to produce personalized products at home. This equipment is very important in creating, providing, and capturing value. According to Dankar et al. (2018), 3D printing can cover the gap between culinary arts and non-professional food artisans. Everyone can reach every recipe and can easily produce by printing that food at home whenever prefers. Moreover, the user can reach the food in desired shape, with the nutritional values required and free from the ingredients that are harmful for the user. The effect of this on people is an issue to be discussed. The question of whether humanity is ready to use technology at home is still being debated.

Attarin et al. (2020) state that 3D food printing is changing the U.S. food industry for millennials, who have special interest about food because of their social, political, and economic consciousness. According to market research by Packaged Facts, there is an increasing demand for customized food since millennials become sensitive to achieve fresh, creative, and personalized foods. There is a trend on the fast-casual foodservice segment and increasing demand for customized food. In this regard, restaurants gravitate towards more diverse food areas such as salads, fusion, bowls, and sushi due to growing global palates thanks to millennials inspiration.

Especially in recent years, social media sharing, recipes and food images have become a source of pride. Flavor is always a sought-after feature. Even the best chefs may not be able to reach the same taste in every try. 3DFP makes the food preparing experience more rational and ensures the same quality result every time. Moreover, it can provide this independently of one's abilities. It allows for mass production foods to be cooked in the user's home. This will affect the user's life from many points. In addition, it is possible to foresee that it will cause big changes in the food sector.

2.1.2 Advantages & barriers of food printing technologies

Automation of the food preparing process has been a topic of companies and the food industry before food printing technology. Robotic-based technologies are developing to automate the traditional food manufacturing for mass production and automate manual processes (Steenhuis, Fang, Ulusemre, 2018). They have tried to make cooking and preparing processes easier for people. Robotic-based techniques used for mass production in food production are generally designed to automate manual operations, reduce workload, save labor costs, and improve food production efficiency (Sun et al., 2015).

Compared to robotic-based techniques, an advantage of 3D printing is that it produces nutritionally, aesthetically personalized food whenever and wherever the user wants. In addition to providing attractive shapes and hard to produce structures 3DFP makes possible to get functional properties like supply nutrition for the unique needs, preferences, taste and dietary of different ages, sexes, occupations, and lifestyles by adjusting the composition, density or structure. (Dankar et al., 2018). So, this technology may become a game changer when it is augmented by interrelating personal medical data, diet, lifestyle, gender, etc. (Tagami et al., 2021). In addition, Pereira et al. state that (2021) customized sensory properties can be created by using multi-food materials, by modeling mechanical properties or creating food with the desired shape, color and flavor.

By 2018, approximately 320 tons of meat has been consumed worldwide (Whitnall & Pitts, 2019), and it is predicted that the market will be expanding 15% by 2027 (OECD/FAO, 2018). There is much evidence of persecution in the fabrication of animals such as chickens and cows by fabrication methods. In addition, they are hazardous for the environment even in humanitarian agricultural practices. Livestock,

especially cows, produce high levels of methane, which is more damaging than global carbon dioxide. Forests that create more grazing, water, pesticides, fertilizers, all cause ecological problems. Water scarcity is a growing problem of the world and livestock contributes significantly. This means that people must either reduce meat consumption or find a more efficient way to produce it. In this sense, 3D food printing may be a way out to solve this problem. Lipton et al. (2010) published the first study on 3D printing of meat. In this study, the authors demonstrated the suitability of 3D printed turkey puree for sous-vide cooking method. In another research, gelatin was added to fibrous meats as a viscosity enhancer to evaluate printability and the applicability of 3D printer (Liu, Ho, & Wang, 2018). Such studies show how this technology can more realistically generate meat products with complex internal structure, containing on-demand functional ingredients and modified textures for enhanced eating experiences. According to Değerli (2016), two fields are specified for meat that cannot be printed but can be modified and used as raw material for food. The first one is to ensure that the pureed meat has the proper structure to maintain its form in the cooking processes after the printing with the addition of enzymes; the other is bioprinting with live cell cultures. Using bio-printers artificial muscle tissue was obtained. Cultured meat is produced in a completely sterile environment. It is healthier than current meat consumption habits. Clean meat does not involve medicine which is injected to animals to save them from diseases.

From another perspective, the review of He et al. (2020) present that as a result of increasing concerns, food industries conduct on studies to find innovative ways to supply meat alternatives. These studies include meat from non-animal proteins, and they try to achieve provide similar experience with appearance, mouthfeel, and smell (Kumar et al., 2017). There are two major alternatives researchers focus on: meat, culture-based meats (in vitro meat) (Bhat & Fayaz, 2011; Hocquette, 2016) and plant-based meat, which is constructed from proteins extracted from plants (Joshi & Kumar, 2015). In addition, fungi-based meat alternatives such as Quorn products (Wiebe, 2004) and insect-based meat products such as burger from Bugfoundation (Germany food company) (Ismail, Hwang, & Joo, 2020), have been launched in recent years.

3DFP can be utilized to develop personalized nutrition for people with special dietary necessities. Studies focused on personalization of food with 3DFP technology continue to be developed. For example, there is a concept project of Open Meals Team, called

Sushi Singularity, about a restaurant that produces personalized sushi planned to be opened in Tokyo. Its vision is producing sushi combined with biometrics to enable hyper-personalization based on biometric and genomic data. Personalized food can be utilized to fulfill nutrition needs of people with special dietary needs by using the selected ingredients (Varvara et al., 2021). For example, 3D food printing can provide a meal suitable for a person with chronic kidney disease who needs a meal with low potassium content (Burke et al., 2020). In addition, this technology can provide attractive food designs with proper form for people who have difficulty on chewing and swallowing. Similarly, Luo et al. (2017) highlighted that supplying proper nutrients, such as proteins, fibers, vitamins, etc. to elderly people might be an effective way to benefit from personalization feature of 3DFP. Furthermore, famine still remains being a problem in some countries and this technology could be valuable to improve food security. Studies show that food products could be enhanced in terms of nutrition by using different sources of nourishment, such as meat, lupine seeds, insects, and algae (Dankar et al., 2018, Zhao et al., 2020)

Additionally, children and teenagers are individuals with special dietary requirements such as vitamins, protein, minerals, and problems of rejection to these nutritious foods. Therefore, since 3DFP is applicable for acquiring food products in desired shape with improved nutritional ingredients, this could be a solution for creating attractive healthy snacks and, offering the nutritional requirements for everyone (Dick et al., 2019).

Moreover, there are some barriers on behalf of 3DFP to overcome before it reaches the end user. Dankar et al. (2018) explain these barriers in four categories. Firstly, there are no regulations regarding the manufacturing of 3D printed food that have been established yet, so, specific guidelines for particular foods, facility examinations, and staff training should be set (FDA, n.d.; Porter et al., 2015; Tran, 2016). Another important point should be taken into consideration for 3D printed food is most of them have a limited shelf life. On the other hand, one of the advantages of edible printing is the ability to create food items only hours before sale or consumption. With this perspective shelf life may not be an issue in food printing unlike traditionally and centrally manufactured items (Porter, Phipps, Szepkouski, & Abidi, 2015). In addition, material set requirement is one of the 3DFP barriers (Lipton et al., 2010). Not every type of food can be printed with current methods, there is a limited variety and quality of ingredients to be used. This limits the meals produced with the technology and

sectors the appliance may spread. Lastly, some meals require a further post printing step like baking, boiling, frying or freeze drying, and this may cause altered textural properties. (Sun, Zhou, Yan, Huang, & Lin, 2018).

2.1.3 Material requirements in food printing

Dick et al., (2019) expresses that there are three categories based on the printability of food ingredients: native printable food materials, non-native printable traditional food materials, and alternative ingredients (Figure 2.1). Natural printables have sufficient flow properties to be easily extruded from the nozzle without additional flow enhancers (Sun et al., 2015). On the other hand, non-native printable food materials require additional flow enhancers to facilitate finishing such as extrusion and baking (Sun et al., 2015). Alternative ingredients mentioned in Section 2.1.3 refer to new sources of functional ingredients used to customize nutrition, such as proteins and fibers acquired from insects, algae, fungi, bacteria (Sun et al., 2015).

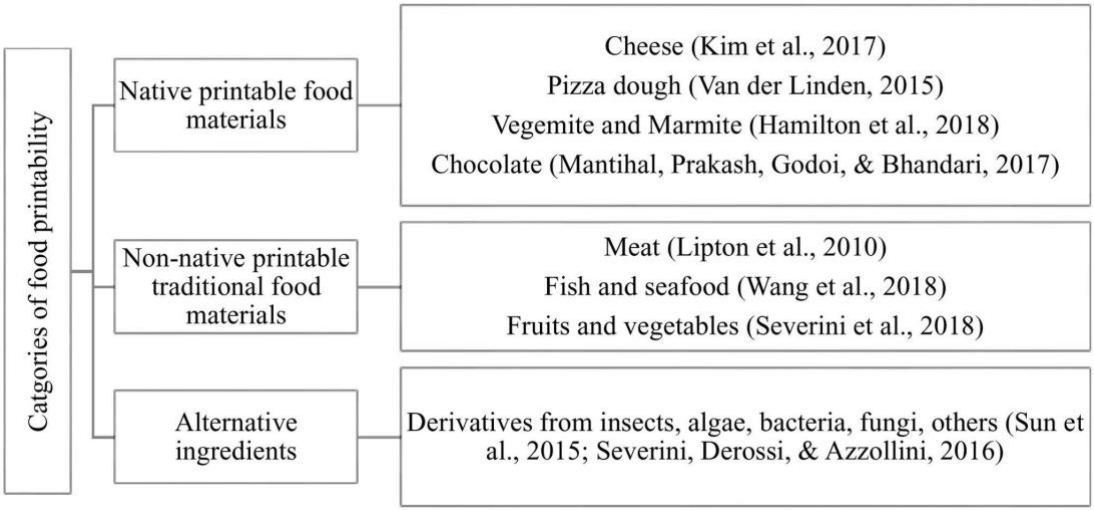


Figure 2.1 : Categories of food printability (Sun et al., 2015, Van der Linden, 2015, Dick et al., 2019).

Selecting materials suitable for 3D food printing and its application is challenging. Materials must meet three essential requirements to be used in 3DFP: printability, applicability, and suitability for post-processing (Godoi, Prakash, and Bhandari 2016; Nachal et al. 2019, Wang et al. 2021).

Printability refers to the ease of the material to be controlled and deposited by a 3D printer and preserving the shape after operation. Materials with good printability can be used to create complex structures. Printing materials should have some physicochemical, rheological (the flow of liquids which do not flow easily), and

mechanical properties, for different printing technologies requiring specific material properties (Liu et al. 2017). Applicability refers to the ability of the material to fulfill certain functions such as building complex geometric designs and structures. The feasibility of 3DFP depends on the properties of the supplied materials and the scalability of production (Nachal et al. 2019). Therefore, the applicability of materials determines the scope of 3DFP technology. Finally, post-process behavior refers to the suitability of a material for processing after printing. Although some foods can be consumed directly, some printed foods may need some form of cooking before eating (Nachal et al. 2019). Post-processing quality may affect appearance and taste of the food and user acceptance.

2.1.4 Future of the food printing technology

Studies on 3D food printers and efforts to apply them continue despite achieving safety, productivity, and economic feasibility remains an important issue. According to Lee (2021) the global 3DFP market is expected to grow to $525.6 million by 2023. As seen in Figure 2.2, the largest global market size of 3DFP service is commercial (43.5%) and it is followed by government (25.8%), hospital (20.8%), and household (9.9%) areas.

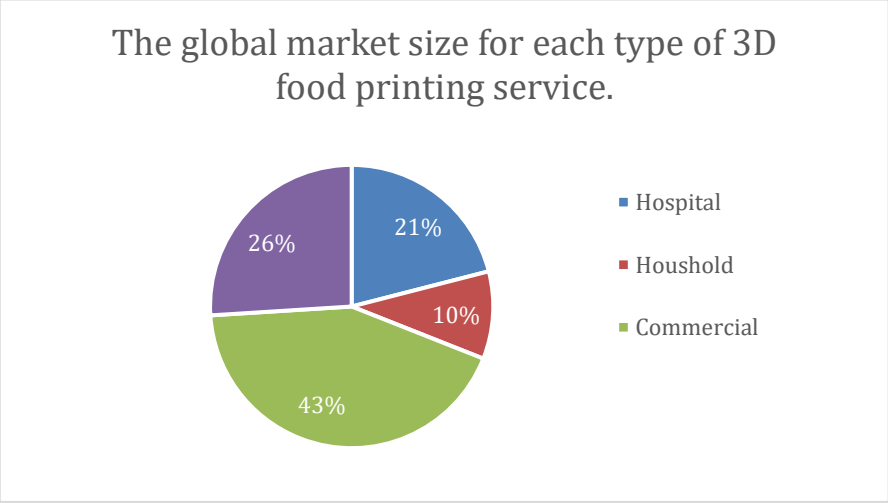


Figure 2.2 : Statistical data of the global market 3D food printing service, Lee (2021) (Adapted from 3D Bioprinting market size, share & trends analysis report by technology market analysis report, available online: https://www.grandviewresearch.com/indust).

Bioprinting is seen as a method that future studies are expected to focus on. Cultures and biological materials of living cells are deposited layer-by-layer. Mostly, inkjet, laser-assisted and micro-extrusion printing is used for these kinds of biological

materials (Teng et al., 2021). The researchers of the University of Missouri print strips of edible porcine tissue by applying 3D printing technology. According to Marga (2012), bio-printed meat will be accepted by vegetarians who choose not to eat meat for ethical reasons. At an affordable price, in the future this technology will benefit the masses that limit their meat consumption and populations that have problems accessing safe meat production. However, the biological printing of meat shows many disadvantages that must be overcome in connection with the long maturation processes to reach the meat to be consumed (Marga, 2012).

3D food printing examples have already appeared in some countries like printing pancakes in Holland. This can be seen as a sign that the popularity of 3D food printers is on the rise (Van Bommel, 2013). According to Tibbits (2013), 4D food printing expands business platforms of this technology and new business ideas to adapt to the current market trends by reducing capital requirements, saving time, reducing inventory space, and improving business efficiency. Similarly, Tibbits (2014) describes the fourth dimension as the transformation over time, emphasizing that printed structures are no longer simply static, dead objects; rather, they are programmable and can transform independently. Teng et al. (2021), defines 4D food printing technology as an extension of advanced 3D printing technology that allows food customization flexibility by adding desired features. Currently, printed food materials are limited to soy protein isolate, starch gels and hydrogel systems, which have external factors such as pH, water absorption, microwave, and temperature. Changes in the characteristics of the printed product, such as color, shape, nutrition, and flavor, are due to differences in material properties, internal structural design, and arrangement of food materials. Teng et al. (2021) stated that future developments regarding the link between internal structure and stimulation for 4D food printing technology should be investigated.

2.2 Food Design & 3D Food Printing

According to Dankar et al. (2018), the way how 3D food printers work has been studied from an engineering perspective, but what can be done creatively has not yet been explored. 3DFP technology has been dealt with by food scientists and mechanical engineers in the fields of technology development and materials, food production, quality, and techniques. Establishing the business model of the new technology can be

studied in the field of business sciences and because of the effects of social life and changed habits it is a case for social sciences. However, it is lacking in the literature to take this technology and application system from a design perspective. Food printing uses digital gastronomy techniques to manufacture food pieces with mass customization in shape, color, flavor, texture, and even nutritional value by integrating 3d printing technology. Digital gastronomy is to implement cooking process knowledge in food fabrication to encompass all aspects of gastronomy and go beyond taste in eating experiences (Sun et al., 2015). Combining 3D printing and digital gastronomy techniques can digitally visualize food manipulation, therefore creating a new space for novel food fabrication at an affordable price. 3DFP transforms customized food design in the form of a digital 3D model to a finished product in a layered structure (Levy et al., 2011). Food and design interact in several ways. Designing the food, the appliance, the system, and service for supplying the ingredients, design of applications to set printers and for modeling the food are examples of these ways.

Kauppi et al. (2019) states that design is more than merely an aesthetic or practical feature of marketing. Instead, they explain design interventions as strategic attempts to facilitate change and influence adoption and eating behaviors of users in their paper about edible insects' adoption. In addition, Zampollo (2016) defines Food Design simply as the link between food and design. She explains it as the design process that leads to innovation in products, services or systems for food and eating, from production, supply, storage and transportation to preparation, presentation, consumption, and disposal. She visualized the sub-categories as Figure 2.3 to show how these Food Design sub-disciplines intersect and intersect and how other disciplines inform and influence Food Design. The International Journal of Food Design is the first academic, peer-reviewed journal entirely devoted to food design research and practice. This journal is a platform for researchers and practitioners from various disciplines who contribute to the understanding of food design. As the journal's website explains, the editors are particularly interested in research that connects culinary arts, hospitality, food science, and culture from a variety of disciplines, including design theory, design education, design history, and industrial design.

3DFP and design interact with several points. As with every product, a printer's design

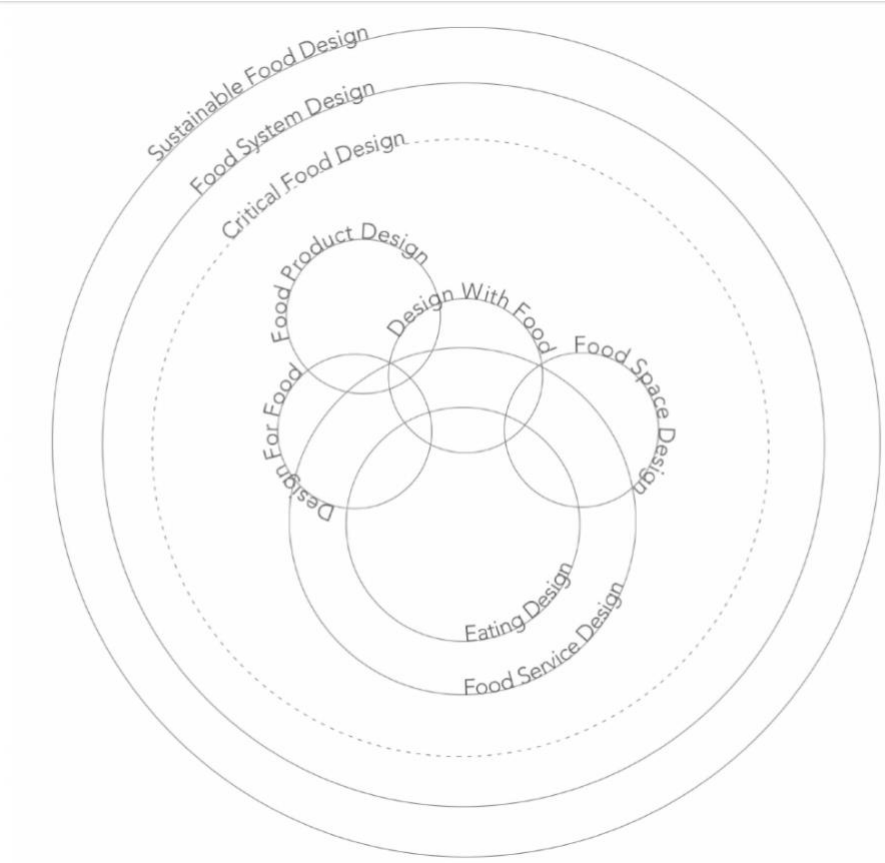


Figure 2.3: Categorization of food design by Francesca Zampollo (2016).

is important for usability, aesthetic, creating a meaning, affordability, availability, creating a lifestyle etc. Target group, technical characteristics of product, production and marketing parameters can limit the design. Another design related issue is the applications to be used with the product. Food printing is a good example for human computer interaction. Food printing requires some digital platforms and systems that need human interaction. It is necessary to select the food, define the recipe and design if necessary, and make data suitable for the printer. Even if these operations will not be done, it should be obtained from online platforms and this information should be transferred to the printer at any time. Another issue is to design this system. Service design is an important part of a food printer's usability and accessibility. Many issues, such as the user's ability in installing the hardware and software, using them, accessing ingredients should be handled as experience design independently from the development of the technology. Selling printers in business-to-consumer and business-to-business models are possible. These two business models may need different products and system design. Among all these design connections mentioned,

interactions between 3D food printing and design revealed in two directions in this study: design of food and design of 3D food printer.

2.2.1 Design of food

Food texture is one of the most important food properties for consumers' acceptance (Laureati et al., 2020). Texture is a key quality attribute used in the fresh and processed food industry to assess product quality and acceptability. (Chen & Opara, 2013)

Kohyama (2015) states that people enjoy eating food using multiple senses. Taste and odor are chemical senses that are perceived as flavor. The fundamental tactile, visual and auditory senses are categorized as physical senses, which are activated by physical stimuli. According to Kohyama, the sense of taste is used only in oral processing, but vision and smell are very important cues in "pre-oral processing." Foods that have good flavor and texture are preferred and consumed. As a result, design of food is a fundamental affecting factor to the intention of users to accept 3DFP technology.

Zampollo (2012) defines a food product as a product for food or with food. Design for food creates products made of non-food materials, and designed for the consumption, preparation and containing of food. Design with food creates products where the material itself is food, i.e., a product made of food. 3DFP involves both in the system. Printers, online platforms, and services are designed for food and also the end product itself is designed.

As mentioned before, other than the necessary equipment to get food printing, one of the parts of this system is the recipe of the meal. After preparing the materials contained in the food to be printed, the order, position, and quantity in which these materials should be printed are described in the system. These recipes are provided to users in some 3D food printer companies. However, with its widespread use, it is necessary that recipes be created and developed by sharing. This technology can help people to obtain food easily that they did not know before. One of the data that the person having the technology should send to the equipment is the description of the design of the meal.

The 3D model of the food can be created by the user as well as provided by online resources. However, for advanced and various options, the user may need to know how to model at some point. For this reason, there are 3D food printer brands that offer a design platform for the user to model. They present an easy interface to customers who

have no experience in modeling or 3D printing. For example, the PancakeBot (https://www.pancakebot.com/design-library/) provides an application for the user to design the pancake. However, in this case, it is very easy to present this service since the pancake is 2-dimensional. After the design and description, this model is converted to the printer language and sent to printing.

When we look at its applications, we see that chocolate and decoration printing is common in this subject. It can be said that there is such a density due to its lack of need for cooking, its suitability to various forms of testing, the fact that different and remarkable forms are regarded as value in the market and their feasibility as a business model. In addition, there are food printing works supported by Barilla pasta in a design competition. We can say that the reason for this is the foresighted work for the future. Open Meals (https://www.open-meals.com/) has been pursuing the digitization of food for years, making quite an impression with their Sushi Teleportation demonstration at SXSW in 2018.

2.2.2 Design of 3D food printer

In Mert's (2008) study, design is defined as a condition that must be met in order to persuade users to buy smart home appliances. She states that devices should “blend in” with the existing environment and should be unobtrusive. Attractive design, e.g., the new look promotes the fact that it's a new idea, a range of sizes for households of different sizes, including a small one-person unit, and the ability to integrate appliances into fitted kitchens are additional benefits that provide user acceptance.

Since 3D printers are developed under the leadership of technology and are developed with a focus on producing without causing mold costs, their appearance is in an industrial form. Mechanical features are prioritized and there are models developed with a focus on production and ease of use, considering the working systems. However, models with body design are also available in the market. For 3D printers, there are users who look for specific shell concerns according to the usage area. For example, in schools, shell and cover models are preferred to protect children from the nozzle part that makes hot production with a safety tool. When the product processed is food, new needs arise in terms of volume, appearance, cleanability and safety of the kitchen product. Form, color, mechanical properties, and the design of the product in many respects will affect the place of the product in the eyes of the users, the

perception of price, the perception of usability, and the area of use. In this study, no study was conducted with users on appliance design, but further research could be conducted on how product design will affect its acceptability in the home environment.

Zampollo (2016) mentions "Design for food" as a subcategory of food design. In this category designer not only works on products like pots and pans, plates, cutlery, and containers, but also from blenders, rice cookers, and toasters, to ovens, fridges, and 3D food printers; and packaging. In short, she defines them as products designed to prepare, cook, serve, contain, and transport food. In the designing process of a pan, designers work with chefs, to learn from them what they need and like in a pan. Zampollo (2016) states that there is an intersection between Food Product Design and Design For Food.

