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Table of Contents

1. Introduction

"Download your preferred design, choose the material you want and send it directly to the Focus 3D food printer. Easy as 1, 2, 3!"

The Website of byFlow[1]

Imagine in kitchens of the future, you will not need your current kitchenware, equipments and cooking skills to make a dish. All you need will be a 3D food printer. You will get to download recipes online, click "print" on the computer, and voila, your meal will be printed and ready for eating. In that case, preparing food will not be the same with 3D food printers available. The first 3D-printed food occurred in the 2000s (Brunner, Delley & Denkel, 2018). Up until recently, 3D food printing still remains a novel food technology. Consequently, in the news reports about the uses of 3D food printing, positive and promissory aspects tended to be highlighted; for instance, the applications of 3D food printers were depicted as futuristic, creative, healthy, efficient, and sustainable options for making foods (Lupton, 2017). There have been some social studies conducted on 3D food printing regarding sociotechnical imaginaries in the online news media (Lupton, 2017) and on consumer reactions (Lupton & Turner, 2016) as well as consumer attitudes (Lupton & Turner, 2018; Brunner et al., 2018) towards 3D food printing. However, developers' perspectives on 3D food printing uses and users remain invisible. Therefore, the research aim of this study is to identify and evaluate how the uses and users are scripted and configured by the developers of 3D food printing technology on their official websites as well as in their promotional videos. This chapter will start with an introduction to the background and context of 3D food printing technology, followed by the research problem, aims, questions, significance as well as the limitations.

Unlike traditional subtractive ways of manufacturing, 3D food printers print additively in a layer-by-layer manner that does not require cutting or removing materials, it is considered more efficient and economical for manufacturing (Yang, Zhang, Bhandari, 2017). 3D food printing is often accentuated with its efficiency. It is claimed that 3D food printing could help reduce the need for labour, which could be beneficial to aging societies (Campbell, Williams, Ivanova & Garrett, 2011). Similarly, 3D food printers are depicted as an efficient device with simple download and printing steps that provides home cooks and people in emergent conditions like soldiers and refugees who seek convenience and time-

[1] [The Focus 3D food printer: easy to connect]. (n.d.). byFlow. Retrieved July 28, 2018, from https://www.3dbyflow.com

saving ways to make foods; therefore, they are often assimilated with home kitchen appliances such as waffle makers and ovens (Lupton, 2017).

Other than the efficiency aspect, 3D food printing is also emphasized by its creative potentials. In the news reports, 3D food printing is often viewed as an innovative, novel and revolutionary technology that could elevate food industries (Lupton, 2017). Since 3D food printers print additively, as long as the computer designs and printing-friendly consistencies of food ingredients allow, any food designs can be printed, liberating users from traditional ways of manufacturing that were confined by the capabilities of making by hand and molds (Campbell et al., 2011). Instructed digitally, digital gastronomy provides a new space for experimenting on creating new shapes, flavors, textures and scents (Zoran & Coelho, 2011).

Apart from efficiency and creative potentials, the health potential of 3D food printing are often accentuated too. With digital instruction, the shaping capability of 3D food printing is regarded useful to make vegetables look more tempting in intricate shapes; for instance, children are more likely to eat 3D printed vegetables in attractive shapes than regular vegetables (Lupton, 2017). Other than intricate shapes, being able to control precisely with digital information, based on individual demands on nutritions, 3D food printers can print food in personalized portions and nutritional requirements (Yang et al., 2017). All in all, digitalized gastronomy of 3D food printing can provide easier access to make more precise nutritional and textural adjustments for eating healthier (Zoran & Coelho, 2011).