Another Food Design sub-discipline is Food Service Design. At the end of the 20th century designers understood the importance of including human beings to the process to predict behaviors to generate successful solutions required. User-centered design generated with this perspective and design started being more about the interaction between people and the object. This means that it is not only about designing a 3D food printer, but also more about designing the situation in which people buy and enjoy that technology and meal: with its environment, human interactions, tangible factors, and outcome. For example, 3D printers are used together in various interfaces for modeling, preparing the model for printing, and controlling printing. These can be internal or external interfaces. By using these interfaces, the user can design the food or choose the existing design and adapt it to himself. The user's 3D perception, education and modeling experience will affect their competence in this regard. The usability and design of these interfaces will affect the user's perspective on the product, the learning process, and the rate of feeling competent.

2.3 Technology Acceptance of 3D Food Printing

According to Varvara (2021), food texture is perceived by the human organism during a meal through a complex system of interconnected stimuli such as vision, hearing, touch and kinesthetics. The mechanisms involved in texture perception have been studied by considering these factors to create acceptable food products that can fulfill nutritional necessities (Derossi et al., 2018;Fahmy et al., 2021; Laureati et al., 2020;).

Briefly, food texture has an important impact on users' acceptance (Chen & Opara, 2013; Kohyama, 2015; Laureati et al., 2020).

Moreover, Kauppi et al. (2019) introduce the benefits and challenges of insect-eating and discuss the factors that are known to influence user acceptance, and categorize factors including adoption strategies into a framework that can be applied in future user studies. In addition, the article provides examples of design interventions to show how design can contribute as a strategy to support the general adoption of insect food by western user. Kauppi et al. (2019) state that there should be more sufficient source about user needs, experiences, behaviors, and goals to effectively stimulate their engagement with insect-based products.

In addition to alternative ingredients, 3DFP offers a new kind of kitchen experience to users. Although some users get used to 3D printing technology, its material is food like vegetables, dough, meat, and chocolate rather than plastic. This may cause friction to own an appliance that prints their daily meal in their home. Technology acceptance models are adapted to this study with the purpose of what kind of friction makes this adaptation process longer and how potential users feel about this new technology, and what is their belief about the 3DFP technology' future.

2.3.1 Theories and models of technology acceptance

Theories and models developed by different disciplines and used in predicting, explaining, and understanding the acceptance process of new products or technologies are explained in this section. Figure 2.4 represents the basic concepts of user acceptance models. The individual reactions and intention to use information technology reacts as the determinants of actual usage. In addition, actual usage in return affects the individual reactions of users. There are some models which emerged to examine determinants of acceptance of a technology from users. These are several models such as Technology Acceptance Model, Theory of Reasoned Action, combined TAM and TPB, Theory of Planned Behavior, Model of PC Utilization, Diffusion of Innovation, Motivational Model and Social Cognitive Theory. Some of these prominent models will be explained in the following sections.

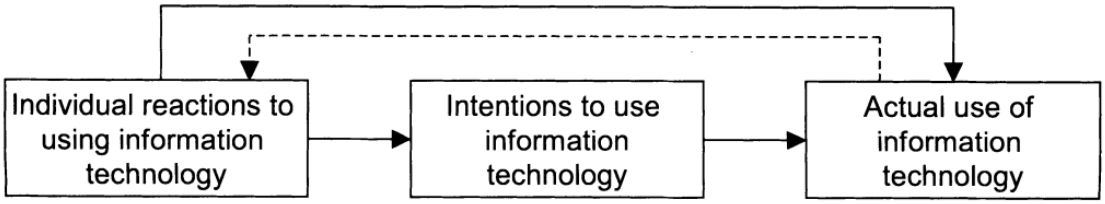


Figure 2.4 : Basic idea on which user acceptance models are based (Sapio et al., 2010).

Theory of Reasoned Action (TRA): This model focused on the field of user behavior. Predictions of user intentions and behaviors and how and in what situation the target user behavior changes are analyzed in this model. According to Venkatesh et al. (2003), "TRA posits that an individual's behavioral intention towards a specific behavior can be considered as a proxy of the behavior itself". Beliefs shape attitudes, and according to these beliefs, behavioral intentions which are instructions that direct people how to behave are formed. (Sheeran 2002). In summary, TRA model states that beliefs, attitudes and intentions are determinants of behaviors as seen in Figure 2.5 (Ajzen and Fishbein, 1984).

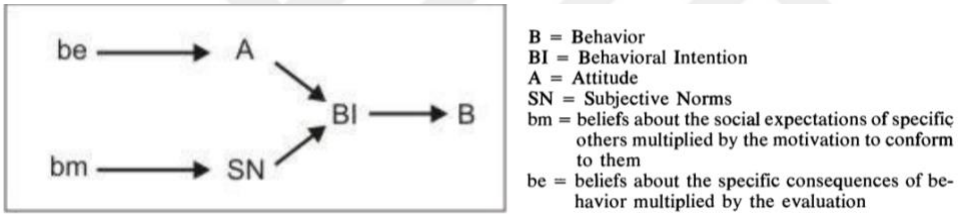


Figure 2.5 : TRA model of Fishbein and Ajzen (1984).

Theory of Planned Behavior (TPB): TPB has originated from the TRA. This model, proposed by Ajzen in 1985, aims to predict the reason why an individual would adopt a behavior. In this model, the perceived behavior control is defined as "perceived ease or difficulty of performing behavior" (Ajzen 1991, p. 188). As Figure 2.6 shows, behavioral intention is the key fact of TPB and the elements affecting the behavioral intention are specified as attitude toward the behavior, subjective norm, and perceived behavioral control.

Both TRA and TPB assume that individuals make a rational decision. As mentioned earlier, this is seen as their limitation.

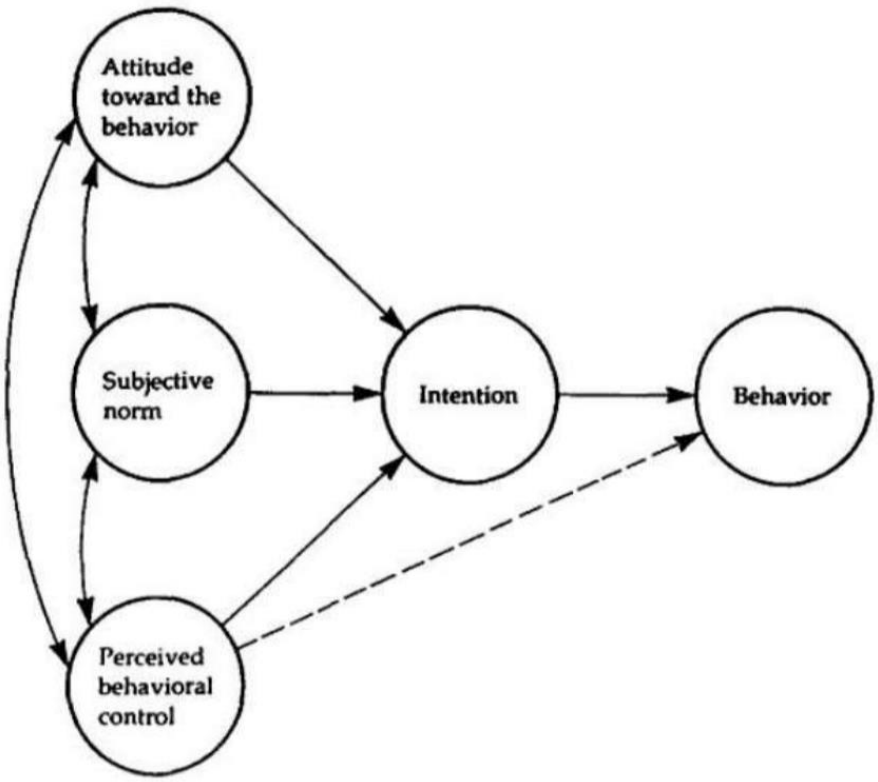


Figure 2.6 : Theory of planned behavior (Ajzen, 1991).

Technology acceptance model (TAM): TAM was proposed to analyze the factors affecting computer acceptance (Davis, 1989). TAM is a flexible theory considering the target user population and technology. The theory consists of two main governing factors as Perceived Usefulness and Perceived Ease of Use (Figure 2.7). Perceived usefulness is the subjective idea of the potential user will develop about the intended action when she/he uses the system. Perceived ease of use can be described as the effortlessness of the system in users' mind, and the user's perception of effortlessness may vary depending on the level of faith of the user about the system (Davis, 1989). As a result of Davis's (1989) studies; "… users are driven to adopt an application primarily because of the functions it performs for them, and secondarily for how easy or hard it is to get the system to perform these functions".

Unified theory of acceptance and use of technology (UTAUT): Recent work by Venkatesh et al. (2003) synthesizes existing models and proposes a comprehensive method; Unified Theory of Technology Acceptance and Use - UTAUT (Wu et al., 2007; Qingfei et al., 2008). The success of the model is its used content, which includes the structures and scale elements of previous technology acceptance models, including TAM.

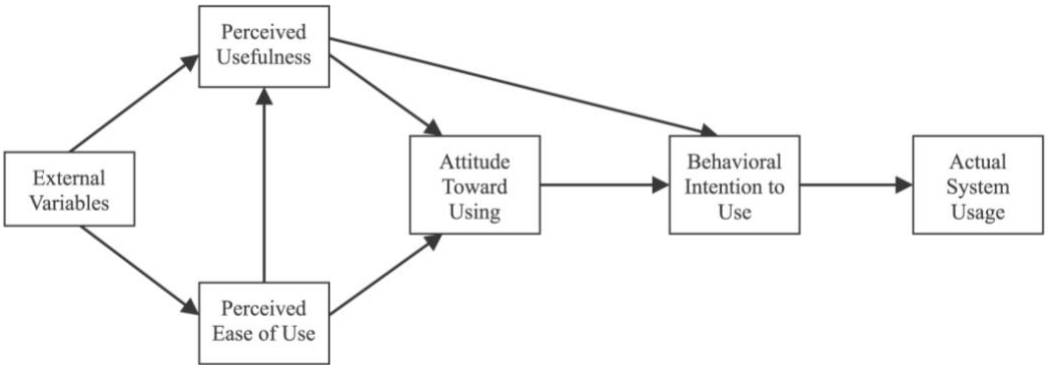


Figure 2.7 : Technology acceptance model (Davis et al., 1989).

Venkatesh and Morris (2003) compared the similarities and differences among the previous models which were used in the context of the information system, all of which had their origins in sociology, psychology, and communications. As seen in Figure 2.8, UTAUT identified four parameters of the acceptance of information systems. The significant constructs are effort expectancy, performance expectancy, social influence and facilitating conditions. Furthermore, four significant moderating variables were identified, gender, experience, age and voluntariness of use.

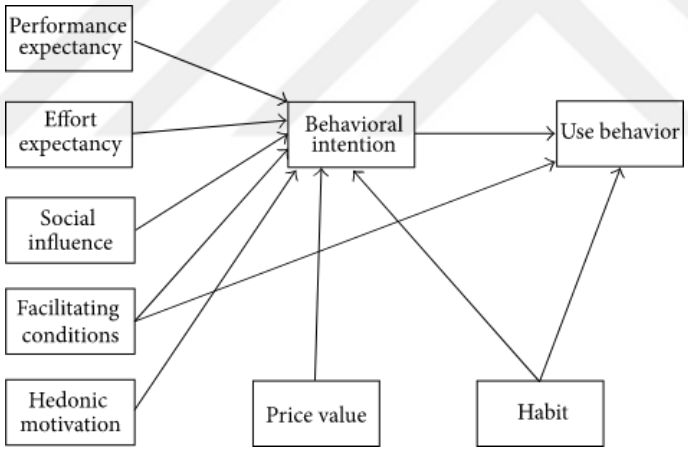


Figure 2.8 : UTAUT model (Vankatesh et al., 2003).

Unified theory of acceptance and use of technology 2 (UTAUT2): UTAUT has been applied to many studies about different technologies in both organizational and non-organizational settings. However, Vankatesh et al. (2012) state that there is a need for a systematic investigation and theorizing of the related factors that would apply to a consumer technology use context. For this reason, UTAUT2 is designed which is based on general outlines of the UTAUT. It is tailored to consumer use context as seen in Figure 2.9. However, in UTAUT2 variables such as age, gender, and experience are added to the frame. Moreover, hedonic motivation, price value and habit have been added as constructs. Different from UTAUT, voluntariness has been dropped as a

variable, to make UTAUT applicable in the context of voluntary behavior. This model has been conducted to self-technology service, adaption of smart mobile device, healthcare industry, learning management software acceptance process and other technology issues (Anatoliy et al., 2012).

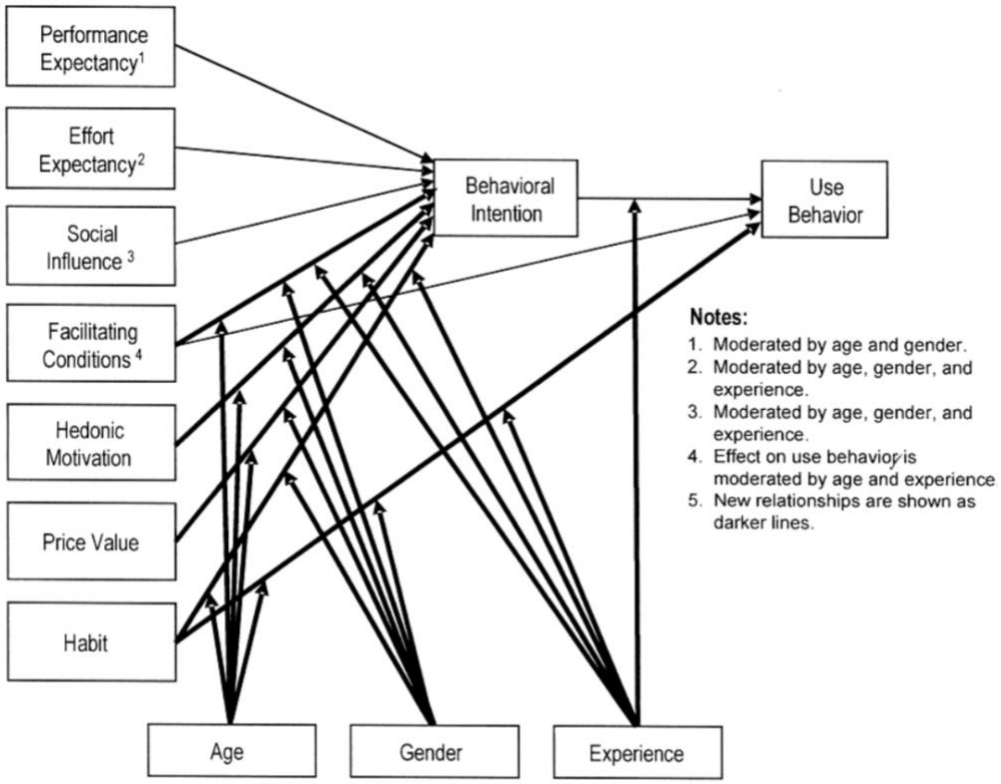


Figure 2.9 : UTAUT2 research model (Vankatesh et al., 2012).

2.3.2 Adapted version of UTAUT2 used in this research

UTAUT2 model is used as a theoretical driver for this study. However, an adapted version of UTAUT2 (Figure 2.10) will be used to suit the context of the study and to achieve its aim. Similar to UTAUT2, in this research Performance expectancy, Social Influence, Facilitating Conditions, Effort Expectancy and Behavioral Intention are independents of use behavior. Moreover, hedonistic motivation and trust are determined as dimensions to examine how users perceive 3DFP technology. However, age, gender, voluntariness, and experience are excluded. Venkatesh et al. (2012) do not consider the role of habit in the current research model. This was since customers should have a wealth of experience using this type of technology to examine the role of habituation. As an external factor, Trust has been included as an extension to the UTAUT2 because the product is proposed to the food industry whose users are

profoundly sensitive about health and nutrients. In this study, based on the general construct of UTAUT2, determinants of the method will be explained in the next sections. The research approached technology acceptance issue for 3DFP in terms of two dimensions: the food produced and the appliance that was printed. The acceptability and barriers for users in both aspects were examined.

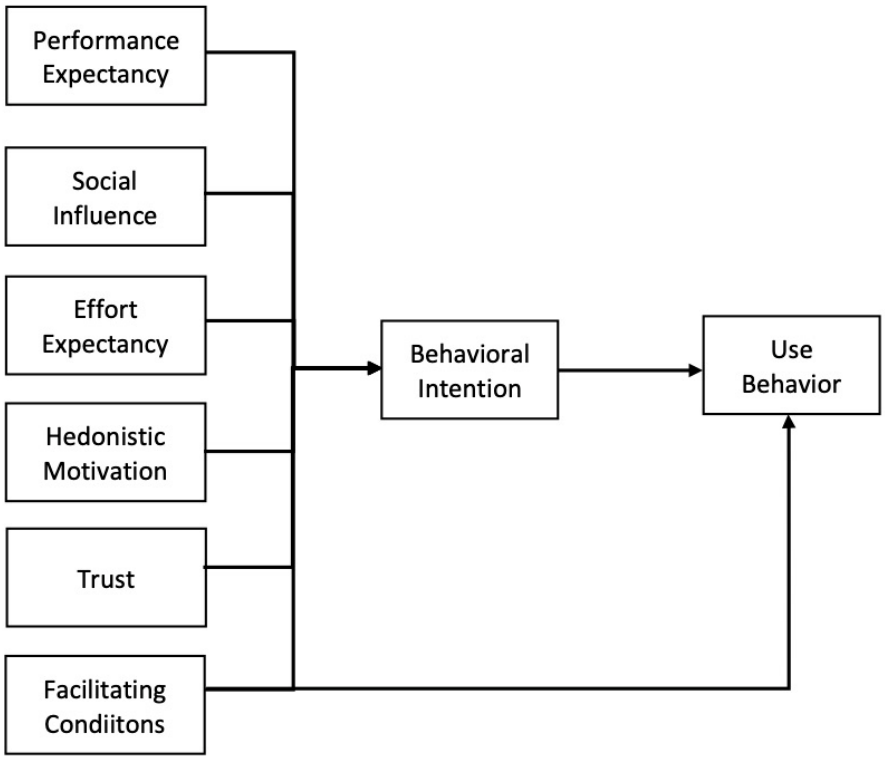


Figure 2.10 : Adapted version of UTAUT2 used in this research.

Performance expectancy (*PE*): PE can be defined as "the degree to which an individual believes that applying technology will help him achieve gains in job performance" (Venkatesh et al., 2003). If customers think that this technology is more advantageous and useful in their daily lives, they will be more to use and accept new technology (Alalwan, Dwivedi, & Williams, 2016; Davis et al., 1989; Venkatesh et al., 2003)

Social Influence (*SI*): In the UTAUT model, social influence is conceptualized as "the degree to which an individual perceives those significant others believe they should implement the new system" (Vencatesh et al., 2003). The information and encouragement provided by the users' social circle can have an impact on intention towards technology as well as awareness (Alalwan, Dwivedi, & Williams, 2016; Alalwan, Rana et al., 2015).

Facilitating Conditions (*FC*): Definition of facilitating conditions is “the degree to which an individual believes that an institutional and technical infrastructure exists to support the use of the system” in UTAUT model (Venkateshet al., 2003). Indeed, using 3DFP technology requires certain skills, resources, and technical background. Although it varies according to the design and resources of the product, the ability to use the internet and interface is required. In addition, some culinary skills and knowledge of 3D modeling may also be required to use certain products or to produce personalized foods.

Effort Expectancy (*EE*): According to Venkatesh et al. (2003) EE is “the scope of convenience associated with the use of a system”. Davis et al. (1989) states that users' intention to accept a technology can be predicted by how easy and less effort it is for users to use it and how positively valued the system. Therefore, due to the special nature of food printing, which requires a certain level of knowledge and skill, expectation of effort can play a crucial role in determining customers' intention to use this technology.

Hedonistic Motivation (*HM*): Venkatesh et al. (2012) states that hedonic motivation and intention to use a technology affects each other directly. Venkatesh et al. (2012), along with extrinsic benefits (i.e., efficiency, usefulness, performance expectancy) in the same model, were examined under the concept of hedonic motivation (Venkatesh et al., 2012). In fact, it has been suggested that intrinsic benefits may have an important role in increasing individuals' intention to adopt emerging systems (i.e., van der Heijden, 2004). This role has greater effect in the case of hedonic systems that includes creativity and uniqueness. (Alalwan et al., 2014; Brown and Venkatesh, 2005; Püschel et al., 2010; van der Heijden, 2004)

Trust (*T*): Trust is often proposed by researchers as an important factor influencing (or influenced by) perceived usefulness (PU) and perceived ease of use (PEU), especially in the e-commerce context. According to Gefen, Karahanna, and Straub's (2003) study, trust, user trust can be defined as the accumulation of user beliefs of honesty, helpfulness, and ability that can increase user willingness. Trust has included technology acceptance studies in the mobile banking and finance sector (Alalwan et al., 2017). In line with Zhou's (2011) study examining the factors affecting users' antecedent trust in mobile banking, it was seen as an important factor in determining users' willingness to use mobile banking. In the food sector there are some papers in

literature about trust and technology acceptance. According to Maijer et al. (2020) perceived benefits and risks may be personal and directly related to product quality, price, or health, but may also relate to broader social issues such as sustainability, occupational safety, public health, or ethics in food production. Since user acceptance of new technologies is based on perception of risks and benefits, informing users about benefits should increase acceptance of processing and similarly awareness of risks should reduce acceptability.

In this study, trust was added to the method as a factor to evaluate the acceptability of 3D food printing technology, which is directly related to health and food.

Behavioral Intention (*BI*): Studies have indicated that behavioral intention has an influential role in shaping the use and acceptance of new systems (Ajzen, 1991; Venkatesh et al., 2003, 2012). Behavioral intention refers to the degree to which a person formulates consciously. It is the plan of users to perform or not perform a certain behavior in the future (Aarts et al., 1998). Behavioral intent has often been measured as users' willingness to repurchase a product from a company and to support it by talking about the company positively (Webb et al., 2007). Many previous studies have proven that behavioral intention plays an important role in actual behavior (Burke, 2002).

3. METHOD

Technology acceptance models applied with only quantitative research methods in many examples. However, Wu (2011) explains the limitations of using only the quantitative method in technology acceptance study in three perspectives. First, all data collected from surveys is self-reported and therefore prone to some well-known biases regarding acceptance, social desirability, and non-responsiveness. Self-reported intention to use may not lead to actual use behavior. Second, quantitative data analysis generally follows the principle of data reduction, using statistical techniques that reduce complex and interdependent human-technology interactions to measurable, linear, and deterministic relationships. Third, closed survey tools are inflexible, which can cause the researcher to miss unexpected but potentially important new discoveries.

Mixed model research involves mixing qualitative and quantitative projects at multiple stages of the study (questions, research methods, data collection and data analysis, and the process of interpretation or inference) (Teddlie & Tashakkori, 2003). A researcher conducts surveys of a large group of people and conducts in-depth interviews with a subsample of these individuals to try to find general trends in the population and provide more detail on unexpected findings that may arise. Mixed methods research is not just about conducting two separate sets of quantitative and qualitative research. Studies and their findings should somehow follow a logic of integration (Creswell & Tashakkori, 2007, cited by Wu, 2011). The researcher collects data sequentially or simultaneously. Sequential application can be explanatory or exploratory (Creswell, 2002, cited by Teddlie & Tashakkori, 2003). In descriptive sequential research, the researcher collects quantitative data and then qualitative data to help explain or refine the quantitative results. In this study, data collected using the mixed method, a survey to collect data from large-scale communities, and a semi-structured interview to gather insights about the same dimensions on the questionnaire were conducted.

3.1 Data Collection

The extended Unified Theory of Acceptance and Use of Technology (UTAUT2) is proposed to clarify the technology acceptance from the user perspective. Therefore, it has been found as the most suitable model covering factors determining users' intention and adoption of 3D food printing. Conceptual model of this study proposed by using its main determinants: performance expectancy (PE), effort expectancy (EE), social influence (SI), hedonic motivation (HM) and facilitating conditions (FC). These are determined as direct determinants of users' intention to accept 3D food printing technology. As in the model of Venkatesh et al. (2012) behavioral intention (BI) and facilitating conditions (FC) were conducted as main predictors of use behavior. The current research model does not consider the role of habit, age, and gender. In order to examine the role of habit, participants should have long time experience in using such technology unlike in this study.

3.2 Survey Design

Survey questions (Figure A.1) are grouped as four parts. The first part is designed for getting demographic information of participants. This part includes two questions for demographic information as age and occupation. These questions are asked to see whether participants concentrate on the same age range or occupation.

The second part aims to explore their relationship with the kitchen, food technology and cooking generally. Habits on food preparation are examined with 7 questions in this part. For the third part video prototyping has been made. By using visual materials (Figure C.3) like video parts, graphics, and illustrations an overall explanation for 3D food printers, its potential benefits and use areas, 3D food printing process, its potential ingredients and some examples of foods which had been produced by printers were presented to participants. After the embedded video two source video links have been added to the survey for participants. The last part consists of 22 Likert scale questions which have been generated according to the UTAUT model. Five options which are 1 to 5 points for each Likert question have been presented to participants.

As a last question additional opinions, comments, questions and suggestions were asked as an open-ended question. Finally, their email addresses were asked to make

contact to invite them to interview as a following section of the study with their voluntariness.

Google Forms application has been used to generate this survey. It was generated, distributed, and answered online. The survey was disseminated by using social media and online communication platforms; Linkedin, Whatsapp.

129 participants have answered the survey from different ages and occupations. The language of the survey is Turkish which is the mother language of all participants.

As seen in the pie chart (Figure 3.1) most of the participants, 81,4%, are in the age range of 25-40. The following ranges are 18-24 with 10,9% and 41-56 with 7%.

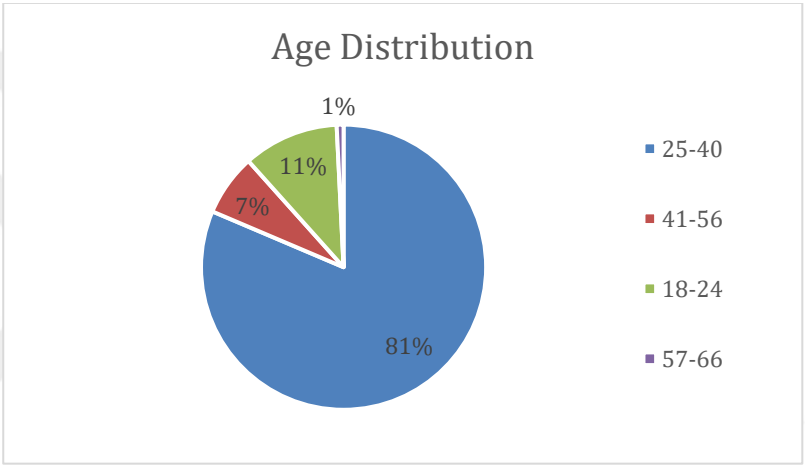


Figure 3.1 : Age distribution of survey participants.

The pie chart (Figure 3.2) shows that 58,1% of the participants state they live with their family and in the following ratio 25,6% of the participants live alone. In addition, 11,6% of the participants live in a shared home which means they have home mates.

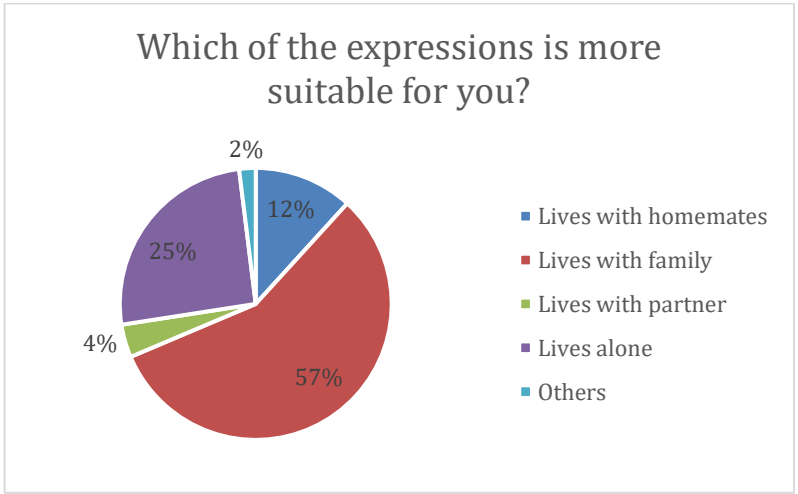


Figure 3.2 : Graphic showing who participants live with at home.

In this question participants are allowed to select multiple answers. As in Figure 3.3, 90 of the participants assume cooking in their home. 37 of them say that their parents make food and followingly 20 of participants state that their partner cooks.

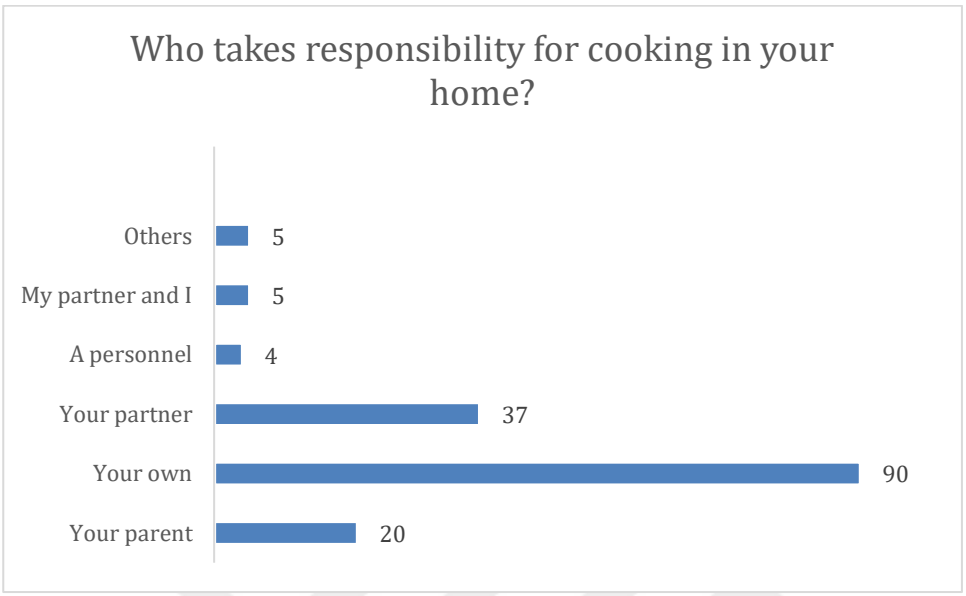


Figure 3.3 : The graph shows distribution of cooking responsibility in home.

3.3 Semi Structured Interview

Participants of the interview were selected from volunteers who wrote an email address to the survey. A meeting with participants has been scheduled. Their kitchen photo was also asked in this conversation to be presented in the meeting. On the day of the interview a reminder message was sent to check availability. Meetings have been carried out via Zoom, an online video chat application. Zoom has become a popular application since the Coronavirus emerged. All the participants have used this platform before. So, they did not have a problem with how to use the application or how to join the conversation.

The interview schedule was based on the previous survey. The questions (Figure B.2) were designed to capture attendees' views, perspectives, experiences on technological acceptance of 3D food printers and 3D printed food. These were supplemented with additional questions concerning attendees' relationship with the kitchen and 3D printing technology. Eight questions were included in the schedule to learn their cooking habits, current experience, and situation of their knowledge about 3DFP. After the first six questions an explanatory video (Figure C.3) was watched and additional information about the technology and its benefits added to this section. Then a few

questions for each parameter of technology acceptance model have been asked to participants. For each parameter, questions have been included to learn perspectives of potential users on both the food and the printer. When necessary, additional questions were added to the study to clarify participants' responses and to provide a detailed account of their opinions. All interviews were conducted by the researcher, and each lasted approximately 40 minutes. Audio recording has started with participants' permission.

3.4 Data Analysis

Satu and Kyngas (2008) stated that content analysis is a method that can be used with both qualitative and quantitative data; and can be used inductively or deductively. The researcher determines the purpose of the study and chooses which one to use. Lauri and Kyngas (2005) suggest the inductive approach if there are not enough current information about the phenomenon. According to Kynga¨s & Vanhanen (1999), deductive content analysis is used when the analysis structure is operationalized based on prior knowledge and the purpose of the study is theory testing.

Categories are parts of the research that can be called the essence of the research used as analysis tools that form the building blocks of the theory to be developed. According to Udo (2019), there are various types of categories in the literature. One of them is theoretical categories, subtypes of analytical categories that refer to an existing theory. There are three basic ways to develop categories: concept-driven (deductive), data-driven (inductive), and concept-driven and data-driven mixing (Udo, 2019). In the concept-oriented approach where analysis is made in this research, the categories are derived from a theory, literature, or research question.

For the content analysis, firstly, the recordings of the interviews were categorized according to theory driven approach. In this study, the research was carried out in two stages. There were dimensions adapted from the UTAUT2 model in both the questionnaire and the interview. Graphical representations of user's tendency were used to analyze the survey's findings descriptively. These projections are provided by the Google Forms application. These graphs are analyzed by density and correlated and compared with the answers gathered in the interview. For analysis, the data collected during the interview were categorized according to dimensions. Parts that

were repeated or considered important by the participants were highlighted. Then, the graphs were supported or compared with the quotations during the analysis.

4. FINDINGS

The results of the research will be analyzed under the following headings. The survey results will be compared with the answers to the questions prepared about the relevant factor in the interview. In addition, the results of the interview will be categorized as appliance and food, and the views of the participants will be evaluated in the relevant factor from two sides. Thus, the reasons for the answers of the survey, the hunch and thoughts of the users will be conveyed in two ways, focused on food and appliances.

4.1 Facilitating Conditions

When we look at the results of the survey, there is almost a similar distribution between ranks, 17,1% strongly disagree with "I have necessary information to use a 3D food printer" while 14% strongly agree with this statement (Figure 4.1). Moreover, 22,5% of them disagree and 20,2% is the rate of the participants who state they agree with the statement. There is a concentration to "either agree or disagree" in the evaluation of whether they have the necessary information to use a 3D food printer (3DFP). This finding coincides with the statements in the answers to the related questions in the interview questions that one cannot give a definite answer without using the appliance. For all the interview participants, the food printer is a technology that they have not yet encountered and used. Although some of them have seen or used a 3D printer and even own it, at least the preparation of the contents and the food printing process is not clear for them. In summary, participants have question marks especially about the form, taste, nutritiveness of the food to be produced.

As the graph shows (Figure 4.2), many participants think that they have and can use a device such as a computer, tablet or phone, which is necessary to use 3DFP. That is not surprising as the participants have already answered a survey that has been spread online. Particularly those who have experience on the 3D modeling program or have used a 3D printer before, trust themselves to be able to grasp the use quickly.

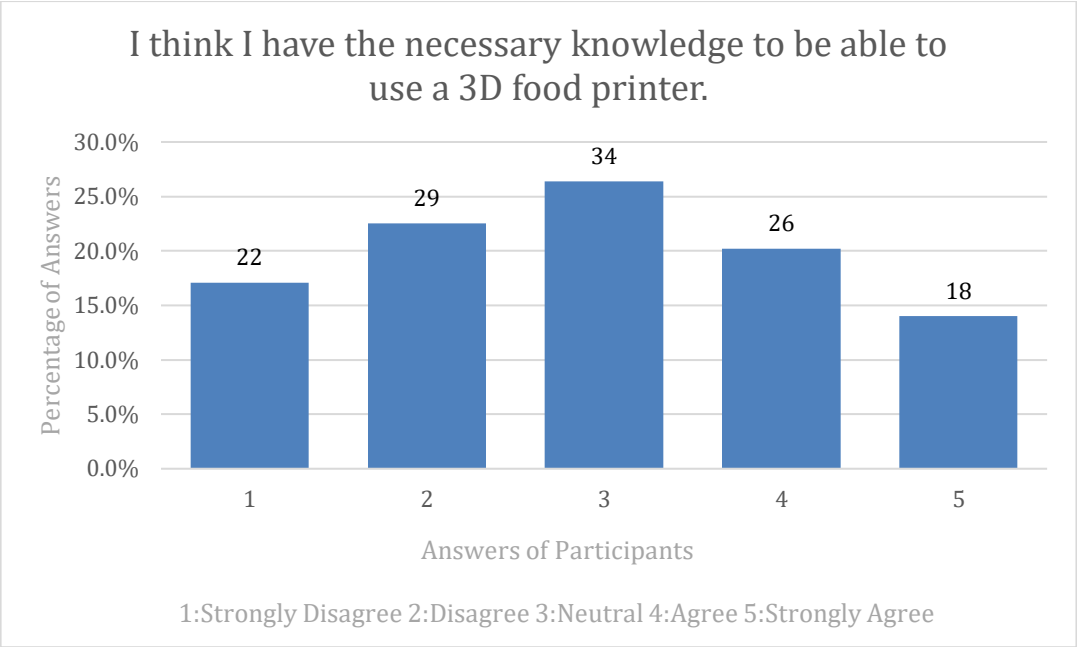


Figure 4.1 : A bar graph showing necessary knowledge to use a 3D food printer.

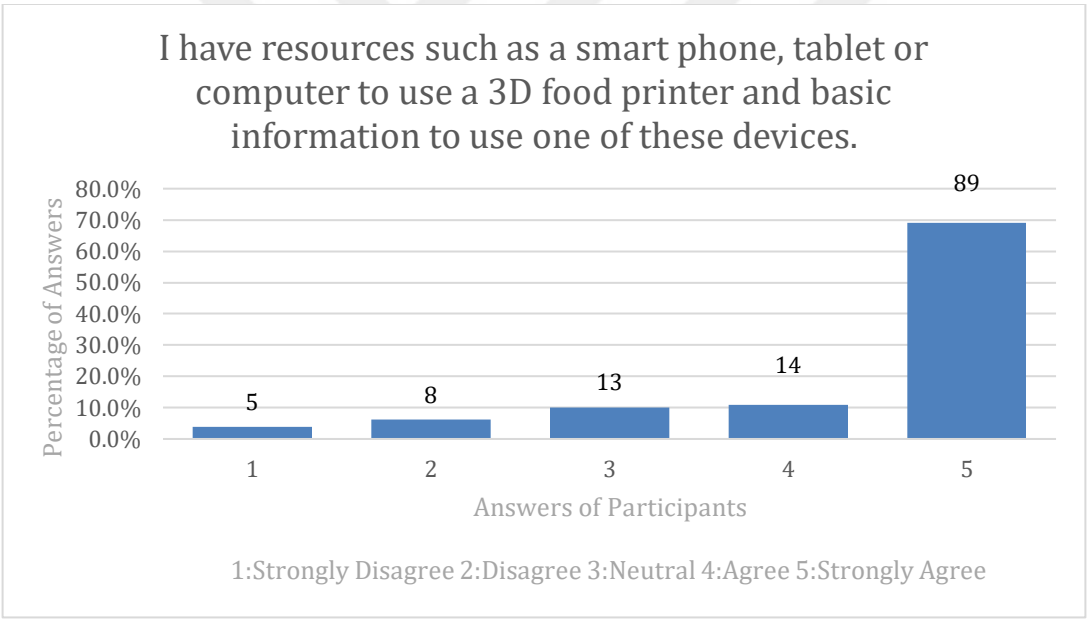


Figure 4.2 : A bar graph showing resources to use 3D food printer.

As seen in the graph (Figure 4.3), 48% of the participants do not favor the idea of starting to use a new product for themselves without a guide such as a user manual. Participant's rate who neither agree nor disagree to "I can start using food printing without guidance" is 24%.

It can be said that those who have received professional training or have experience in modeling or similar technologies consider themselves more competent in using food printers. However, despite her lack of experience, P6 says "I think I have the necessary

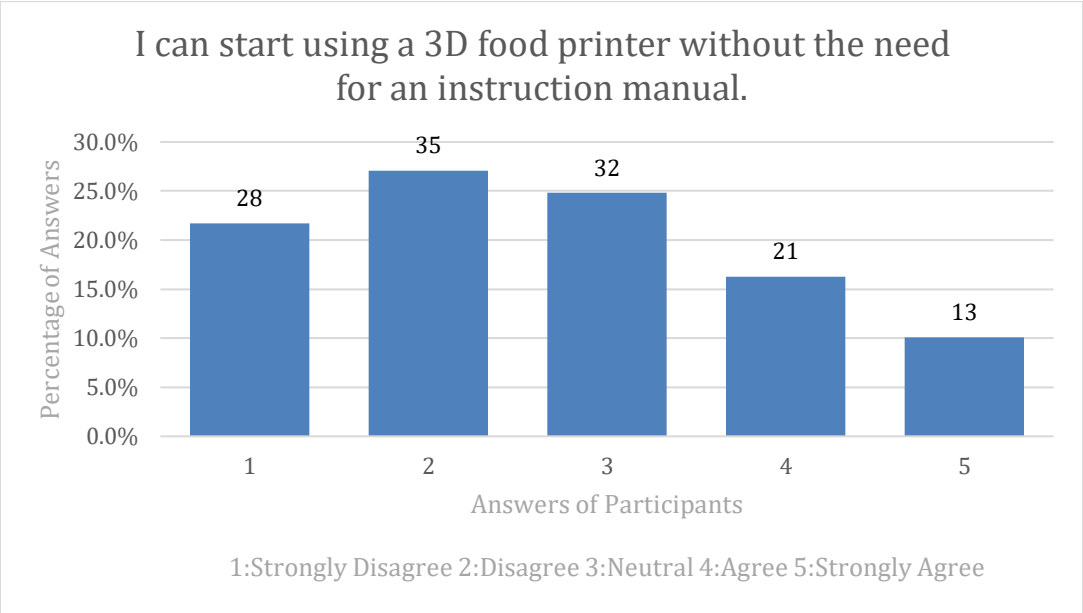


Figure 4.1 : A bar graph showing need of instruction to use 3D food printer.

knowledge. I may need the user manual from time to time. We can handle this as we are already in the age of technology." She thinks she can use it on her own, even if she needs to be directed rarely. In this statement, the participant states that we are in a period where we encounter many new technologies every day. In addition, although they do not know modeling, there are users who think that they will learn to use the product with supports such as instructions and booklets when they buy it. For example, P8 says "If someone gives a directive, I can use it. I can't code or model, but if they give me a user manual booklet, I will learn and use it. Modeling etc. is not my field of interest." However, the same person states that people's reactions and financial situation may prevent them from using this product. In addition, many participants have questions about accessing cartridges, preparing, or finding ingredients.

Among the responses from the participants, there are also those who are worried because they do not know what to do when the appliance breaks down, whom to contact or how to fix it themselves. P5, who is from generation Z, worries about that and says "My concern depends on what I will need. What will I do if it doesn't work? Who will I apply to repair it? How can I fix it myself?"

P4 who had culinary training said, "I don't know how to design, I can't design in 3D." says. It can be said that although the participant has a good command of the cooking process, he needs support regarding modeling and appliance use. On the contrary, P3

is an experienced user of 3D printers but has concerns on preparation ingredients and differences of food printing. He explains that:

> "I have no barriers to using it. Since I use a 3D printer, I am in control of the process. But I would like to learn the material well. What will I put in it? Just serving the food in a standard container. It can be a short promotional video or a booklet before it."

In addition, P2 whose husband and herself can do 3D modeling and own a 3D printing machine considers herself lucky to be able to use this appliance. She says;

> "I can bake what is printed in the kitchen in the oven. I also have kitchen utensils, but it should be explained in an enlightening way that you can get the materials from here, that is how the appliance is cleaned. When I first bought it If I am using a product for the first time, I read the user manual. If I've used it before, I wouldn't look if I'm familiar with it. For example, when I bought a food processor, I read the manual. I will definitely check the manual for this product. Maybe I'll watch some videos."

In addition to the user manual, the demand for video narration content stands out among the participants.

Although there was no specific question about price in the survey, many participants during the interview stated that they thought that the price of the 3D food printer would not be suitable for their budget when it first came out, but they could buy it after it became widespread, in response to various questions. P1 explains his concerns on using the appliance as "Access to the cartridges and the price may prevent me from using them in their current form."

The participants were asked about the obstacles that prevent the consumption of food coming out of this appliance, it was seen that they were open and willing to try, they had the necessary kitchen skills, and it was learned that the tools could be used with the appliance. However, they stated that there are other obstacles in front of them to buy or use. Participants 2, 4, 7 and 10 said that they did not know exactly what the requirements were. There were participants who asked questions about the requirements, could not clarify their opinion, or answer conditional because they could not predict the process without using it clearly. P10 says, "I can't say anything until I try, I want to try it first. But I'm open to trying. The taste should convince me before I buy it." She states her bias on the ready to use supplied ingredient:

> "I can buy the ingredients, but what comes out of the industrially produced content is important. Let's say I threw broccoli in it, I know the nutritive value. It's thought-provoking to put the

> mass-produced content and eat the printout. It is more convenient to prepare it with the product at home and eat the printout but taking the content from outside is confusing for me."

Although P9 doesn't see his current ability and knowledge to use the product enough, he has self-reliance to learn necessary skills. "Since I know how to use a printer to print objects, I think I will be able to adapt to food. I can also learn to prepare cartridges as ingredients."

P4 says "I don't know how to make ingredients either. I am dependent on the manufacturer of the appliance. But if we can do it with a simple blender, why not? If there is a recipe, I can make it myself." says. He also mentions possible concerns:

> "If I were a normal person, I would keep a distance from these. But I also know molecular cuisine and I consume it. It is necessary to look at the ingredients and print out rather than the machine. There is agar agar, for example, binding, I know it is herbal. But for someone who does not know it is strange."

P6 who is a dietitian looks from another perspective to food supply and expresses herself:

> "This was my first thought when I first heard of this appliance. We may be biased when it comes to 3-dimensional food, but after watching the video, I see that we have a recipe, we add the nutrients, and it gives us the product in the model we want. We can observe the process. I don't mind if we get what we put in. I would pay attention to the contents of the cartridge I supply from outside. I would read the contents of the cartridge and I don't want to use it if there is anything troublesome."

4.2 Social Influence

47.3% of the survey participants stated that they would be welcomed positively by the people around them when they used a 3D food printer (Figure 4.4). Although this rate is fairly higher than those who think that they will not respond positively (24.8%), 27.9% of the participants gave the answer neither agree nor disagree to this question intensively.

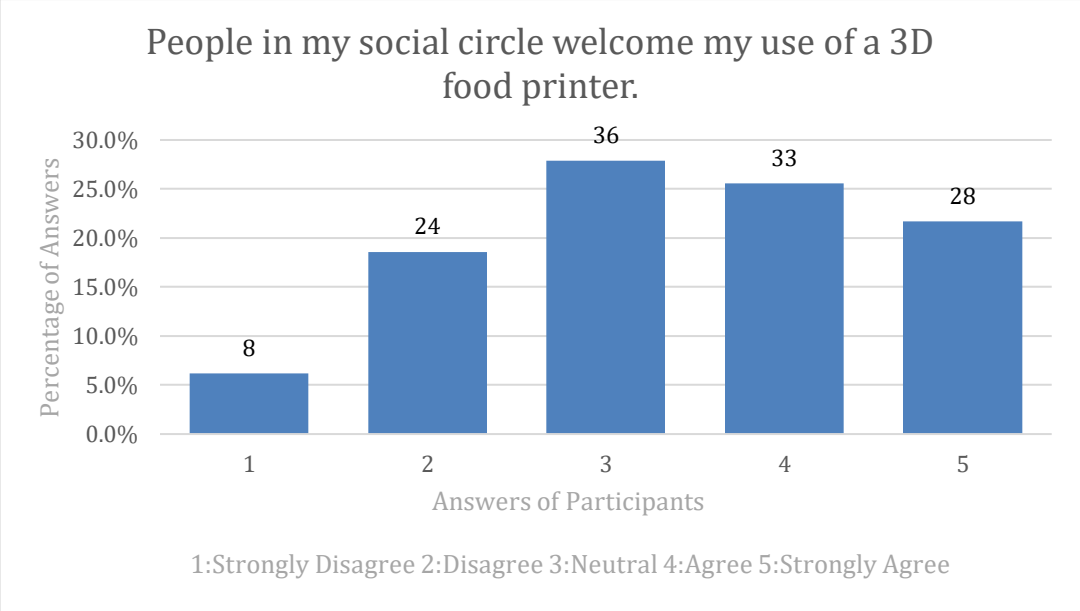


Figure 4.4 : A bar graph showing social circle attitude to use of 3D food printer.

As seen in Figure 4.5, those who agree with the statement "I will be a pioneer in promoting this technology in my social circle to use a 3D food printer" correspond to 35.7% of the participants. Moreover, 30.2% of the participants say they absolutely agree. Only 16.3% of the participants rejected the statement by saying that they do not agree and strongly disagree.