Aside from the potentials of efficiency, creativity and health benefits, 3D food printing is often related to the potentials of social contribution towards sustainability. Inscribed to print with alternative food ingredients such as insects, algae, cultured meat, and so forth, they may help alleviate food shortage problems by reconstructing more sustainable food sources like insects that were traditionally less acceptable to the general public into more appetizing food (Gorkin & Dodds, 2013; Mims, 2013; Yang et al., 2017). In the study of Lupton (2017), she also discovers that the news reports about 3D food printing overlaps with cultured meat when it is associated with global problems about food and environmental sustainability. Moreover, manufacturing food additively rather than in a substrative manner that requires removing materials and becoming inevitably wasteful, 3D food printing can avoid the wastes caused by subtractive manufacturing, so 3D food printing is regarded to be inherently green (Campbell, 2011). Last but not least, since food can be reconstructed with 3D food printing, 3D food printers are considered having potentials in reducing food waste caused by tossing ugly food away, because ugly food were given a second life when being 3D-printed in attractive shapes (Lupton & Turner, 2016).

However, despite the promissory potentials of 3D food printing, it is discovered in the work of Lupton & Turner (2016) that consumers are generally skeptical towards the use and the value of 3D food printing. The negative responses from the consumers offer opportunities to reflect on food in our daily lives. By reflecting and addressing the concerns of the consumers, it may help to better communicate with the consumers in order for them to feel more acceptive towards 3D food printing. In particular, based on the consumer responses and opinions on 3D food printing, the reformulations of the uses as well as the users of 3D food printers are necessary for the further developments and more acceptance of the novel food technology. The uses and purposes of 3D food printing technology still remain fluid and open for being shaped until the technology itself and the food it makes become normalized and prevalent (Lupton & Turner, 2018).

Still being developed, the prices of 3D food printers remain high in comparison with other common kitchen appliances, and 3D food printers still operate quite slowly and have limited functions (Reeves, 2014; Sun et al., 2015; Lupton, 2017). It was identified that the benefits and promises of 3D food printing were often emphasized, whereas its potential disadvantages and danger remain absent in online news media; however, the promissory claims about 3D food printing are often located in the speculative future (Lupton, 2017). Novel food technologies such as GM (genetically modified) foods have been seen as “Frankenfoods” and faced with anti-GM movements despite their potentials for social contributions, and cultured meat has often aroused unsettled feelings and disgust too (Verbeke, Marcu, Rutsaert, Gaspar, Seibt, Fletcher & Barnett, 2015). However, as a novel food technology, 3D food printing is often associated positively in online news accounts (Lupton, 2017).

It is discovered in the literature that how 3D food printing is expected to be useful in certain uses is inconsistent with how consumers think about those uses indicate. The uses and meanings of 3D food printing still require further configuration. Since the expected uses and users do not go hand in hand with how consumers think about the anticipated uses and users because the expected uses and users are presented to be more promissory in online news, it would be interesting to investigate the perspectives of 3D food printing developers. In particular, it would be intriguing to learn how the developers of 3D food printers script the uses and users to their potential customers when they already target to sell the 3D food printers rather than just the future potentials of the novel food technology.

In the social researches of the reviewed literature on 3D food printing, the studies have covered from the sociotechnical imaginaries in the online news media (Lupton, 2017) and on consumer reactions (Lupton & Turner, 2016) as well as consumer attitudes (Lupton & Turner, 2018; Brunner et al., 2018). While the online news accounts and the sociotechnical imaginaries constructed in the news reports might be infused with the expectations of various actors such as entrepreneurs, news reporters, and so on, the expectations of 3D food printing uses and users might be expanded and more optimistic than reality. As for the studies on consumer reactions and attitudes, they could serve as reflections on the uses, users and meaning of 3D food printing. An investigation on the developers' perspective on the uses and users of 3D food printing could enrich the understanding of social studies on the novel food technology, because it enables a closer and more realistic take of how the technology could make sense in daily lives.