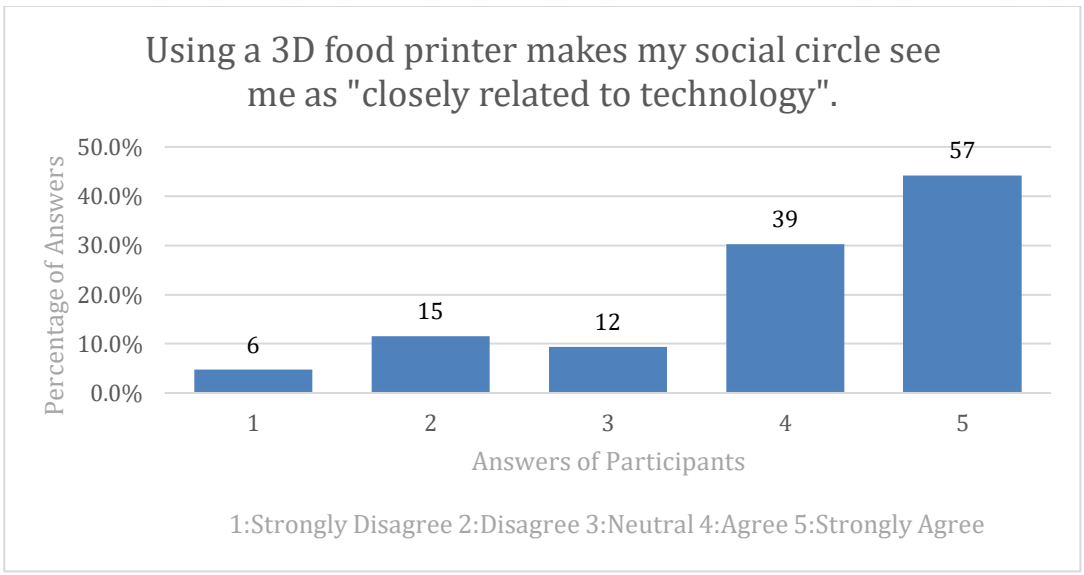


Figure 4.2 : A bar graph showing being pioneer for recognition of 3D food printer.

Most of the participants, 74,6% as seen in the graph (Figure 4.6), think that they would be seen as closely related with technology when they use 3DFP.

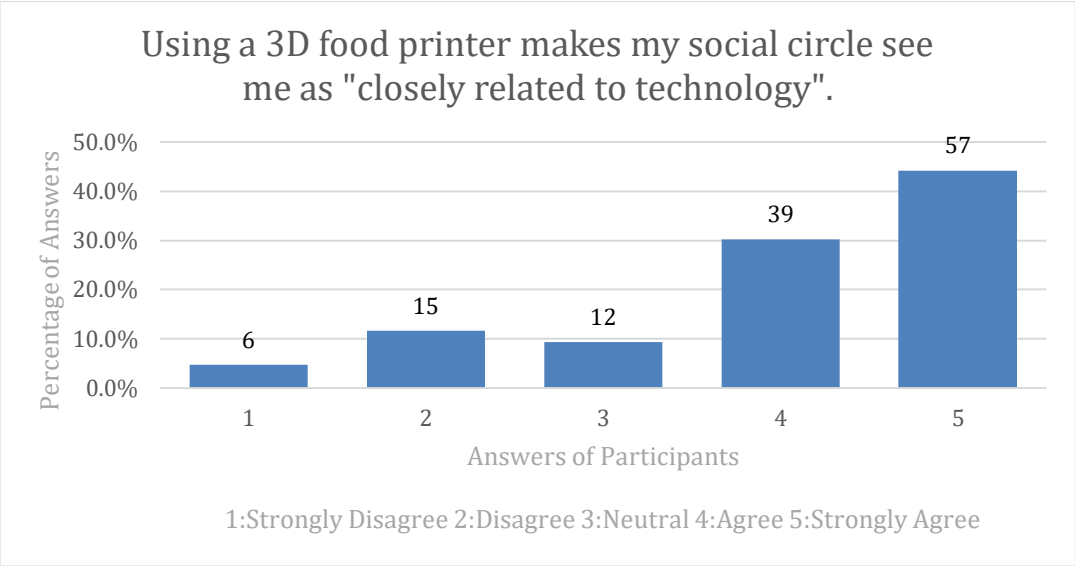


Figure 4.3 : A bar graph showing social circle attitude regarding its relationship with technology.

Only 5.4% of the 129 participants think that using a 3D food printer will negatively affect their social relations (Figure 4.7). By a large margin, participants agree that it will not adversely affect them. 89.2% of the respondents who gave the answer strongly agree and agree.

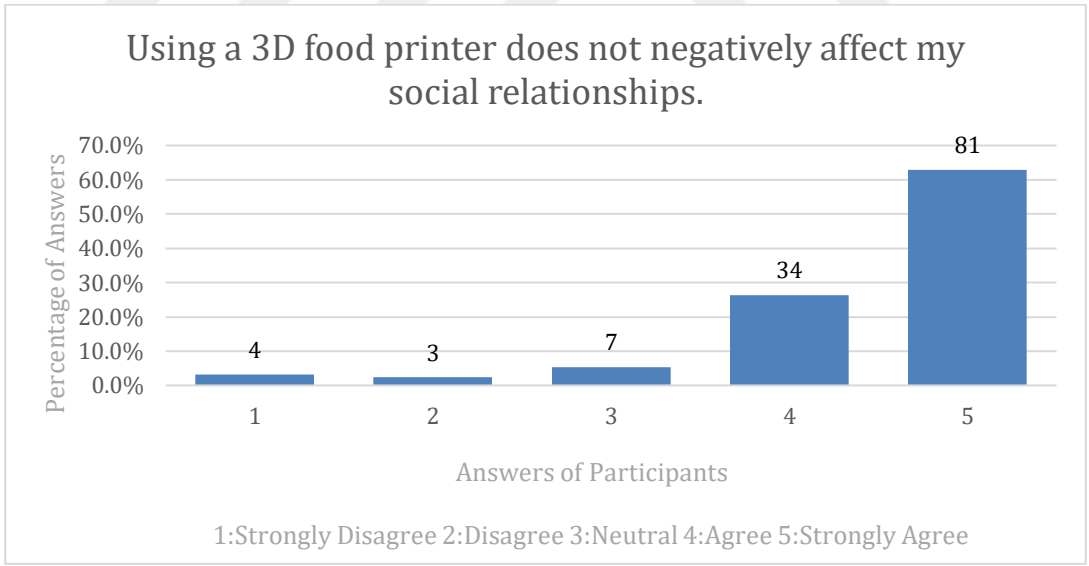


Figure 4.4 : A bar graph showing the effects of 3D food printing in the social circle.

In the interview there are some participants who say that they can be found strange by some people around them. On the contrary some of them claim that their social circle will accept them easily. For instance, P3 states that some of the people around it will be prejudiced against the food produced with a 3D food printer:

> "They do not look very warm. It is not welcome in my family. They say that I eat dirty food." P4, on the other hand, exemplifies the reactions of those around him who are not open to innovation, "Are you weird? Is it normal?".

He says he can be excluded from his environment. On the other hand, P6 does not think that the people around her will react negatively because he will associate it with her profession. She says "I don't think they will react negatively. They may find it strange the first time they see it. They don't think negatively about my use because I work on nutrition." P7 reveals her expectation as: “They may find my use strange at first, but they say this woman is trying something again. Then they get used to it and don't show much reaction.” Moreover, she talks about her similar experience:

> “When I bought a robot vacuum cleaner, it was a new product for my environment. At first, some saw it as unnecessary, they thought it was a simple product. But then when they saw it from me and saw that it was useful, when I suggested it, they wanted to buy it too.”

With the questions asked in the semi-structured interview (Figure B.2), it was questioned who could use this product for the first time in their environment and its effect on their decision to use it.

In addition, when asked who will be affected by using this product, the answers are quite varied. While some users said that seeing them in advertisements would be effective, others stated that they were not affected by the advertisements and that they could only rely on the experience of someone who uses them. P6 “Advertisements, influencers do not impress me much. I may have relatives who bought it and used it. I may have dietitians who use it for health reasons.” she said. However, P5 said:

> "Ads, people around me, but mostly advertising companies. If they are very popular in environments such as TV and social media, I will be influenced. If a detailed revised and analyzed version comes before me... I can be persuaded by others, but mostly advertisements”

With these questions, both the ideas of others about their own use and the importance of this for them, as well as the characteristics of individuals around them as potential users of this technology were investigated. P2, a 27-year-old participant, who studied industrial design and works as a user experience designer, explains her thoughts as:

> “It is consumed by innovative people like my colleagues, our generation, my husband, our friends. If I was the first to use it, the girls at our company would come to see it and ask for a photo or video of it.”

P2 described the reactions of those around her about using 3DFP as follows:

> “My mother and grandmother have difficulty in understanding, hesitate, do not like to try new things and see it as unnecessary. Someone needs to explain, or you will go and cook, you will tell and show them, they will hardly be convinced. They would say not to use it because it has low nutritional value. My father wouldn’t like it either, as he is very against technological things. He would look for a pot of food.”

To the participant, who said that her parents would be reactive, when asked, "If you had a 3D food printer in your kitchen, who would you invite as guests and what would you offer them?" She replied as:

> “If I were to invite guests, I would make a printed dish. I used different meats. If the people I invite are on a diet, I would do this for you by tweaking the ingredients and customizing the same dish just because I did this for you. I would definitely try dessert using parametric design or something. I would call my college friends or my parents. My friends like these things, it would be fun between us. I would call someone who would be curious, have a clear vision, and would like to try. My parents would also come out of curiosity, but I don't know if they would eat it."

There are people around her who have different personalities, ages and socio-cultural backgrounds and have different views. However, the fact that they will show different reactions does not prevent him from using or acquiring the product. Moreover, he states that even if they do not support it, they will also be curious and want to see it.

P3, who has a regular sports habit and an accompanying diet, states that the sports coach can encourage him to use this technology and says:

> “My mother wouldn't try. She is distant from such things. Even if it tastes very good, it cannot be tried if it is a little artificial, which is sold in that market. She has prejudice. But my siblings try. Since they are the Z generation, they are curious about new things. They can try first.”

However, he states that their interest will not motivate him to buy. He says that he will not invite his middle and old aged relatives as guests, and even when they come, he will cover the product and not want it to attract attention. However, he states that he wants to invite his peers of his age and make a show with the presentation he prepared. He states that his friends will not think that this product is unnecessary, and that he can even print funny shapes so that they can have a conversation. P7 says that she will invite her close acquaintances to dinner and wants to make cakes designed according to their personalities and interests:

> "Different appearances of the same dessert. If someone is about football, for example, a cake designed for football. Or personalized salads or appetizers, I would do things that would stay at the table throughout the meal and make the table look good."

P9 states that advertisements can guide him and make him believe in the practicality of the product. She says that if a reliable big brand puts this technological product on the market, it will be convinced that the product is accessible, its problems have been solved, tests have been made and that it can be used. The participant, who says that the product will remain "science fiction" for his parents, states that if he uses it first, he can prevent them from being strange by introducing it to the people around him.

Participants are willing to buy the product after trying it in a restaurant or at the home of a friend who uses it, or when they hear positive comments from people who use it. They are influenced by their environment, but the fact that they will be found strange by a group does not prevent them from using it.

4.3 Effort Expectancy

Effort expectancy is about the positive value of the system, how easy and effortless it is for users to use it. In the survey, respondents were asked to rate the ease of modeling and printing, and the ease of setting up the printer according to a recipe in an online program. The rate of those who say that they do not think that it will be difficult to create a model and print is 41.9%. As can be seen in Figure 4.8, the rate of participants from strongly agree to strongly disagree has gradually decreased.

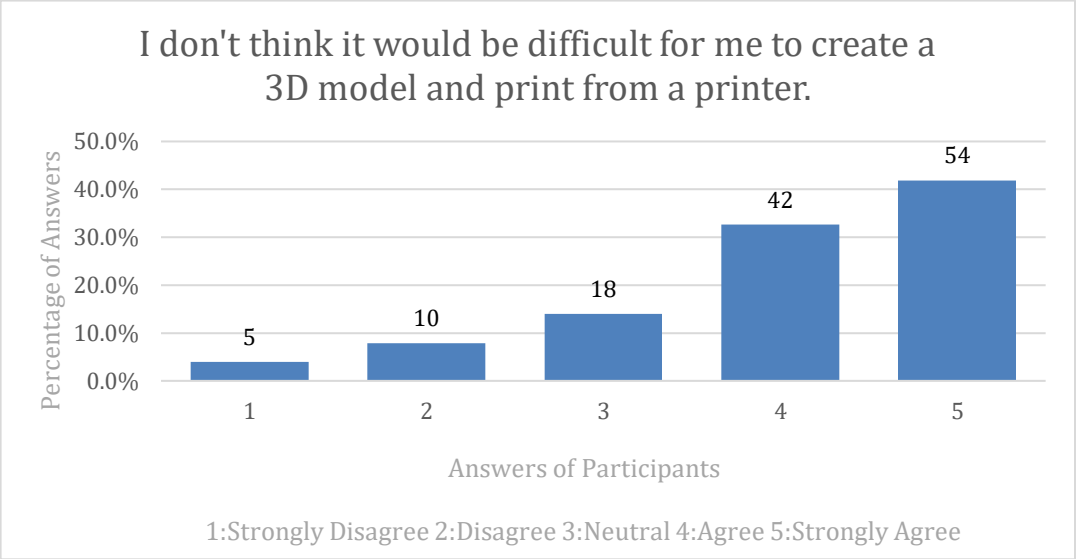


Figure 4.5 : A bar graph showing easiness of creating model and printing.

As can be seen in the graph (Figure 4.9), most of the respondents, 50.4%, stated that it would be easy to make print settings according to the recipe given in an online application, and 37.2% said it would be easy. Those who strongly disagree with this

statement make up only 0.1% of the group. In this case, it can be said that the users' effort expectancy for 3DFP is positive based on the survey results.

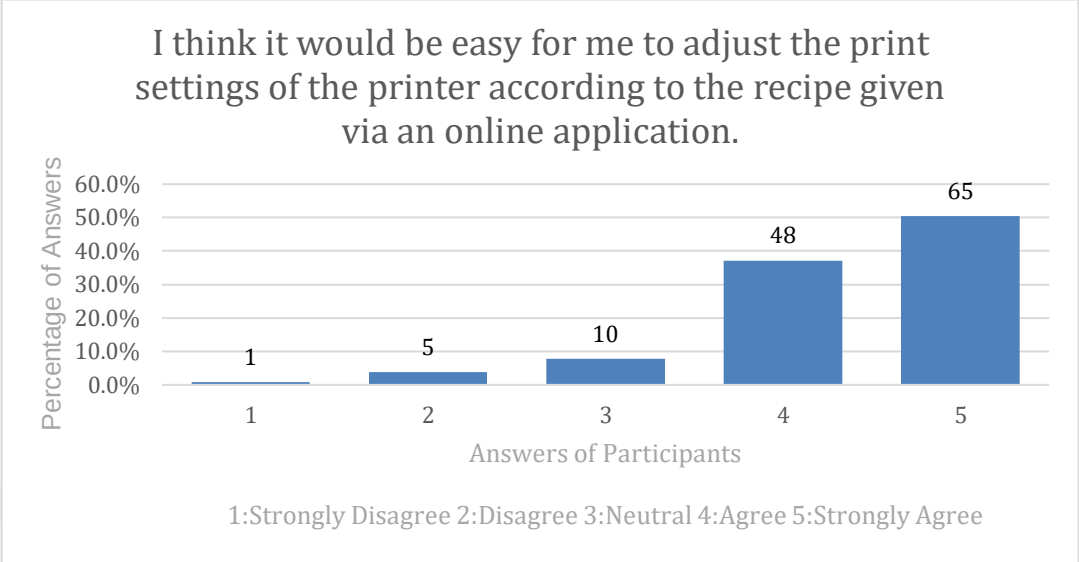


Figure 4.6 : A bar graph showing easiness of setting print in online application.

Similarly with the other results become intense on the positive parts of the graph. As seen in the graph (Figure 4.10) on this topic participants believe that they can handle the issues on preparing ingredients with necessary form and according to the recipe. According to graphs, preparing ingredients is perceived as slightly difficult from modeling and setting the print steps. The ratio of those who say “neither agree nor disagree” is 23,3% which is higher than other graphs on effort expectancy issue.

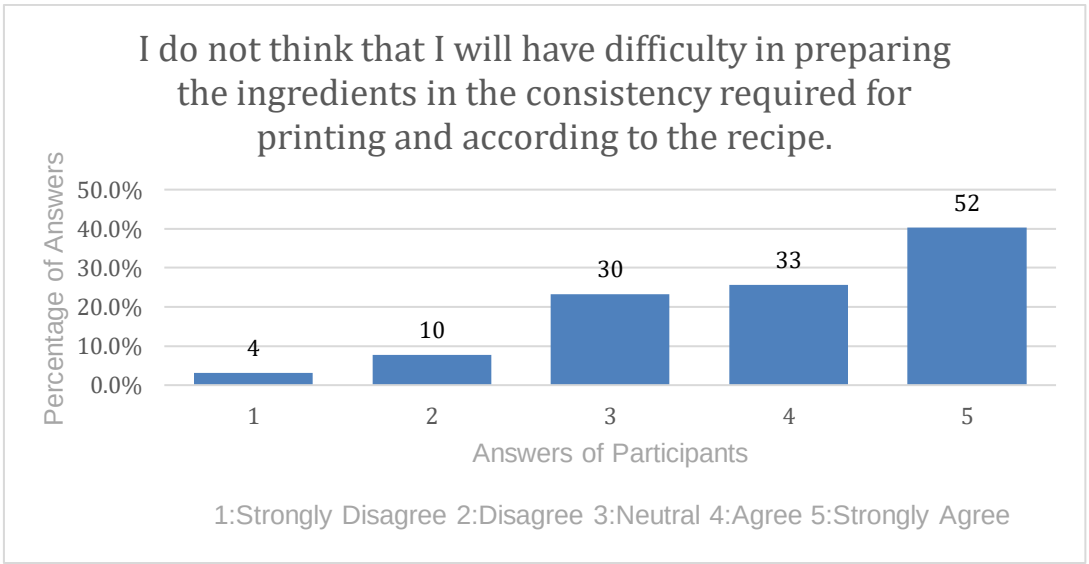


Figure 4.7 : A bar graph showing easiness of preparing ingredients.

In the interview, participants were asked to compare the traditional cooking method with the 3DFP method in terms of ease and difficulties. Some of the potential users believe that 3DFP can reduce the waste of time. P6 says:

> "After putting the product in this appliance, it will turn it into a dish with a fancy presentation. I will save time. At that time, I can make another stage of another dish. Also, If the cooking part is included in this technology, we will get rid of the problems of undercooking and overcooking. In traditional methods, we do it (control) in our own way, like tasting while cooking."

She also mentions that 3DFP can cook the food more precisely. Moreover, P10 says, "If I'm living alone or doing it for my small family, I may save time. Maybe I'll start it from my mobile phone before I get home. It simplifies processes. But in terms of taste, it would take time to get close to what people are doing today. It won't force me if I've been trained in the first place." She was concerned about the taste issue of the printed food.

In addition, P8, expresses herself with these sentences:

> "It's hard if you have to sit and model (the food). In the other (traditional culinary) you just use your hand. I need to use my mind on the printer. Modeling is tricky. I don't want to produce ordinary foods with ready-made models. If I have a product, I would like to use my own creativity."

She states that she would like to print personalized and creative foods and explains that modeling can be more difficult than traditional culinary, as it requires cognitive skill and effort.

From another perspective, P5 and P11 assert that cooking is a loveable process. P5 says "There is not much benefit other than preparing the materials. Other parts are fun. It is a pleasure for those who cook on special occasions. I don't want to be saved. I would like to do the presentation myself." He doesn't want to leave the whole process entirely to the appliance because he worries that the machine will be talked about all evening. P1 says:

> "With my dream appliance, I won't have to go to the restaurant to eat. But the cartridge will be hard to find. Very good if it will be available. All I need is to find a quality, essential cartridge. Maybe it will be difficult to find the cartridge and not be able to supply it and we will need to prepare it at home."

He concerns supplying or preparing the ingredient. Moreover, it can be understood that the abilities of 3DFP affects his effort expectancy.

Similarly, the general comment of the other participants is that they are not sure which stages the appliance can meet in the cooking process. The samples of 3D food printers in the market today also have different characteristics and the types of food they are oriented towards. For this reason, the participants thought about their expectations and the product they dreamed of while answering. P1 complains about the time constraint and conveys his expectation as follows: "I cook the main dish. It cooks the rice. I wish I could put the onion, eggplant, etc., and it would give me the dish. It is a dream in this era to expect an educated person to cook every day."

P8 talks about the use of resources that it doesn't normally consume as content and explains his expectations from the appliance as follows: "I would like it to do the cooking, peeling and chopping stages. Let's just put the ingredients, prepare that (3DFP) cartridge, then take it out and cook it. Square-shaped soup... Let me put an insect in, take out that hot cookie." P4 expresses his expectations about what stages this appliance can cover in the kitchen, saying, "If the pots and pans are going to be heat treated, you seem to give up on the whole kitchen. Except for the refrigerator." P2, on the other hand, says that her expectation will depend on the use and form of the ingredient, and exemplifies: "If mücver (vegetable patty) is sold, I will get rid of chopping, whisking, and straining. If I am going to make a cake, for example, without whisking. I don't know how it is right now, but I can get rid of the mixer, strainer and chopping."

The preparation of the contents was evaluated as the most difficult step in both 3DFP and traditional methods. While some of the participants want the appliance to perform all the operations, some consider preparing food as a fun and therapeutic process.

4.4 Performance Expectancy

As seen in the graph (Figure 4.11), the answers of the participants focused on "neither agree nor disagree" (39.5%), and the intensity is very similarly distributed between agree and disagree. This distribution can be interpreted as they have difficulty in comparing with other methods, they use today in terms of usefulness for an appliance that they have not used yet. Therefore, we can assert that they remain undecided.

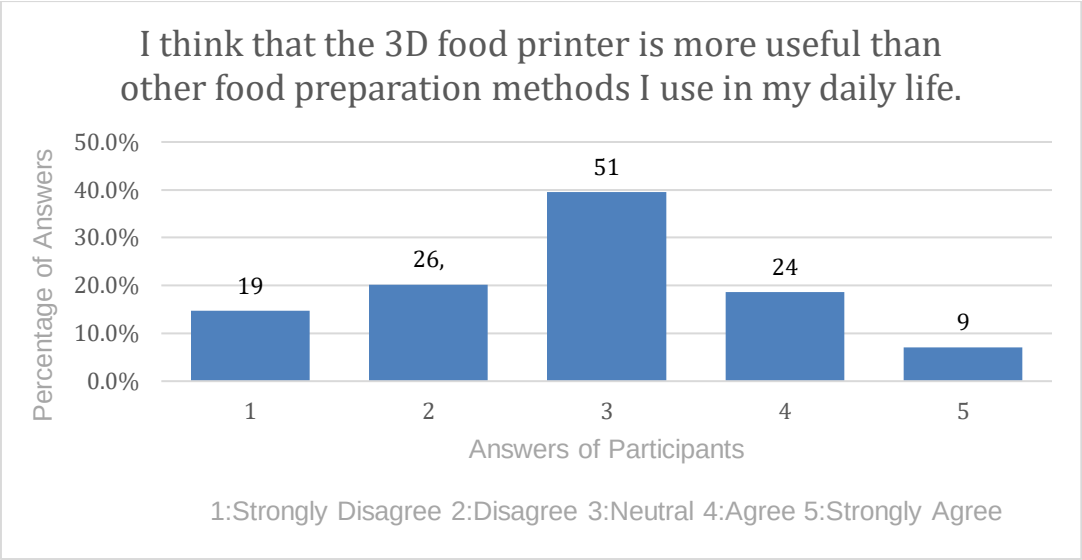


Figure 4.8 : A bar graph showing usefulness of 3D food printer.

When we look at Figure 4.12, the rate of those who think that 3DFP will speed up the cooking process is 27.9%, the rate of those who strongly agree that it will speed up is 17.1%. The percentage of the total participants who think negatively about accelerating is 40%. Although this graph reveals the idea that it will accelerate the distribution, it is seen that the participants are not sure about this situation. P3 explains the possible impact of using 3DFP on his daily life as follows:

> "If there is a wide variety in the main material and I change the hopper in one machine and print chocolate that day, I change the hopper in the morning and print something for breakfast. I'll take a shake with me. The opportunity to do different things without much effort motivates me. It saves time. After pressing the button, I will continue my normal life, since I will not be waiting for it."

As can be seen in the chart in Figure 4.13 25.6% of the participants do not think that they will cook more successfully with 3DFP. However, most (38%) abstain from this issue. When we look at the answers to the related question in the interviews, it is seen that the participants have difficulty in making comments without trying the taste of the food. Rather than producing the current food better, the P8 expectation dreams of obtaining new foods through this appliance: "I would like to make shaped fruits and such. It tastes different, looks different. I would like to produce something that doesn't exist right now. New things that I can't go and buy and eat."

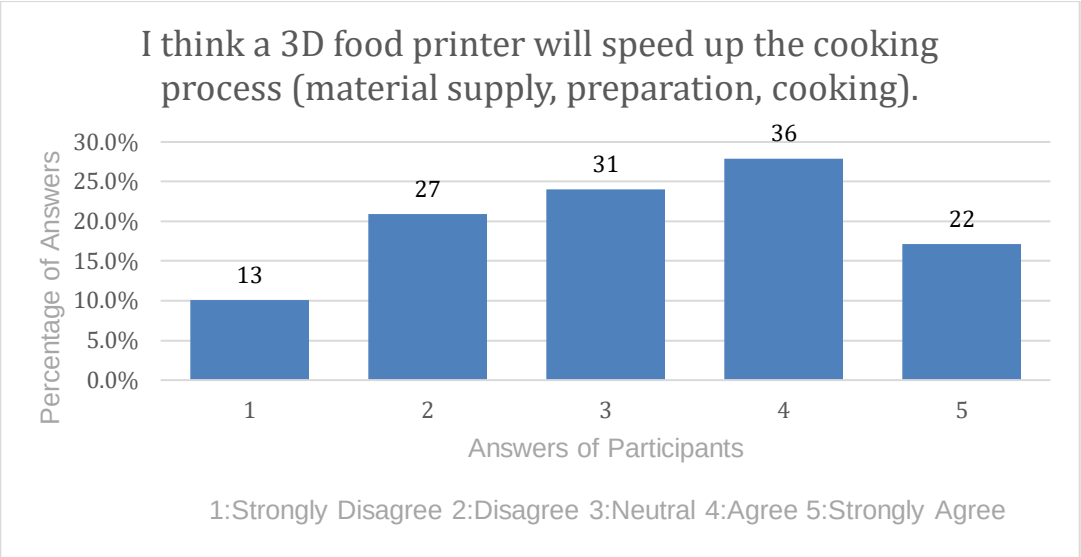


Figure 4.9 : A bar graph showing participants attitude on speed of 3D food printer.

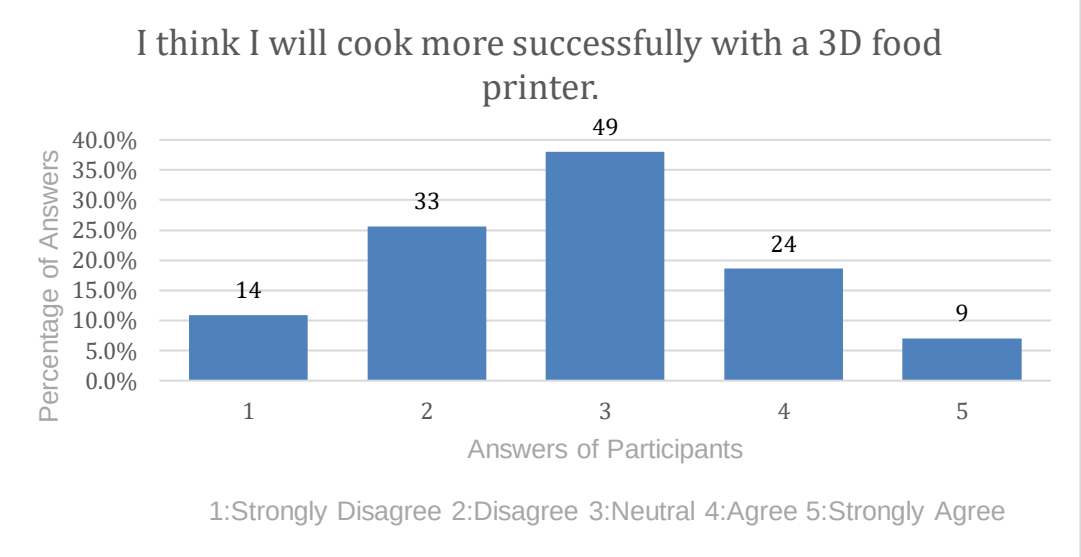


Figure 4.10 : A bar graph showing the success of cooking with a 3D food printer in participants' expectation.

Considering the performance of 3DFP technology, it has a system that promises many benefits to its users. Determining which of these benefits will create value for users is very important for widespread use. From this point of view, in the interviews participants were asked about the potential uses and benefits, which are valuable to them. P7, who is a kindergarten teacher and mother of a 5 years old boy, appreciates all of the benefits but focuses on using 3DFP for creating attractive food for children. She says:

> "It can be used in kindergartens, primary school cafeterias. It can be used in dishes chosen by children, such as cheese and broccoli, and vegetables. It can convince me that it will speed up and bring practicality to buy it for my home. I would like it to shorten the preparation process."

P5 says, "People who need to follow a special diet may use the printer, lactose intolerant, celiac, pregnant, elderly, bodybuilders. It can be beneficial for scrutinized people. It can save money, meat companies too. Veganism becomes a necessity." She said: "It has come to fruition," and summarizes the factors that will lead her to use this appliance for herself: "The need for a faster and healthier meal instead of fast food in time and busy life can convince me." From a similar perspective, stating that she doesn't like vegetables and does not prefer to consume them, P2 says:

> "...that's why I always have a vitamin deficiency, I don't like legumes or anything. I have a B12 and iron mineral deficiency, but I would appreciate it if it blended vitamins with the things I love. For example, I eat chocolate, but it has iron in it. I always must take supplements. It can also be useful for those who want to lose weight or for children. Children generally reject eating things that don't look pretty. For example, they dilute it and feed it puree to babies. It can be beneficial for people who have babies and elderly patients."

She adds "It is important to save time and practicality." She states that she is confused on what to expect from 3D food printers with current abilities. She says:

> "My satisfaction depends on its content. It seems like anything can be done if even meat can be processed. Let's say a bread is going to be made, the ingredients are mixed and fermented. Every food process is different. I think food produced with 3DFP will be limited at first. There will probably be simple two-three-ingredient products. For example, it is taken from there and fried. It doesn't feel like we can print out and eat everything from this product. We include it in the process, maybe we can put the food that comes out of there into another meal/process."

She doesn't see the printer as competent to involve all food types. She conditions expanding abilities for willing to use this product.

From another perspective P6 focuses on achieving the food for an attractive presentation of the meal "Especially presentation. Because I'm far from presentation. I can also buy it to improve my food choices or for my patients." Since she is a dietitian, her attitude to food technologies is more professional. When the issue comes to design and shape of food it is observed that participants relate this technology to dessert production.

Another issue that attracts the attention of the participants is that solutions that will solve the world's meat production and consumption problems such as vegan meat production and bioprinting become accessible with this technology.

There are two contrary perspectives on this issue among participants. Some participants support and accept the use of 3D food printer as a supplier of meat consumption. P10 says “Vegan meat production can convince me to buy a printer. Production will be easy, and it won't make me think it will damage the world." On the contrary some participants think that society is not ready to consume the meat produced in this way. P9 expresses his opinion on the issue with these sentences:

> "I don't want the meat produced there. I prefer things that will be produced with more vegetables. I will appreciate mixing a few things and obtain something that I know both its taste and nutritional value. I don't prefer to get meat from this appliance anyway. I think there are many years for a meat production machine. It's not accessible for now. My life may not be enough.”

4.5 Hedonistic Motivation

Role of intrinsic benefits in accelerating individuals' intention to accept systems have been studied in this research with related questions (Figure A.1). Majority of the participants (75,2%) stated that they would enjoy modeling their food to print. Only 7% of them rejected this idea as seen in Figure 4.14.

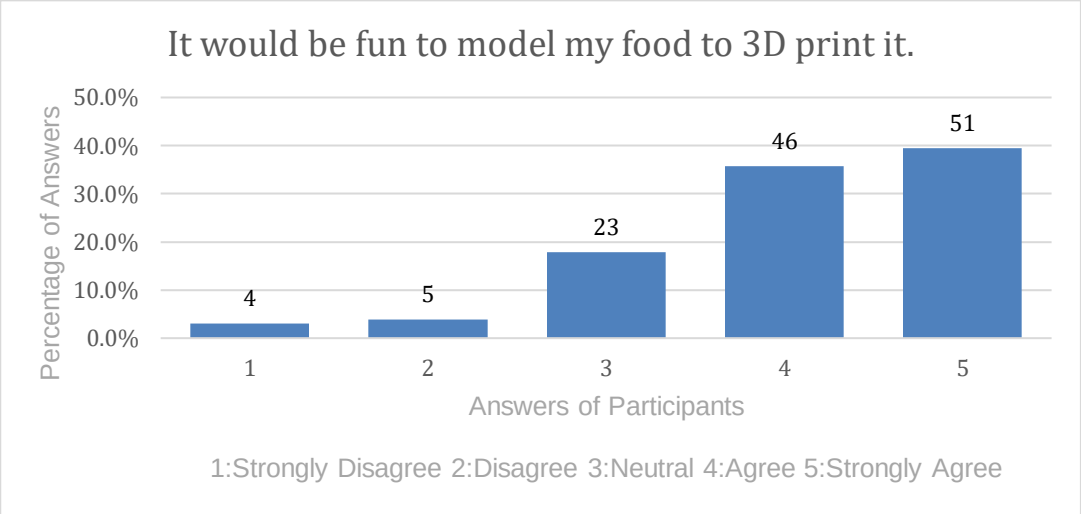


Figure 4.11 : A bar graph showing enjoyment of modeling for 3D food printer.

Moreover, in the survey, participants were asked to evaluate that obtaining the food they designed the model is enjoyable. Figure 4.15 presents that 46,5% of the participants definitely agree with this statement. Moreover, 36,4% of them indicate their agreement. Only 7% of participants reject the idea in total.

Lastly, “I enjoy eating 3D printed food” statement evaluated by participants to determine hedonistic motivation. As seen in the graph (Figure 4.16) there is an upward curve in terms of agreement and number of participants. Majority of the participants agree with the idea. Their feelings and thoughts are tried to figure out deeply with the interview questions on owning and using a 3D food printer and consuming the food produced by it.

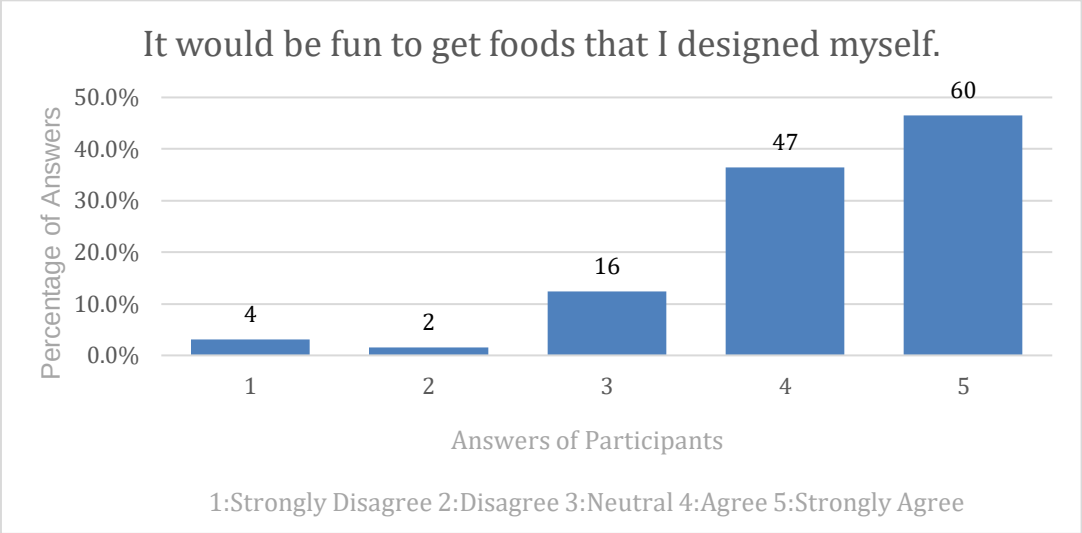


Figure 4.12 : A bar graph showing enjoyment of getting 3D printed food.

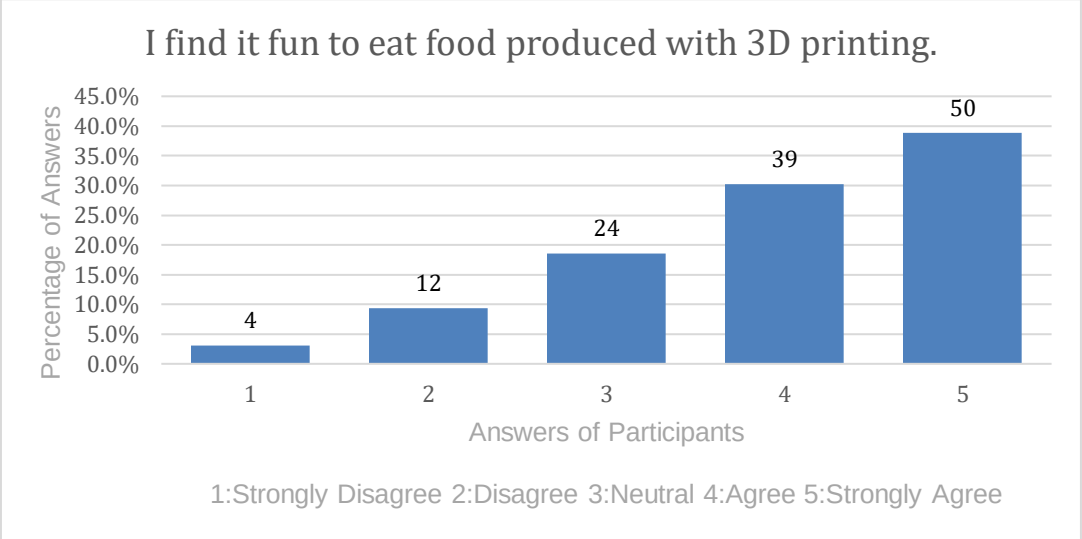


Figure 4.13 : A bar graph showing enjoyment of eating 3D printed food.

In the interview, feelings, and thoughts of people about using this appliance are examined. P1, determines how he feels when buy and uses this technology as “Wealthy, saved time, happy.” He states that he does not need to go somewhere else to eat as the reason for these feelings. Moreover, P3 finds it cool using this kind of technologic and unknown appliance for others. He also mentions some conditions on

his feelings: "If it tastes good, it's cool." He narrates his cool usage story as "I'm at work. I press start on the phone. That pressure is starting. If there are colleges next to me, I would tell them about my appliance."

P6 states that her feelings may change over time:

> "I feel strange at first, but it becomes normal as I get used to it. Where I will use it is important, maybe it will become indispensable. Especially the thought of saving time may be to make it easier for people who have no practice in cooking, but for me, the form of the food is interesting."

On the other hand, P5 prefers to use this appliance only when she does not want to cook or if it is necessary. Because she enjoys cooking in a traditional way. She also gives an example of a ready to use cake mix brand which has been unsuccessful when users only must add water to make cake. Then the brand changes its strategy in a way that users participate more in the process. She explains:

> "When the number of materials to be added by the user and their effort were increased, people bought it. 3DFP wouldn't be something I would use daily. However, I find it interesting for some benefits such as saving time and effort and offering healthy choices."

Moreover P9, defines cooking as therapy and an enjoyable part of his daily life if he has time. However, he says if he has a 3D food printer, he would feel updated and consider himself to keep up with the technology.

Secondly, the following question was formulated to get insights on hedonistic motivations: How would you feel when you consumed the food produced in a 3D food printer? P8 explains that the most important thing for her is the taste of the food: "If it tastes good, I will eat it with pleasure. I will also eat things with good visuals, but I will not eat it if I don't like the taste just because it is high in protein or nutritious." However, some participants look from a more pragmatic way. For example, P9 expresses that he attaches importance to potential ecological benefits of this technology, and he believes it may serve him more fertile opportunities in the kitchen. He told that:

> "If it throws things away and makes them waste less, it will be pleasing. I would feel environmentally friendly. If the appliance is smart and tells me to print food containing broccoli which expires soon that would be nice. Moreover, it may serve me meals with parts of vegetables that I normally can't consume."

For P4, his feelings depend on the food's properties: "It depends on what kind of product comes out; its texture, taste. It's what I'm going to eat that will most likely be homogeneous. That homogeneity may not be satisfactory for me."

4.6 Behavioral Intention

Behavioral intention is an individual's readiness to perform a given behavior. In the survey two questions were asked to evaluate motivations of participants to use 3DFP technology in the future.

As seen in the graph (Figure 4.17), the participants who do not think that they will use a food printer in the future make up 28% of them. However, a total of 50.4% participants state that they will use it.

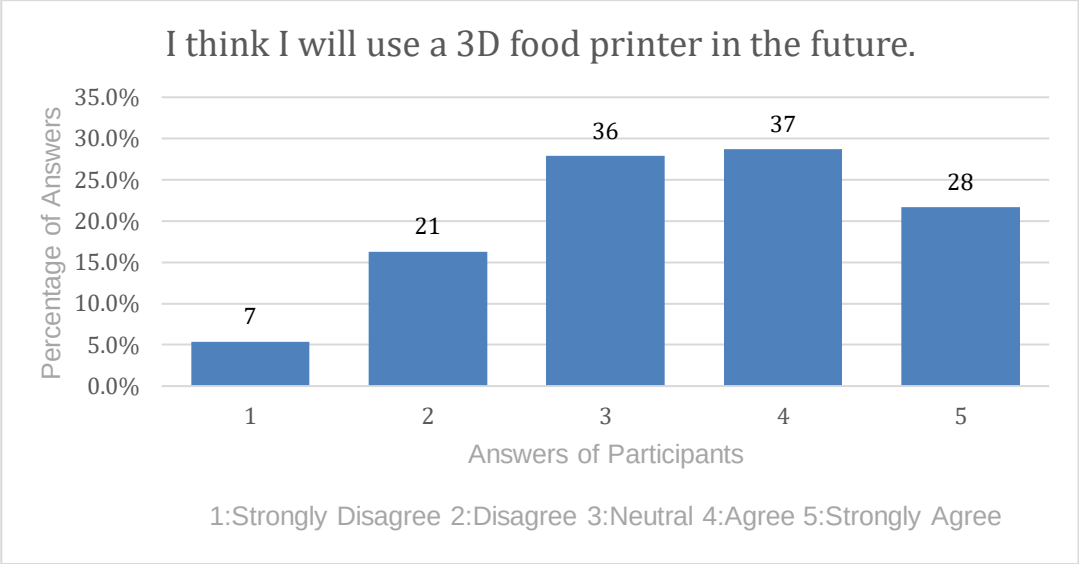


Figure 4.14 : A bar graph showing intention to use 3D food printer in the future.

Looking at the results of the survey, it is seen that the number of participants who want to try the 3D food printer is high if they have access, that is, when they come across an accessible product (Figure 4.18). Only 9.3% stated that they did not want to try even if they had access. As high as 40.3% of the participants said that they would definitely want to.

When asked about future use cases, they predicted that the price of the appliance would be high for them. For example, P2 says, "We'll see how much it sells for when it comes out, whether we can buy the ingredients. Maybe we don't have a budget when it first comes out, but later, it will be affordable, and I think it will be in every house."

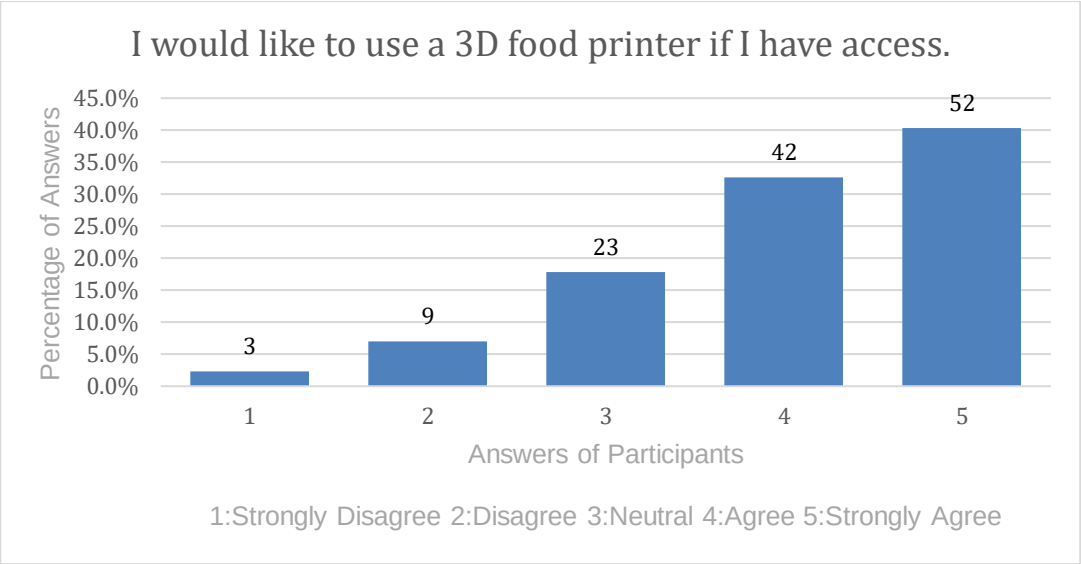


Figure 4.15 : A bar graph showing intention to use 3D food printer when it becomes accessible.

P1 says it will look at the price performance ratio:

> "I can buy price/performance and functionality if it shortens meal preparation time. If I can produce food suitable for my weekly diet. I am an innovative person; I would like to try and test it. Whether it is healthy to use it worries people. I will be sure by seeing and tasting. If there are workshops, I would like to start with them. Taste, I'd see what's in it and try it."

Although the general thought of the P5 is positive, it is possible to say that she has concerns both in terms of efficiency and price:

> "Not a bad idea. Life will get more intense. It will be difficult to find time. It's better than being eaten from the outside. But it is economical, time depends on situations. How often can I use it, and how long does it take?"

Similar concerns and perspectives were seen in P4's statements:

> "I am open to use; I like different things. I would like to buy the technology to examine it because I am curious about the product to be released. I probably don't have enough money. Also, what will the nutritional value of the products they produce be?"

There are different viewpoints as well. For example, P9 says:

> "I don't think it can ever enter my house, but I can buy it at a point where its abilities develop. It is not just for printing shapes, but when it is switched to a system like the Nespresso brand in the supply of capsules, when it is preserved and used for a longer time."

Nespresso as a well-known coffee brand has been given as an example several times in the interview from different users. Its supply chain is wide, and people appreciate their variety. P6 said:

> "I don't prefer it right away at the first stage because I like to cook. I like to be at every stage, but I don't know what the future will show. We are in the age of technology; I can think of practicality and attractive food presentation."

Moreover, being in the age of technology has been mentioned several times during the interviews. In this period, it has become normal for the participants to encounter new technologies and adapt them to their lives.

Respondents were asked whether this product will be more common in professional kitchens or homes in the future. All the participants said that they thought it would become widespread in professional kitchens first. P10 said:

> "It will be more common in professional kitchens at the initial stage. It also has the seller market it as a product in a restaurant or cafe. It is used as a marketing strategy. I think I'll try the food there, if I like the taste, then I'll buy it at home."

P7, similarly, the same dish served in professional kitchens with a large number in the same design. She states that it will provide more efficiency there and says, "If it becomes widespread in a year in professional kitchens, it will take 10 years at home." P4 says:

> "It is used more in luxury restaurants. The difference in the first stage of the thing to be printed is its shape. You can customize the image. Upscale restaurants are where visuals are important. Then it can be for the home when it is accepted by the society."

He adds his opinions on the future of 3DFP:

> "The scarcity of some resources (like water) will affect our lives and we will turn to alternative food sources. There won't be enough meat. In this way, this product will also reach homes if needed. The first product to be released is tested and a home model is also launched."

Moreover, P8 states her concerns about the future and mentions some situations which encourage her to buy a 3D food printer:

> "Maybe in the future I can use it to shape things like chocolate. I can calculate the proportions of nutrients and already make a chart; I can arrange a child's nutrition. I make sure that it is a kind of protein and a kind of carbohydrate. I have such awareness because I am a nurse, but if I had a child with special needs, I could have it. Maybe for them mineral calorie calculation can be taken because it will be more precise. Apart from that, it can be used when we cannot eat animal meat in the future, when we need to eat insects, when we need to find another protein source because there are problems in the production of animals. I don't want to take insects at home and bring them back to that form, but I can eat them when I don't see them. I can eat insect-containing food with the cartridge ready."

P6 looks from a professional perspective to its usage areas:

> “I can take it to improve my food preferences and make the recipe original and upset what I eat in terms of balanced nutrition. It can be considered for my patients to try this technology in line with the field I work in (dietary). It may become widespread in restaurants that make hotel-style mass meals. Since the first thing it reminds me of is the presentation, there are hotels that want it. It can even reduce the number of employees. Such technologies can be expensive at first. For example, when dough machines first came out, there weren't many in the houses. This is common in professional kitchens and then in homes.”

P4 explains his opinion on its potential use as follows:

> "In vegan and vegetarian products. Because those who reach this tool can also reach the meat. They must have a more refined diet/need. For example, a person who gets allergic when he eats something made in the same kitchen with peanuts, can get this product."

P3, on the other hand, does not think that he needs this product at home and states that he can go and consume it in restaurants, and that he will enjoy the meal with an excellent design that comes to him there. He explains that:

> "When I just looked at it as shaped food, I didn't know why I would put it somewhere in my house and take up space. But I thought it might be different if the food will be produced in a short time and its content will be something special. I stay away from the use of supplements and protein powder, too. Is the food that comes out really reliable? What brand does it use? It needs to build trust."

He also expresses his reservations about the form of the food:

> “I was not attracted to pureeing the material and loading it into the tank. I know what chocolate is. But I didn't like the idea of printing out a mixed puree like sausage. I wouldn't hesitate to do something that is not a mixture, which I know in its main form. They mix everything and make it like soup for babies. They don't seem palatable.”

4.7 Trust

Confidence in the appliance and the food produced seems to be essential for the acceptability of a food technology. In the survey, one question was asked each to measure the confidence in the appliance and the food. The graph (Figure 4.19) shows that 34,1% of the participants express that they neither agree nor disagree with the statement of “I trust 3D food printers to produce healthy food”. However, the ratio of the participants who reveal their agreement, which is 44,2%, is higher than the ones who disagree.

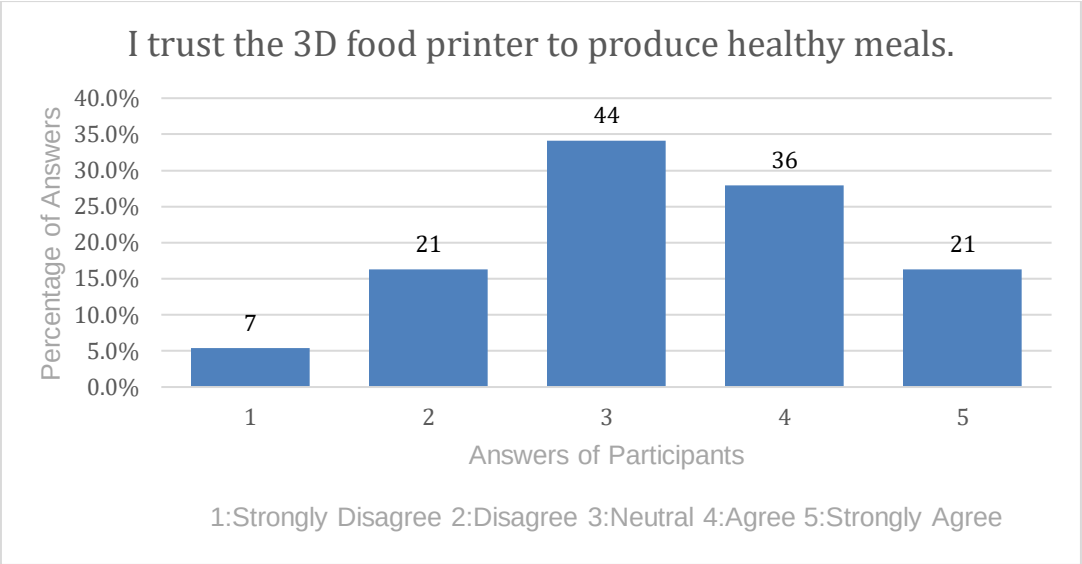


Figure 4.16 : A bar graph showing trust for producing healthy food with 3D food printer.

As seen in Figure 4.20, according to the survey results, the opinions of the participants about the expression "I trust the output" are concentrated on the option "neither agree nor disagree".

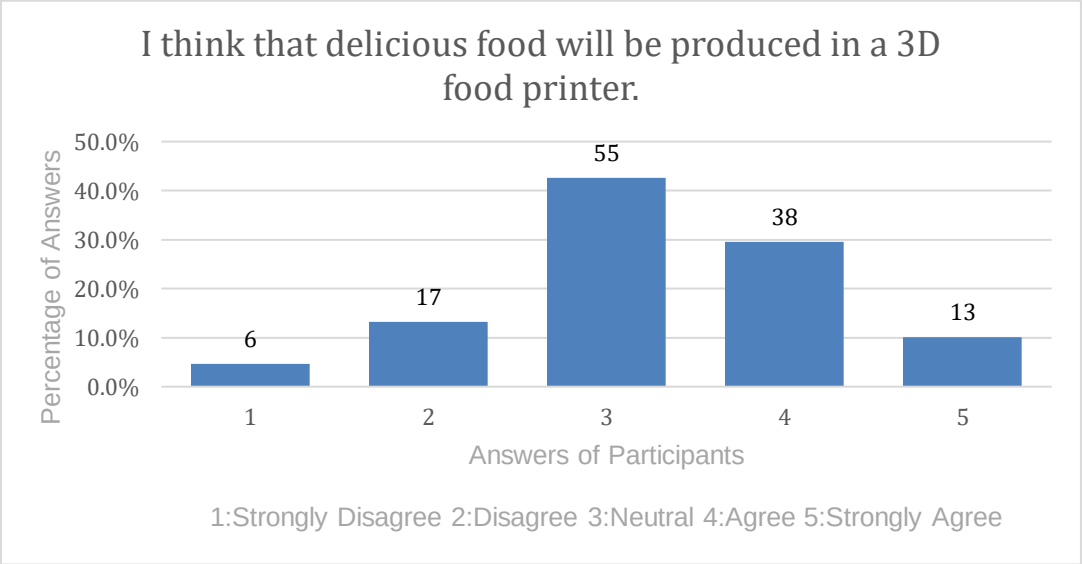


Figure 4.17 : A bar graph showing trust for producing delicious food with 3D food printer.

Furthermore, Figure 4.21 shows that approximately 50% of participants say they trust this appliance to produce food correctly even if they do not see the process. On the contrary 17% of them contradict this statement.

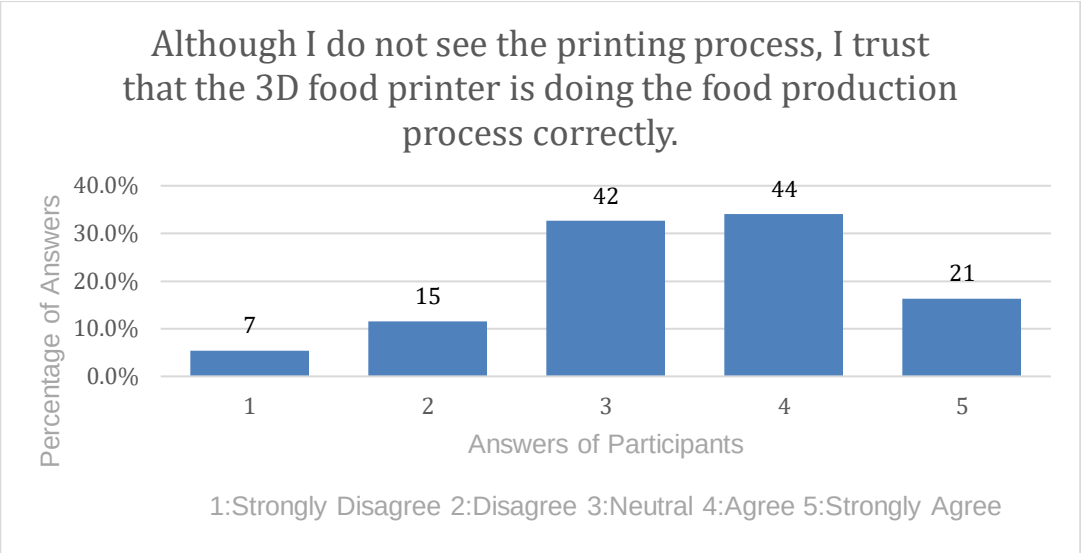


Figure 4.18 : A bar chart showing confidence that a 3D food printer will work as expected.

Lastly, as seen in Figure 4.22 approximately 40% of participants think that this appliance does not cause home accidents even if they are not sure about it. Moreover, 19,4% of them are sure that it does not cause home accidents. On the other hand, 21,7% of them disagree with this opinion in total.

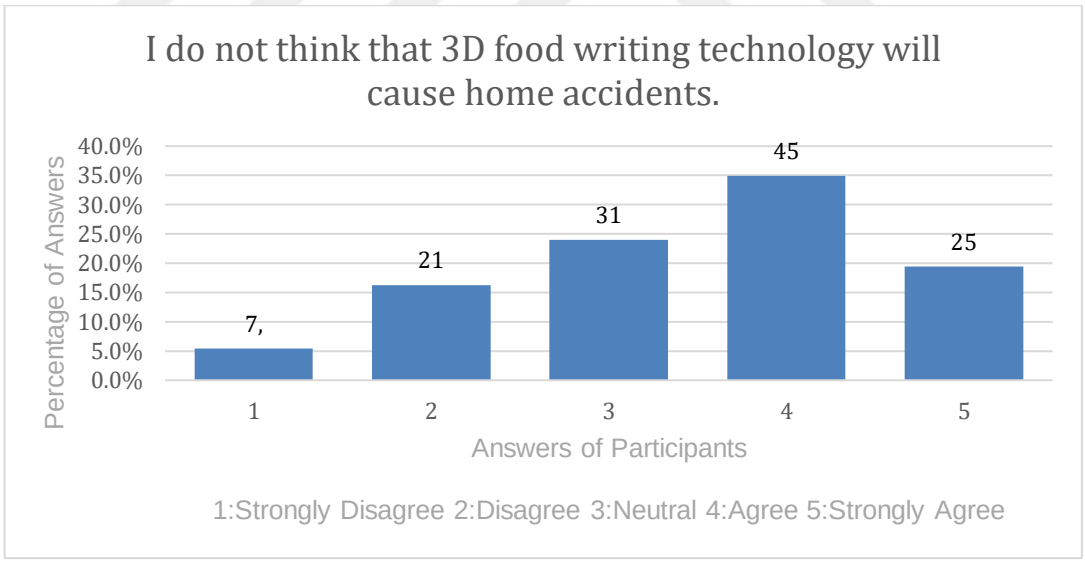


Figure 4.19 : A bar chart showing trust to safety of 3D food printer.

In the interviews, some participants stated that they needed to get to know the appliance more and taste the food in order to feel confident. P1 lists his conditions for trust as follows:

> "I buy it to try, but I don't trust the output at first. I wonder what it will be like. How is the cleaning, material, heater of those pipes? Will it have a carcinogenic effect? Health issues will

> be the priority, and secondly, the religion of the food used in this country. whether it conforms to sensitivities."

While P7 stated that she is paying attention to the content of the food she consumes, she said that she will look at what they put in before purchasing the cartridges that she will use with this product.

P10, on the other hand, says that she has reservations about the nutritional values of the food obtained as the output:

> "I'm sure it brings out very good things from the form. It feels like a shape-focused product. There is concern about the loss of nutritional value and the nutritional value reliability of those taken from outside becomes a question mark. What matters is the nutritional value and the absence of chemicals."

When the participant evaluates the examples she sees, she trusts that the form of the food will come out as designed and evaluates the product as focused on form studies. However, she says that the health and safety of the food is due to the additives and the loss of nutritional value during production, especially if it is a ready-made cartridge. Similarly, P2 said:

> "I would like information on how the company's ingredients were created. It should be written on the product. There should be a video of the production process. I would like data that there is nothing that will negatively affect my health. I would like information on what they add so that it has a long life."

From another point of view, P4 expresses his ideas as:

> "If it came to me, it probably passed a lot of testing. If the brand is launched from a big company, I trust it, but if it's a startup, I don't. Is human interaction tested? Local companies don't do that because nobody cares about R&D."

He associates his trust with the company which launches the 3D food printer.

With the technology's abilities another issue occurs according to P9. He says:

> "From what I've read, it's already reliable enough, but what surprises me is to eat something in the form of something else. Cube-shaped fish, for example. It confuses me that the form is different from its content. It sounds strange. Other than that, of course I trust this technology."

A food is associated with its taste, color, shape, smell. From this point of view, while the different shape specified for insect consumption is considered positive, this may be a concern for some of the user.

5. CONCLUSION

The aim of this thesis study is to define the factors affecting the user acceptance of 3D food printing technology in the home environment. Since there is no specific model for an appliance that has not been experienced with the study, current acceptance models are analyzed in terms of their applicability and application areas. The results are valuable in that they can be evaluated in this technology as a theoretical scope that contributes to further research rather than design practice of an appliance.

In order to understand the factors affecting the acceptance of 3D food printing technology by the user, an exploratory research study was conducted. It is expected that this thesis will contribute to food design, technology acceptance and their connection with 3D food printing by providing a basis for further research.

In this study, a survey consisting of open-ended questions and Likert scale questions was answered by 129 participants. A semi-structured interview was conducted with 10 of these participants. With this research, the acceptability of 3DFP technology in the home environment in terms of printer and printed food was investigated, and unlike the examples in the literature, this research and analysis was associated with food design. An adapted version of the UTAUT2 model was used for this. Moderating variables in the UTAUT model; age and gender is not considered in this research because of the lack of variety of respondents. Voluntariness is also invalid for this research. Because in this study personal invention of users has been examined and there is not a mandatory situation. In the analysis phase, grouping was made under the determined categories of the model. The graphs in the survey results (Figures 4.1-4.22) and the interview outputs were compared and the hypotheses and research questions were evaluated with the findings. Participants stated that their social circles may express different views on the use of this appliance and the consumption of printed foods. It was stated that although they will receive both positive and negative feedback, neither situation will affect the participant's decision to purchase and use this product. The participants said that the appliance should add practicality and time to their lives, but that they can decide to buy this appliance when they need it and they

would like to try the food in a restaurant before taking it home. Some users stated that it would be effective to try it at someone else's home or to hear positive comments from someone who uses it. A dietitian participant, who evaluates it from a professional point of view, states that this technology will be useful for patients and users with special needs in environments such as hospitals, while seeing the use of this technology for home decoration purposes. Personalized food attracts the attention of the participants, and they see this feature as a means of entertainment. The survey and interview results show that consuming a designed food and its customizability attracts attention. Although the participants do not have experience in modeling or using a 3D printer, it can be said that they believe that they will be able to use this appliance with some guidance and instruction when it is released. They stated that they encounter a new technological product and experience every day and are open to learning, but this result may be related to the participant profile and different results may emerge when the research is expanded with a larger group. Although some users complain that they can't find time to cook, and instead of ordering food, they stated that it would be advantageous to save time and reach healthy food by using this appliance, but some users described the cooking experience as therapy and stated that it was a relaxing and enjoyable activity. However, they said that they could use this technological product as an auxiliary kitchen tool, and they would not want it to carry out the whole process. Some of the users think that their budget will not be enough to buy the appliance when it is released, and they say that they can only get it when it becomes widespread and the price drops. Another point that the participants stated about the characteristics is the importance of the taste of the food. No matter how good the form is, there were users who stated that they would not continue to use it if they did not like its taste. Concerns about the taste and texture of the food produced with this appliance were at the forefront in the discourses of the participants. When it comes to meat production, it can be said that it motivates users because it makes them feel useful to the world for some users. However, the quality and price of the food was considered important.

From the perspective of some users, the biggest benefit of a new product is the practicality and time gained through its use. For some, the greatest benefit is that it makes it possible to consume food without harming the environment. For some participants, making their presentations more effective was considered an important benefit. Although not in terms of hardware, it can be said that the participants had

difficulty in assessing whether they were sufficient to use this appliance because they did not recognize the appliance.

Regarding efficiency expectancy, some of the participants thought that this product would save them time. However, there is a prevailing opinion that experience will affect this view and that technological capability will be effective in terms of time and effort. Efficiency may vary depending on how the technology is implemented, how it is served to the user, and the design of the product, interfaces, supply system.

Another issue on which the participants disagreed is performance expectancy. It has been observed that users have concerns about the quality, taste, and texture of the product to be printed. It was also stated that the ingredient preparation process can be challenging. However, hedonistic motivations were found to be high. Although it is not under construction, it can be said that the thought of consuming personal and specially designed foods motivates them. However, this motivation is not enough for some participants to buy the appliance. They were told that to buy an appliance they believe it is necessary to meet their needs first or having strong references for that appliance would be effective. Regarding trust, it was seen that the participants would be cautious about the purchased ingredient. Although the participants think that this appliance will work correctly and be strong in printing the designed food, they have concerns such as the materials from which the ingredients are made, the method of production, storage conditions and access to them. With the developments in the food sector and the increase in the consumption of packaged foods, the awareness of the users about the quality of their food has increased. The demand for natural and healthy food will also be important for the users of this product. There were participants who stated that trust can be strengthened in connection with the brand. In addition, it can be said that the cleanliness of the appliance and the reliability of the materials raise concerns. However, the relationship between the appliance's performance and the effort required to use it properly was unclear for users. Participants often fail to distinguish their predictions of these determinants. These two determinants can provide a positive attitude towards using the new product when users experienced the appliance and be satisfied.

The impact values of the factors affecting the acceptability of the appliance and the summary of positive and negative user comments are displayed in the form of an

infographic (Figure 5.1). Similarly, a summary of assessments on the acceptability of pressed food can be seen in Figure 5.2.

Social influences, credibility, facilitating conditions, hedonistic motivation, and user attitude are not as effective as performance and effort expectations. In general, it has been found that the participants attribute their purchasing and use decisions to productivity, satisfaction by food, and responsiveness to needs.

This thesis shows that the function of the product is the first criterion for its users and is partly related to the capabilities of the relevant technology. However, it is difficult to talk about the adequacy of this function without using it yet.

In general, although the participants expressed their satisfaction with the possible benefits, it can be said that they do not have the necessary experience to buy this appliance yet, just having the designed food is not enough when combined with financial concerns, and they do not want to buy the appliance and the food that comes out without trying it. In addition, it can be said that the meat consumption problem has not yet affected itself as a difficulty in reaching meat for the participants. Changes in circumstances and improvement of the technology on printing time, food quality and cost issues may motivate users to use this technology.

5.1 Discussion

In this study, the user was not made to use neither an interface nor a 3D food printer because these appliances have not been easily available yet. Also, they have not consumed 3D printed food.

Users' perceptions may alter when they meet the appliance and the food. Findings of this study reflect their tendencies and preconceptions. When we look at the other studies on acceptance of 3D food printing technology, Pliner and Hobden (1992) mention food neophobia (fear of trying new foods) which may cause concern on users to eat 3D printed foods according to the study of Manstan and McSweeney (2020). Metcalf, Wiener, and Saliba (2021). They conducted research with food neophobia scale and the food choice questionnaire to determine users' attitudes toward a novel food. In the line of this study the novel product's it is reported that early users have higher levels of food neophobia. Moreover, their motivating factors were defined as health, natural content, mood, familiarity, and ethical concern.

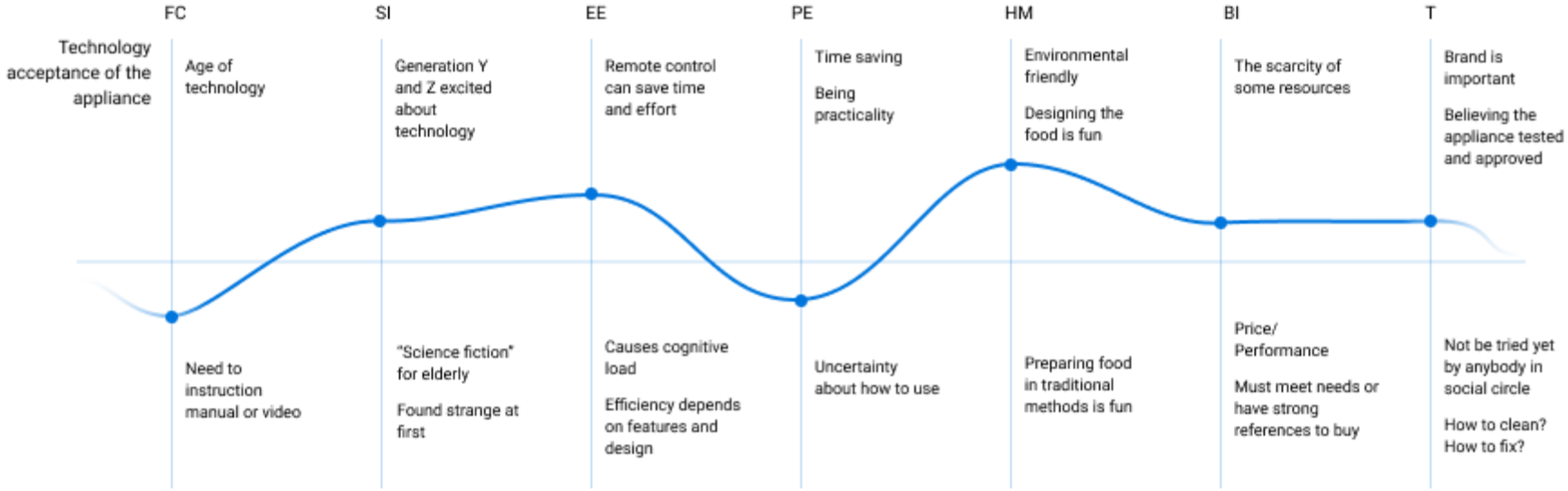


Figure 5.1: Values of technology acceptance determinants for 3D food printer.

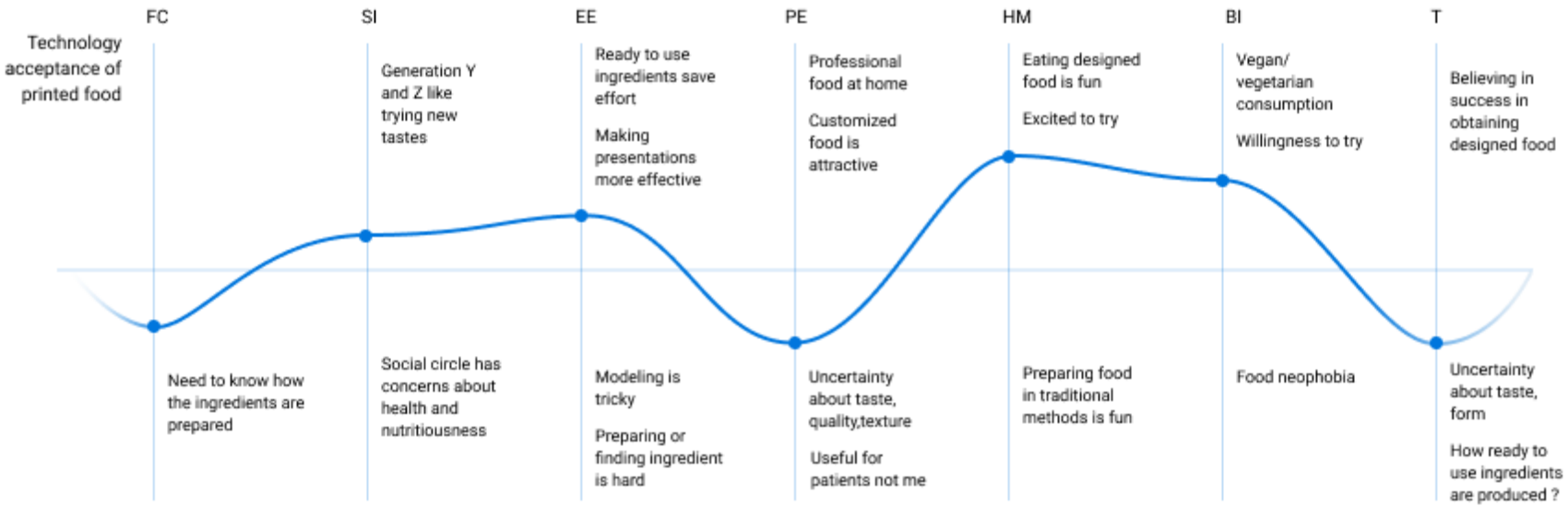


Figure 5.2: Values of technology acceptance determinants for 3D printed food.

Manstan and McSweeney (2020) reveals that 28% of 329 participants believed 3D printed foods were unacceptable and not safe, however, 72% of the participants were eager to try it. Moreover, similar authors reported in a following study that the sensory qualities of the 3D printed food were better than the conventional ones. In this study the participants expressed their willingness to eat 3D printed foods and felt they were sustainable after consuming the "3D printed" cookie (Manstan, Chandler, and McSweeney 2021). Caulier, Doets, and Noort (2020) also achieved a similar result in their study focused on the acceptance of 3D printed snack bars. As a result, according to the paper of Kewuyemi et al. (2021) it can be said that there are potentials for the scale-up of 3D printed food. However, users should have more knowledge on the acceptance and consumption of it.

The design team that will work on a product with this technology should be multidisciplinary. User experience design requires studies in areas such as user interface design, service design, packaging design and 3D product design. By looking at the outputs of this research, it can be said that the user will need guiding content from the first encounter. Saving time and being practical come to the fore as the main benefits that will add to the life of the user. When we consider the experience holistically, multiple scenarios are possible for the use of this product. There are versions where the modeling and contents are supplied ready-made or made by the user himself. In order to provide ready-made user-ready content, it should be reliable while saving time and the problem of variety limitation should be solved. If he is going to use this product, there is a user opinion that he wants to show his own creativity. For these users, even if they do not have modeling experience, a platform should be provided where they can perform the design. The point and capabilities of the technology will be an important factor affecting the acceptability of the food and the appliance.

While working on the acceptance of technology, designers adapt the method to their own work, as in this study. Survey data will not be enough for design research. The designer needs the user's stories. Insight about the experience and needs of the user is obtained through on-site observation or the stories told by the user. In this research, it was the interview that allowed the reasons for the survey results to be understood and associated with user profiles. The path to acceptability of a new technology is through the user's current experience.

5.2 Limitation of the Study

This study has some technical limitations. The survey results are limited to the number of participants, which may not be sufficient to generalize to the entire population. Tamminenb and Salovaara (2009) criticized the technology acceptance models with a design-oriented perspective and states that the active interpretation processes of the users contribute significantly to the use and acceptance of the product. Therefore, it is not possible to consider users as a single segment of people.

Technology acceptance models are not sufficient to evaluate the acceptance of a technology because quantitative research lacks insight for a design that meets users' needs. Croswell (2003) states that quantitative and qualitative research have their own strengths and weaknesses. Combining them in a mixed methods approach has become a favored approach in a variety of research fields. According to Tamminenb and Salovaara (2009) the designer benefits from the experiences of the users by supporting quantitative research with the qualitative method. In this study data were collected through interviews and questionnaires. However, observing the experience of users is missing in this study.

Moreover, this study was conducted on online platforms due to the COVID-19 pandemic situation, therefore all the participants had interaction and at least a certain level of ability to use technological devices like computers or smartphones.

5.3 Further Studies

This thesis study can be described as a descriptive rather than representative approach due to the relatively small sample of surveys and interviews. However, more research is needed to reveal a more specific technology acceptance pattern. With larger survey samples and varying participants, the research area should be broadened to make some generalization.

In the future, the food can be tried and the acceptance of the participants as a result of the test can be examined. Thus, more clear data can be obtained on the acceptability of the food consumed in terms of visual quality, taste, and form.

Printing meat is an epochal feature on its own. It may be explored with specific research. In addition, with a study in which the appliance is inspected by users, it can

be studied which features of a product that will be in the kitchen will be effective for acceptability. A product or service design study can be conducted based on the outputs of this research by conducting research with designers specific to this technology.

As mentioned in the Section 5.2 all of the participants are above a certain threshold in terms of their relationship with technology. They received the link of the survey via a social media application. Then, they answered the questions on a website. In a further study technology acceptance dimension can be examined according to technological competence of participants.

By observing in the domestic environment current habits and experience of users can be internalized deeply. Because of the COVID-19 restrictions, visiting people in their home is not safe and available during the time which this research has conducted. In further research the experience of users on cooking and preparing food can be studied and with this study how current experience affects the acceptance of a novel experience can be examined specifically.

REFERENCES

3D Food Printing Conference. (2021, December 1). Retrieved January 7, 2022, from https://3dfoodprintingconference.com/program/

Aarts, H., Verplanken, B., & van Knippenberg, A. (1998). Predicting behavior from actions in the past: Repeated decision making or a matter of habit? Journal of Applied Social Psychology, 28(15), 1355–1374. https://doi.org/10.1111/j.1559-1816.1998.tb01681.x

Ajzen, I. (1991) "The theory of planned behavior", Organizational Behavior and Human Decision Processes, Vol. 50 No. 2, pp. 179-211

Alalwan, A. A., Dwivedi, Y. K., & Williams, M. D. (2016). Customers' intention and adoption of telebanking in Jordan. Information Systems Management, 33(2), 154–178.

Alalwan, A. A., Dwivedi, Y. K., Rana, N. P., Lal, B., & Williams, M. D. (2015). Consumer adoption of Internet banking in Jordan: Examining the role of hedonic motivation, habit, self-efficacy and trust. Journal of Financial Services Marketing, 20(2), 145-157.

Alalwan, Ali Abdallah; Dwivedi, Yogesh K.; Rana, Nripendra P. (2017). Factors influencing adoption of mobile banking by Jordanian bank customers: Extending UTAUT2 with trust. International Journal of Information Management, 37(3), 99–110. doi:10.1016/j.ijinfomgt.2017.01.002

Derossi, A., Caporizzi, R., Paolillo, M., Oral, M. O., & Severini, C. (2021). Drawing the scientific landscape of 3D Food Printing. Maps and interpretation of the global information in the first 13 years of detailed experiments, from 2007 to 2020. Innovative Food Science & Emerging Technologies, 70, 102689. doi:10.1016/j.ifset.2021.10268

Attarin, Sharmin and Attaran, Mohsen (2020) "Food Printing: Evolving Technologies, Challenges, Opportunities, and Best Adoption Strategies," Journal of International Technology and Information Management: Vol. 29 : Iss. 1 , Article 2.

Beyer, Hugh & Holtzblatt, Karen. (1999). Contextual Design. interactions. 6. 32-42. 10.1145/291224.291229.

Bhat, Zuhaib & Bhat, Hina. (2010). Prospectus of cultured meat - Advancing meat alternatives. Journal of Food Science and Technology. 48. 125-140. 10.1007/s13197-010-0198-7.

Burke, R.R. (2002) Technology and the Customer Interface: What Consumers Want in the Physical and Virtual Store. Journal of the Academy of Marketing Science, 30, 411.

Burke-Shyne, Suailce & Gallegos, Danielle & Williams, Tim. (2020). 3D food printing: nutrition opportunities and challenges. British Food Journal. ahead-of-print. 10.1108/BFJ-05-2020-0441.

Caulier, S., Doets, E., & Noort, M. (2020). An exploratory consumer study of 3D printed food perception in a real-life military setting. Food Quality and Preference, 86, https://doi.org/10.1016/j.foodqual.2020.104001

Chen, Lan & Opara, Umezuruike. (2013). Approaches to analysis and modeling texture in fresh and processed foods – A review. Journal of Food Engineering. 119. 497. 10.1016/j.jfoodeng.2013.06.028.

Creswell, J. W. (2014). Qualitative, quantitative and mixed methods approaches. Sage.

Dankar, I., Haddarah, A., Omar, F. E., Sepulcre, F., & Pujolà, M. (2018). 3D printing technology: The new era for food customization and elaboration. Trends in food science & technology, 75, 231-242.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical constructs. Management Science, 35, 982–1003.

Degerli, Celal. (2020). 3 Boyutlu (3D) Yazıcı Teknolojisinde Et Ürünleri Üretimi. Turkish Journal of Agriculture - Food Science and Technology. 8. 1018-1026. 10.24925/turjaf.v8i5.1018-1026.2978.

Design Library. (n.d.). Retrieved October 14, 2021, from https://www.pancakebot.com/design-library/

Derossi, A., Caporizzi, R., Paolillo, M., & Severini, C. (2021). Programmable texture properties of cereal-based snack mediated by 3D printing technology. Journal of Food Engineering, 289, 110160.

Derossi, A., Caporizzi, R., Azzollini, D., & Severini, C. (2018). Application of 3D printing for customized food. A case on the development of a fruit-based snack for children. Journal of Food Engineering, 220, 65-75.

DeskX, Shovava, Day, T. I., Comma, & Colorsheets, V. (2020, August 21). Tokyo Restaurant Offers 3D-Printed Sushi Tailored to Your Health Needs. Retrieved September 13, 2021, from https://mymodernmet.com/3d-printed-sushi-singularity/

Dick, A., Bhandari, B., & Prakash, S. (2019). 3D printing of meat. Meat science, 153, 35-44.

Fahmy, A. R., Amann, L. S., Dunkel, A., Frank, O., Dawid, C., Hofmann, T., … Jekle, M. (2021). Sensory design in food 3D printing – Structuring, texture modulation, taste localization, and thermal stabilization. Innovative Food Science & Emerging Technologies, 72, 102743. doi:10.1016/j.ifset.2021.102743

FDA. (n.d.). U S Food and Drug Administration Home Page.

Fishbein, M., & Ajzen, A. (1980). Understanding Attitudes and Predicting Social Behaviour. Preventive-Hall. Inc., Englewood Cliffs.

Gefen, D., Karahanna, E., & Straub, D. W. (2003). Trust and TAM in online shopping: An integrated model. MIS quarterly, 51-90.

Gholamipour-Shirazi, A., Norton, I. T., & Mills, T. (2019). Designing hydrocolloid based food-ink formulations for extrusion 3D printing. Food Hydrocolloids, 95, 161-167.

Godoi, Fernanda C.; Prakash, Sangeeta; Bhandari, Bhesh R. (2016). 3d Printing Technologies Applied for Food Design: Status and Prospects. Journal of Food Engineering, S0260877416300243–. doi:10.1016/j.jfoodeng.2016.01.025

Gruzd, Anatoliy & Staves, Kathleen & Wilk, Amanda. (2012). Connected scholars: Examining the role of social media in research practices of faculty using the UTAUT model. Computers in Human Behavior. 28. 2340–2350. 10.1016/j.chb.2012.07.004.

He, J., Evans, N. M., Liu, H., & Shao, S. (2020). A review of research on plant-based meat alternatives: Driving forces, history, manufacturing, and consumer attitudes. Comprehensive Reviews in Food Science and Food Safety. doi:10.1111/1541-4337.12610

Hertafeld, Evan; Zhang, Connie; Jin, Zeyuan; Jakub, Abigail; Russell, Katherine; Lakehal, Yadir; Andreyeva, Kristina; Bangalore, Sneha Nagaraj; Mezquita, Jerson; Blutinger, Jonathan; Lipson, Hod (2018). Multi-material Three-Dimensional Food Printing with Simultaneous Infrared Cooking. 3D Printing and Additive Manufacturing, (), 3dp.2018.0042–. doi:10.1089/3dp.2018.0042

Hocquette, Jean-François. (2016). Is in vitro meat the solution for the future?. Meat Science. 120. 10.1016/j.meatsci.2016.04.036.

Huang, L., Gao, G., Zhang, H., Chen, J., Fang, Y., & Dong, S. (2020). Self-dissociation-assembly of ultrathin metal-organic framework nanosheet arrays for efficient oxygen evolution. Nano Energy, 68, 104296.

Ishamri, Ismail & Hwang, Young-Hwa & Joo, Seon-Tea. (2020). Meat analog as future food: a review. Journal of Animal Science and Technology. 62. 111-120. 10.5187/jast.2020.62.2.111.

Joshi, V.G., & Kumar, S. (2015). Meat Analogues: Plant based alternatives to meat products- A review. International Journal of Food and Fermentation Technology, 5, 107-119.

K. Porter, J. Phipps, A. Szepkouski, S. Abidi. (2015). 3D opportunity serves it up additive manufacturing and food United Kingdom

Kauppi, Saara-Maria; Pettersen, Ida Nilstad; Boks, Casper (2019). Consumer acceptance of edible insects and design interventions as adoption strategy. International Journal of Food Design, 4(1), 39–62. doi:10.1386/ijfd.4.1.39_1

Kewuyemi, Y. O., Kesa, H., & Adebo, O. A. (2021). Trends in functional food development with three-dimensional (3D) food printing technology: prospects for value-added traditionally processed food products. Critical Reviews in Food Science and Nutrition, 1–38. doi:10.1080/10408398.2021.1920

Kohyama, Kaoru (2015). Oral Sensing of Food Properties. Journal of Texture Studies, 46(3), 138–151. doi:10.1111/jtxs.12099

Kuckartz, Udo. (2019). Qualitative Text Analysis: A Systematic Approach. 10.1007/978-3-030-15636-7_8.

Kuo, C. C., Qin, H., Cheng, Y., Jiang, X., & Shi, X. (2021). An integrated manufacturing strategy to fabricate delivery system using gelatin/alginate hybrid hydrogels: 3D printing and freeze-drying. Food Hydrocolloids, 111, 106262.

Kyngas, H. , & Vanhanen, L. (1999). Content analysis as a research method [Finnish]. Hoitotiede, 11, 3-12.

Laureati, M., Sandvik, P., Almli, V. L., Sandell, M., Zeinstra, G., G., Methven, L., Wallner, M., Jilani, H., Alfaro, B. And Prosperio, C. (2020) Individual differences in texture preferences among European children: development and validation of the Child Food Texture Preference Questionnaire (CFTPQ). Food Quality and Preference, 80. 103828. ISSN 0950-3293 doi: https://doi.org/10.1016/j.foodqual.2019.103828

Lipton, Jeffrey & Arnold, Dave & Nigl, Franz & Lopez, Nastassia & Cohen, Dan & Norén, Nils & Lipson, Hod. (2010). Multi-material food printing with complex internal structure suitable for conventional post-processing.

Liu, C & Ho, C & Wang, Jia-Chang. (2018). The development of 3D food printer for printing fibrous meat materials. IOP Conference Series: Materials Science and Engineering. 284. 012019. 10.1088/1757-899X/284/1/012019.

Liu, Z., Zhang, M., Bhandari, B., & Wang, Y. (2017). 3D printing: Printing precision and application in food sector. Trends in Food Science & Technology, 69, 83-94.

Liu, Zhenbin & Zhang, Min & Bhandari, Bhesh & Yang, Chaohui. (2017). Impact of rheological properties of mashed potatoes on 3D printing. Journal of Food Engineering. 220. 10.1016/j.jfoodeng.2017.04.017.

Luo, D., Lin, Z., Li, S., & Liu, S. J. (2017). Effect of nutritional supplement combined with exercise intervention on sarcopenia in the elderly: A meta-analysis. International journal of nursing sciences, 4(4), 389-401.

Malone, Evan & Lipson, Hod. (2007). Fab±Home: The personal desktop fabricator kit. Rapid Prototyping Journal - RAPID PROTOTYPING J. 13. 245-255. 10.1108/13552540710776197.

Manstan, T. and McSweeney, M.B. (2020), Consumers' attitudes towards and acceptance of 3D printed foods in comparison with conventional food products. Int J Food Sci Technol, 55: 323-331. https://doi.org/10.1111/ijfs.14292

Manstan, Tiffany & Chandler, Sarah & McSweeney, Matthew. (2020). Consumers' attitudes towards 3D printed foods after a positive experience: An exploratory study. Journal of Sensory Studies. 36. 10.1111/joss.12619.

Marga, Francoise; Jakab, Karoly; Khatiwala, Chirag; Shepherd, Benjamin; Dorfman, Scott; Hubbard, Bradley; Colbert, Stephen; Gabor, Forgacs (2012). Toward engineering functional organ modules by

additive manufacturing. Biofabrication, 4(2), 022001–. doi:10.1088/1758-5082/4/2/022001

Meijer, G. W., Lähteenmäki, L., Stadler, R. H., & Weiss, J. (2020). Issues surrounding consumer trust and acceptance of existing and emerging food processing technologies. Critical Reviews in Food Science and Nutrition, 1–19.

Mert, W., Suschek-Berger, J., & Tritthart, W. (2008). Consumer acceptance of smart appliances. Smart domestic appliances in sustainable energy systems (Smart-A).

Metcalf, D. A., Wiener, K. K. K., Saliba, A., & Sugden, N. (2021). Evaluating the acceptance of hemp food in Australian adults using the theory of planned behavior and structural equation modelling. Foods, 10(9), 1-14. [2071]. https://doi.org/10.3390/foods10092071

Mingshuang Wang, Dongnan Li, Zhihuan Zang, Xiyun Sun, Hui Tan, Xu Si, Jinlong Tian, Wei Teng, Jiaxin Wang, Qi Liang, Yiwen Bao, Bin Li & Ruihai Liu (2021): 3D food printing: Applications of plant-based materials in extrusion-based food printing, Critical Reviews in Food Science and Nutrition, DOI: 10.1080/10408398.2021.1911929

Nachal, N. & Moses, J.A. & Karthik, Pothiyappan & Chinnaswamy, Anandharamakrishnan. (2019). Applications of 3D Printing in Food Processing. Food Engineering Reviews. 11. 10.1007/s12393-019-09199-8.

OECD/FAO (2018), OECD-FAO Agricultural Outlook 2018-2027, OECD Publishing, Paris/FAO, Rome, https://doi.org/10.1787/agr_outlook-2018-en.

Oral, M. O., Derossi, A., Caporizzi, R., & Severini, C. (2021). Analyzing the most promising innovations in food printing. Programmable food texture and 4D foods. Future Foods, 4, 100093.

Pallottino, F.; Hakola, L.; Costa, C.; Antonucci, F.; Figorilli, S.; Seisto, A.; Menesatti, P. (2016). Printing on Food or Food Printing: a Review. Food and Bioprocess Technology, 9(5), 725–733. doi:10.1007/s11947-016-1692-3

Phuhongsung, Pattarapon & Zhang, Min & Bhandari, Bhesh. (2020). 4D printing of products based on soy protein isolate via microwave heating for flavor development. Food Research International. 137. 109605. 10.1016/j.foodres.2020.109605.

Pereira, Tatiana & Barroso, Sónia & Gil, Maria. (2021). Food Texture Design by 3D Printing: A Review. Foods. 10. 320. 10.3390/foods10020320.

Pérez, Bianca & Nykvist, Hanna & Brøgger, Anja & Larsen, Maria & Falkeborg, Mia. (2019). Impact of macronutrients printability and 3D-printer parameters on 3D-food printing: A review. Food Chemistry. 287. 10.1016/j.foodchem.2019.02.090.

Piyush, Kumar, R., & Kumar, R. (2020). 3D printing of food materials: A state of art review and future applications. Materials Today: Proceedings, 33, 1463-1467.

Pliner, Patricia & Hobden, Karen. (1992). Development of a scale to measure the trait of food neophobia in humans. Appetite. 19. 105-20. 10.1016/0195-6663(92)90014-W.

Porter, K., Phipps, J., Szepkouski, A., Abidi, S. (2015). 3D opportunity serves it up: Additive manufacturing and food. Deloitte University Press. Retrieved December 12, 2021, from https://www2.deloitte.com/content/dam/insights/us/articles/3d-printing-in-the-food-industry/DUP_1147-3D-opportunity-food_MASTER1.pdf

Qingfei, M., Shaobo, J. & Gang, Q. (2008). Mobile Commerce User Acceptance Study in China: A Revised UTAUT Model. Tsinghua Science and Technology, 13 (3), 257-264.

Redefine Meat @ The Media. (2021b, July 5). Redefine Meat. Retrieved January 7, 2022, from https://www.redefinemeat.com/news-media/

Salovaara, Antti & Tamminen, Sakari. (2009). Acceptance or Appropriation? A Design-Oriented Critique of Technology Acceptance Models. 10.1007/978-1-84800-385-9_8.

Sapio, Bartolomeo & Turk, Tomaz & Cornacchia, Michele & Papa, Filomena & Nicolò, Enrico & Livi, Stefano. (2010). Building scenarios of digital television adoption: A pilot study. Technology Analysis & Strategic Management. 22. 43-63. 10.1080/09537320903438054.

Satu Elo; Helvi Kyngäs (2008). The qualitative content analysis process. , 62(1), 107–115. doi:10.1111/j.1365-2648.2007.04569.x

Severini, C., Derossi, A., Ricci, I., Caporizzi, R., Fiore, A. (2017). Printing a blend of fruit and vegetables. New advances on critical variables and shelf life of 3D edible objects. Journal of Food Engineering, S0260877417303643–. doi:10.1016/j.jfoodeng.2017.08.025

Sputnik Türkiye. (2021, December 8). Ankara Üniversitesi'nde 3D yazıcıyla gıda üretildi: "Yapay değil, sağlıklı ve doğal ürünler." https://tr.sputniknews.com/20211208/ankara-universitesinde-3d-yaziciyla-gida-uretildi-yapay-degil-saglikli-ve-dogal-urunler-1051560239.html

Steenhuis, Harm-Jan; Fang, Xin; Ulusemre, Tolga (2018). [IEEE 2018 Portland International Conference on Management of Engineering and Technology (PICMET) - Honolulu, HI (2018.8.19-2018.8.23)] 2018 Portland International Conference on Management of Engineering and Technology (PICMET) - Strategy in 3D Printing of Food. , (), 1–6. doi:10.23919/PICMET.2018.8481817

Sun, J., Peng, Z., Yan, L., Fuh, J., & Hong, G. (2015). 3D food printing an innovative way of mass customization in food fabrication. International Journal of Bioprinting, 1(1), 27-38. doi:http://dx.doi.org/10.18063/IJB.2015.01.006

Sun J., Zhou W., Yan L., Huang D., Lin L.-Y. (2018-03). Extrusion-based food printing for digitalized food design and nutrition control. Journal of

Food Engineering 220 : 1 - 11. ScholarBank@NUS Repository. https://doi.org/10.1016/j.jfoodeng.2017.02.028

SUSHI SINGULARITY. (n.d.). Retrieved January 7, 2022, from https://www.open-meals.com/sushisingularity/index.html

Svanæs, Dag & Seland, Gry. (2004). Putting the users center stage: role playing and low-fi prototyping enable end users to design mobile systems. 479-486. 10.1145/985692.985753.

Tagami, Tatsuaki; Ito, Erina; Kida, Risako; Hirose, Kiyomi; Noda, Takehiro; Ozeki, Tetsuya (2021). 3D printing of gummy drug formulations composed of gelatin and an HPMC-based hydrogel for pediatric use. International Journal of Pharmaceutics, 594(), 120118–. doi:10.1016/j.ijpharm.2020.120118

Tashakkori, A., & Teddlie, C. (2003). Handbook of Mixed Methods in Social and Behavioral Research. Thousand Oaks: Sage.

Tashakkori, A., & Teddlie, C. (2010). SAGE handbook of mixed methods in social & behavioral research (2nd ed.). SAGE Publications, Inc. https://www.doi.org/10.4135/9781506335193

Tibbits , S. (2013) The emergence of 4D printing. TED Conference Retrieved from https://xueshu.baidu.com/usercenter/paper/show?paperid=7aab222d57e25224ddb6f954f98e6e70&site=xueshu_se&hitarticle=1

Tibbits, S. (2014), 4D Printing: Multi-Material Shape Change. Archit Design, 84: 116-121. https://doi.org/10.1002/ad.1710

Tran, Jasper. (2016). 3D-Printed Food. 10.31228/osf.io/qsfvh.

Van der Heijden, H. (2004). User acceptance of hedonic information systems. MIS quarterly, 695-704.

Van der Linden, D. (2015). 3D Food printing Creating shapes and textures. The Netherlands: TNO Innovation for Life.

Varvara, R.-A., Szabo, K., & Vodnar, D. C. (2021). 3D Food Printing: Principles of Obtaining Digitally-Designed Nourishment. Nutrients, 13(10), 3617. MDPI AG. Retrieved from http://dx.doi.org/10.3390/nu13103617

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003) User acceptance of information technology: Toward a unified view. MIS Quarterly 27(3), 425-478.

Venkatesh, Viswanath & Thong, James & Xu, Xin. (2012). Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology. MIS Quarterly. 36. 157-178. 10.2307/41410412.

Webb, T. L., Sheeran, P., & Luszczynska, A. (2009). Planning to break unwanted habits: Habit strength moderates implementation intention effects on behaviour change. British Journal of Social Psychology, 48(3), 507-523.

Whitnall, T., & Pitts, N. (2019). Global trends in meat consumption. Agricultural Commodities, 9(1), 96–

99. https://search.informit.org/doi/10.3316/informit.309517990386547

Wickens, C. D., Barnett, B., Stokes, A., Davis, T. Jr., & Hyman, F. (1989). Expertise, Stress and Pilot Judgment. In AGARD-CP-458: Human behavior in high stress situations in aerospace operations. (pp. 9/1-15). Neuilly Sur Seine, France: AGARD

Wiebe, M. G. (2004). QuornTM Myco-protein - overview of a successful fungal product. Mycologist, 18(1), 17–20. http://doi.org/10.1017/S0269915X04001089.

Wu, Philip. (2011). A Mixed Methods Approach to Technology Acceptance Research. Journal of the Association for Information Systems. 13. 10.17705/1jais.00287.

Wu, Y. L., Tao, Y. H. & Yang, P.C. (2007). Using UTAUT to explore the behavior of 3G mobile communication users. Proceedings of the Industrial Engineering and Engineering Management Conference 2007, (pp. 199-203).

Teng, X., Zhang, M., & Mujumdar, A. S. (2021). 4D printing: Recent advances and proposals in the food sector. Trends in Food Science & Technology.

Tian, Y., Chen, C., Xu, X., Wang, J., Hou, X., Li, K., Lu, X., Shi, H., Lee, E. S., & Jiang, H. B. (2021). A Review of 3D Printing in Dentistry: Technologies, Affecting Factors, and Applications. Scanning, 2021, 9950131. https://doi.org/10.1155/2021/9950131

Zampollo, Francesca. (2012) Designing New Meanings: A Design Method for Eating Design, in Israsena, P., Tangsantikul, J. and Durling, D. (eds.), Research: Uncertainty Contradiction Value - DRS International Conference 2012, 1-4 July, Bangkok, Thailand. https://dl.designresearchsociety.org/drs-conference-papers/drs2012/researchpapers/156

Zampollo, Francesca. (2016). What is Food Design? The complete overview of all Food Design sub-disciplines and how they merge..

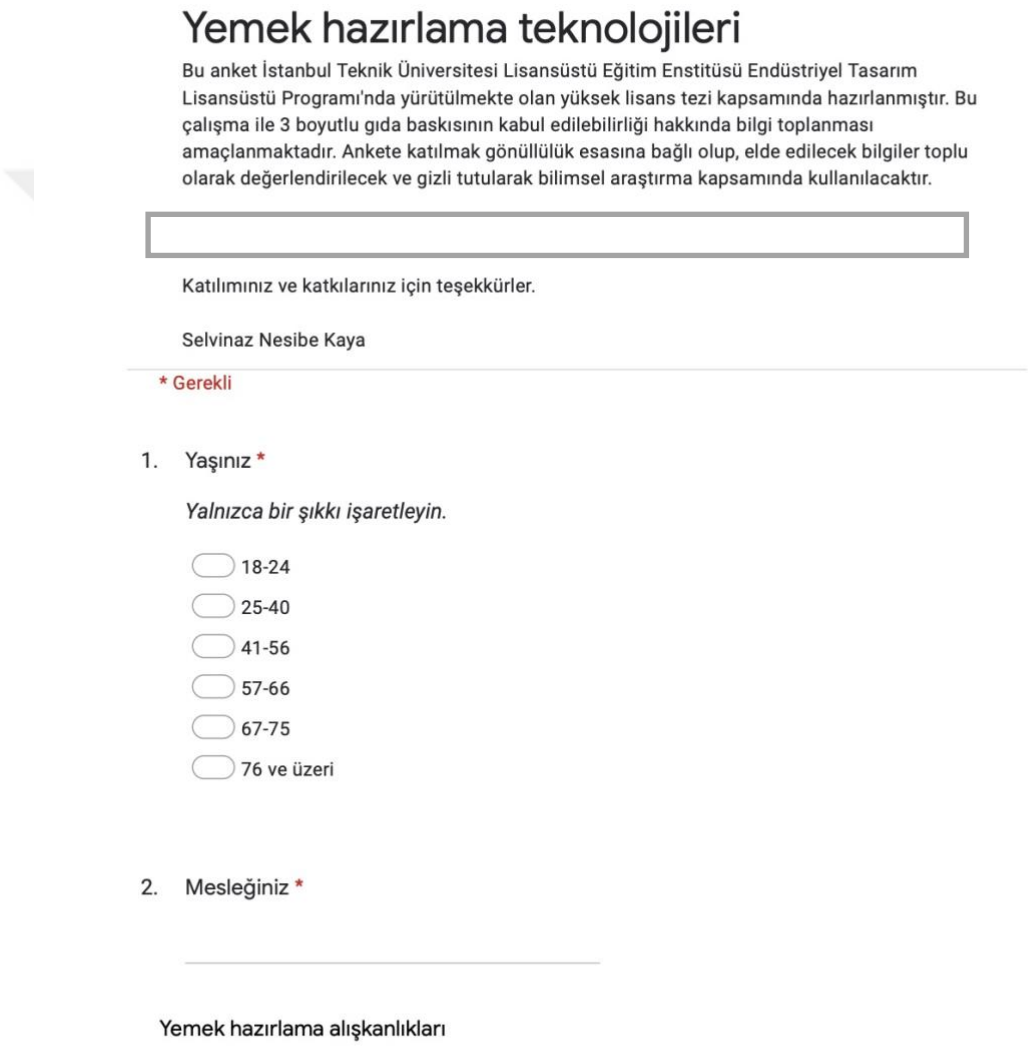
Zhao, L., Zhang, M., Chitrakar, B., & Adhikari, B. (2021). Recent advances in functional 3D printing of foods: A review of functions of ingredients and internal structures. Critical Reviews in Food Science and Nutrition, 61(21), 3489-3503.

Zhou, T. (2011). An empirical examination of initial trust in mobile banking. Internet Research.

Zhu, Sicong & Stieger, Markus & Goot, A.J. & Schutyser, Maarten. (2019). Extrusion-based 3D printing of food pastes: Correlating rheological properties with printing behaviour. Innovative Food Science & Emerging Technologies. 58. 102214. 10.1016/j.ifset.2019.102214.

APPENDICES

APPENDIX A: Survey Questions



Yemek hazırlama teknolojileri

Bu anket İstanbul Teknik Üniversitesi Lisansüstü Eğitim Enstitüsü Endüstriyel Tasarım Lisansüstü Programı'nda yürütülmekte olan yüksek lisans tezi kapsamında hazırlanmıştır. Bu çalışma ile 3 boyutlu gıda baskısının kabul edilebilirliği hakkında bilgi toplanması amaçlanmaktadır. Ankete katılmak gönüllülük esasına bağlı olup, elde edilecek bilgiler toplu olarak değerlendirilecek ve gizli tutularak bilimsel araştırma kapsamında kullanılacaktır.

Katılımınız ve katkılarınız için teşekkürler.

Selvinaz Nesibe Kaya

* Gerekli

1. Yaşınız *

Yalnızca bir şıkkı işaretleyin.

- 18-24
- 25-40
- 41-56
- 57-66
- 67-75
- 76 ve üzeri

2. Mesleğiniz *

Yemek hazırlama alışkanlıkları

Figure A.1: Survey questions.

3. Aşağıdakilerden hangisi size daha uygun bir ifadedir? *

Yalnızca bir şıkkı işaretleyin.

- ◯ Ailemle yaşıyorum
- ◯ Paylaşımlı evde yaşıyorum
- ◯ Yalnız yaşıyorum
- ◯ Diğer: _____

4. Evde yemek yapma sorumluluğunu kim üstlenmektedir? *

Uygun olanların tümünü işaretleyin.

- ☐ Anneniz/Babanız
- ☐ Kendiniz
- ☐ Eşiniz
- ☐ Çalışan/Görevli

Diğer: ☐ _____

5. Evde yemek yapılma sıklığı nedir? *

Yalnızca bir şıkkı işaretleyin.

- ◯ Her gün
- ◯ Haftada birkaç kez
- ◯ Haftada bir
- ◯ Ayda birkaç kez
- ◯ Diğer: _____

Figure A.1 (Continued) : Survey questions.

6. Pandemiden önce evde yemek yapılma sıklığı neydi? *

Yalnızca bir şıkkı işaretleyin.

- ◯ Her gün
- ◯ Haftada birkaç kez
- ◯ Haftada bir
- ◯ Ayda birkaç kez
- ◯ Diğer: _____

7. Bir öğün için yemek hazırlamanız ortalama kaç saat sürmektedir? *

Yalnızca bir şıkkı işaretleyin.

- ◯ 10 dakikadan az
- ◯ 10 dk - 30 dk
- ◯ 30 dk - 1 saat
- ◯ 1-2 saat
- ◯ 2 saatten fazla
- ◯ Diğer: _____

8. Sizin için mutfağınızdaki en teknolojik eşya hangisidir? Neden? *

_____

Figure A.1 (Continued) : Survey questions.

9. Yeni gıda teknolojilerinden aşağıdakilerden hangileri hakkında bilgi sahibisiniz? *

Bilgi sahibi olmadığınızı düşünüyorsanız bu soruyu geçebilirsiniz.

Uygun olanların tümünü işaretleyin.

- [ ] 3 boyutlu gıda yazıcısı
- [ ] Vegan et üretimi
- [ ] Kültür eti
- [ ] Mikrobiyal fermantasyon
- [ ] GDOlu yiyecekler ve CRISPR
- [ ] Nanoteknoloji uygulamaları
- [ ] Hiçbiri hakkında bilgi sahibi değilim
- [ ] Diğer: _____

3 Boyutlu Gıda Yazıcısı Nedir?

Lütfen aşağıdaki soruları yanıtlamadan önce videoyu izleyin.

https://youtu.be/K6VdprTGeqA

http://youtube.com/watch?v=K6VdprTGeqA

Kaynaklar

https://www.youtube.com/watch?v=x6WzyUgbT5A

https://www.youtube.com/watch?v=B0Ty6wgM8KE

Değerlendirme

Aşağıdaki ifadeleri değerlendirerek
1 puan "Kesinlikle katılmıyorum",
2 puan "Katılmıyorum",
3 puan "Kısmen katılıyorum",
4 puan "Katılıyorum",
5 puan "Kesinlikle katılıyorum" ifadelerine karşılık gelecek şekilde sizin için en uygun seçeneği işaretleyiniz.

Figure A.1 (Continued) : Survey questions.

10. 3 Boyutlu gıda yazıcısı kullanabilmek için gerekli bilgiye sahip olduğumu düşünüyorum. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

11. 3 boyutlu gıda yazıcısı kullanmak için gerekli akıllı telefon, tablet veya bilgisayar ve bu cihazlardan birini kullanacak basit cihaz bilgisi gibi kaynaklara sahibim. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

12. Kullanma kılavuzu gibi bir yönlendirmeye ihtiyaç duymadan 3 boyutlu gıda yazıcısı kullanmaya başlayabilirim. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

13. Sosyal çevremdeki insanlar 3 boyutlu gıda yazıcısı kullanmamı olumlu karşılar. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

Figure A.1 (Continued) : Survey questions.

14. 3 boyutlu gıda yazıcısı kullanmak sosyal çevremin beni "teknolojiyle yakından ilgili" olarak görmesini sağlar. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

15. 3 boyutlu gıda yazıcısı kullanarak sosyal çevremde bu teknolojinin tanınması için öncü olurum. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

16. 3 boyutlu gıda yazıcısı kullanmam sosyal ilişkilerimi olumsuz etkilemez. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

17. 3 boyutlu model oluşturup yazıcıdan baskı almanın benim için zor olacağını düşünmüyorum. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

Figure A.1 (Continued) : Survey questions.

18. Yazıcının baskı ayarlarını çevrimiçi bir uygulama üzerinden verilen tarife göre düzenlemenin benim için kolay olacağını düşünüyorum. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

19. İçerikleri baskı için gerekli kıvamda ve tarife göre hazırlamakta zorlanacağımı düşünmüyorum. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

20. 3 boyutlu gıda yazıcısının günlük hayatta kullandığım diğer yemek hazırlama yöntemlerine göre daha kullanışlı olduğunu düşünüyorum. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

21. 3 boyutlu gıda yazıcısının yemek yapma sürecini (malzeme temini, hazırlık, pişirme) hızlandıracağını düşünüyorum. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

Figure A.1 (Continued) : Survey questions.

22. 3 boyutlu gıda yazıcısıyla daha başarılı yemek yapacağımı düşünüyorum. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

23. Yemeğimin 3 boyutlu baskısını almak için modelini oluşturmak eğlenceli olacaktır. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

24. Modelini kendi tasarladığım yiyecekleri elde etmek eğlenceli olacaktır. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

25. 3 boyutlu baskı ile üretilmiş yiyecekleri yemeyi eğlenceli bulurum. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

Figure A.1 (Continued) : Survey questions.

26. Erişimim olduğu takdirde 3 boyutlu gıda yazıcısı kullanmak isterim. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

27. Gelecekte 3 boyutlu gıda yazıcısı kullanacağımı düşünüyorum. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

28. 3 boyutlu gıda yazıcısına sağlıklı yemekler üretilmesi konusunda güvenirim. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

29. 3 boyutlu gıda yazıcısında lezzetli yemekler üretileceğini düşünüyorum. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

Figure A.1 (Continued) : Survey questions.

30. Baskı aşamasını görmesem de 3 boyutlu gıda yazıcısının yiyeceği üretme işlemini doğru yaptığına güvenirim. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

31. 3 boyutlu gıda yazma teknolojisinin ev kazalarına sebep olacağını düşünmüyorum. *

Yalnızca bir şıkkı işaretleyin.

	1	2	3	4	5	
Kesinlikle katılmıyorum	◯	◯	◯	◯	◯	Kesinlikle katılıyorum

32. Gelecekte 3 boyutlu gıda yazma teknolojisinin ne şekilde yönleneceğini, nasıl ve nerelerde kullanılacağını düşünüyorsunuz? *

33. Araştırmanın ikinci kısmında sizinle iletişime geçebilmem için mail adresinizi paylaşır mısınız?

Figure A.1 (Continued) : Survey questions.

34. Yanıtlarınız için teşekkürler. Belirtmek istediğiniz ayrıca bir yorum ya da soru varsa lütfen yazınız.

Bu içerik Google tarafından oluşturulmamış veya onaylanmamıştır.

Google Formlar

Figure A.1 (Continued) : Survey questions.

APPENDIX B: Interview Questions

Görüşme Soruları

Bu görüşmede iki yönden bakarak 3B gıda yazıcısı hakkında konuşacağız: cihaz ve yiyecek.

Mutfakla aranız nasıldır? Son pişirdiğinizi hatırladığınız yemek nedir?

Beslenme alışkanlığınız nasıldır? (vegan vs.)

Yemek yapma sürecinizden bahseder misiniz? (Tarife mi bakar? Annesini mi arar? Kendi mi yapar baştan sona? Tabağı süsler mi?)

Yemek yaparken en zorlandığız noktalar hangileridir? neden?

Daha önce 3 boyutlu yazıcı kullanma deneyiminiz olduysa nerede nasıl tanışıp kullandınız, neler hissettiniz bahseder misiniz?

3 boyutlu yazıcı teknolojisinin kullanıldığı alanlardan biri de gıda baskısı. İlk nerede nasıl duydunuz bu teknolojiyi? Ne hissettirdi size?

-Video-

3 boyutlu gıda yazıcısı kişiye özel besin içerikleriyle kişiselleştirilmiş yiyeceklerle sağlığınıza ve bedeninizin ihtiyaçlarına uygun şekilde beslenmenize olanak sağlar. Çiğneme güçlüğü yaşayan kişiler için uygun formda yiyecek oluşturmak mümkündür. Ayrıca çeşitli modeller, tasarımlar ile elde üretilmesi güç şekillerde yiyecek sunumları hazırlanabilir. Bir diğer kullanım alanı olarak günümüzde 3 boyutlu gıda yazıcısıyla vegan et üretimi ve hayvanların hücrelerinin çoğaltılmasıyla gerçek etin hayvanları kesmeden ve doğaya zarar vermeden et üretmek mümkün hale gelmiştir.
Aşamalar: 3 boyutlu gıda baskısı sürecindeki model seçimi ya da modelleme, malzeme hazırlığı, baskı süreci baskı sonrası işlemler ve son olarak tabakta baskıyla elde edilmiş yiyeceği sunar.

Bu teknoloji ile ilgili ne düşündünüz?

Mutfağınızda nereye yerleştirirdiniz?

Behavioral intention

Gelecekte bu ürünü almak ya da kullanmak hakkında ne düşünüyorsunuz?

Profesyonel mutfak (restoran) ve ev kullanımını karşılaştırdığınızda hangi alanda daha yaygın olacağını düşünüyorsunuz? Neden?

Figure B.2 : Interview questions.

Yakın gelecekte bu ürün sizce yaygınlaşır mı? Kimler tarafından nerelerde kullanılıyor olur? (evdeki durumla ilgili ne düşünüyorsunuz?

Ev kullanımını düşündüğünüzde hangi gıdanın üretiminde daha yaygın göreceğimizi düşünüyorsunuz?

Facilitating conditions

Bu teknolojiden ev tipi ürün çıksa satın alır mısınız? Neden? (pahalı olur/lezzetli olmaz, blender yok…)

Bu cihazdan çıkan gıdayı tüketir misiniz? Neden? (kurabiye yapımını düşünseniz…)

Bu ürünü ilk kez kullanmaya nasıl başlarsınız?

İlk hangi gıdayla başlardınız? Nasıl tüketirdiniz?

Social influence

Bu ürünü almaya kim yönlendirebilir? Neden?

Bu cihazda üretilen gıdayı tüketir dediğiniz kişiler kim olabilir? neden? Bu sizi satın almaya yönlendirir mi?

3 boyutlu gıda yazıcınız var diyelim, ne baskısı almak, bu yemeği kimlerle paylaşmak isterdiniz? Nasıl kullanırdınız? Neden?

3 boyutlu gıda yazıcısı kullansanız sosyal çevrenizin (aile ve arkadaşlarınızın) tepkisi ne olur? Buna benzer çevreniz için yeni bir teknoloji kullandığınız oldu mu? Nasıl tepkiler aldınız?

Effort expectancy

3 boyutlu gıda yazıcısından hangi yemek yapma süreçlerini karşılamasını beklersiniz?
Hangi ürünlerin görevlerini karşılamasını beklersiniz?

Geleneksel yemek hazırlama yöntemleriyle 3 boyutlu gıda baskısı sürecini karşılaştırdığınızda hangi adımların sizi zorlayacağını hangilerinin hayatınızı kolaylaştıracağını düşünüyorsunuz?

Performance expectancy

Bu üründen çıkan gıdaların potansiyel faydaları (yukarıdakilerden örnekler farklı beslenme türlerine özgü vegan et vb.) hakkında düşünceleriniz nedir? Gelecekte hangi sebep sizi 3 boyutlu gıda yazıcısı almaya yönlendirebilir?

Evinizde böyle bir cihaz olduğunu hayal edelim hangi gıdayı bu cihazla elde etmek isterdiniz?

Figure B.2 (Continued) : Interview questions.

Hedonistic motivation

Bu teknolojiyi alıp kullandığınızda nasıl hissedersiniz?

Bu teknoloji hakkında size ilgi çekici heyecanlandırıcı gelen noktalar nelerdir? Neden?

Bu üründen çıkan gıdayı tüketirken nasıl hissedersiniz? Bu gıdalarla ilgili ilgi çekici, heyecanlandırıcı noktalar nelerdir?

Trust

Bu teknolojiyi evinize alırken çekinceniz olur mu?

Bu ürünü kullanıyor olsanız üreteceği gıdanın lezzet, içerik ve form bakımından güvenilirliği hakkında ne düşünürsünüz?

Figure B.2 (Continued) : Interview questions.

APPENDIX C: Explanatory Video

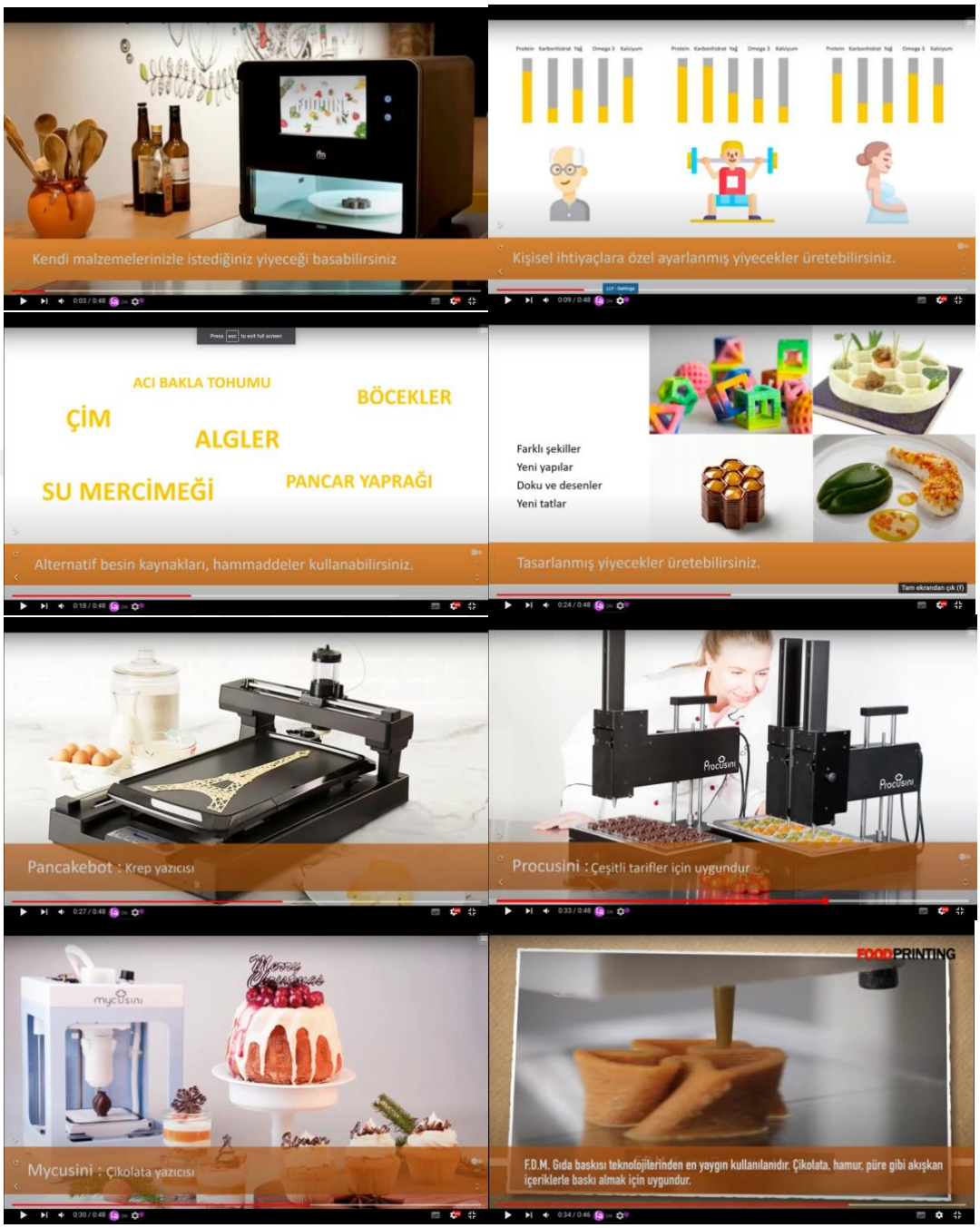


Figure C.3 : Screenshots from the video.

CURRICULUM VITAE

PHOTO

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Place and Date of Birth **:**

E-Mail **:**

EDUCATION:

- **B.Sc.** **:** 2018, Middle East Technical University, Faculty of Architecture, Department of Industrial Design

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- 2021-2022 ISTANBUL Mikro Group A.Ş

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