Given the lack of social research on how the developers of 3D food printing make sense of the novel food technology, this study will aim to identify and evaluate how the uses and users are scripted and configured by the developers of 3D food printing technology on their official websites as well as in their promotional videos. The chosen developers of 3D food printing included BeeHex, Procusini, byFlow, Food Ink and Natural Machines. The selected developers are all located in the Western world. The objective of the research is to identify how the uses, the users and the promises of societal contributions are presented by the developers in order to for them to make sense of this novel food technology. Particularly, how are the uses of 3D food printers framed in relation to conventional food preparation by the developers? How are the users of 3D food printers conceived by the developers? What do the developers expect or promise 3D food printers to contribute to the society? In the developers' depictions about uses and users of 3D food printing, how does the future interact with the present time? These questions will serve as main foci of investigation when studying the official websites and videos made by the developers.

This study will contribute to the social studies on 3D food printing, providing an understanding on how the developers make sense of the uses and users of the novel food technology. This will help address the current shortage of researches from the perspectives of developers on 3D food printing. Nevertheless, it should be noted that to make this study manageable and feasible for a master's thesis, the study scope is confined by the number and materials of the selected developers and the regions they are located in. The generated results and findings may not necessarily be able to be generalized to all the developers or in all the regions. Moreover, since this study will be conducted with qualitative methodological approaches, the study results can be subjective. However, the qualitative approaches also allow more in-depth understandings. Overall, the research design aims to provide some understandings on how the developers make sense of a novel technology with its uses and users. Although the findings could be subjective due to the research scope and methodological approaches, this study aims to provide a missing piece for the social studies on the developers' take on 3D food printing and how they make sense of the novel food technology.

In chapter one, the context of the study has been introduced. The research problem, questions have been presented. The value of this research has been justified, and the limitations have also been explained.

In chapter two, the literature about 3D food printing will be reviewed by first giving an overview about 3D food printing as a novel food technology, followed by the recurring themes about 3D food printing, consumer attitudes towards 3D food printing, being a novel food technology in the making and the uses and users to be configured.

In chapter three, the sensitizing concepts used for analysis will be introduced. The concepts consisted in two major categories. In the category of uses and uses in design practices of technology, the concepts of “configuration,” “bi-directional configurations of users,” “scripting users as well as uses” and “users as consumer-citizens” will be included. For the second category regarding sociology of expectations, the “performativity of expectations,” “unfulfilled expectations," “temporal and socio-spatial variances of expectations” will be discussed.

In chapter four and five, the research questions and methodological approaches will be presented. How and what materials are selected as well as preliminary preparation for analysis will first be illustrated. Then, how combining “qualitative content analysis” as the main methodological approach and “multimodal critical discourse analysis” as an auxiliary approach will be in practice will be explained, followed by the section of the overall design of the analysis.

In chapter six, the study results and analysis will be discussed. The first section will be about the digitalized food production of 3D food printing. The second section will center around the creative, fun and attractive potentials of 3D food printing. The third section will be on the health aspect of 3D food printing. As for the last section will be how the expectations of 3D food printing are formulated in relation to the present time and the future.

In chapter seven, the study will be concluded by summarizing the key research findings relevant to the research aim and questions. Additionally, reflections on the contribution as well as the limitation of this study will be discussed in order to propose opportunities for future researches.

2. State of the Art

This chapter reviews the current discussions and research studies relevant to 3D food printing technology. To give a general understanding, it begins with an introductory section about 3D food printing, from its historical background, its technical operation to the private companies as well as the public organizations that have been involved in the development of 3D food printing. The second aspect of this chapter delves into the recurring themes of 3D food printing mentioned in the literature, highlighting the often-emphasized benefits and promises of 3D food printing. Inspired by the work of Lupton (2017), the specified four themes are: “increased efficiency,” “benefits to health,” “promotion of creativity” and “contribution to sustainability.” After looking into the positive themes of 3D food printing, the next section inspects the studies on consumer attitudes towards 3D printed food, in order to have a better understanding towards consumer acceptance of 3D food printing. The section covers from the positive, the ambivalent to the negative consumer attitudes towards the novel food technology. The concept of “being natural” and implications of consumer attitudes will also be indicated. Lastly, drawing from the literature, the final section delineates how 3D food printing is still a novel food technology in the making. The functionality and the legislation still require further developments and establishments. Moreover, the future benefits and promises serve as a guiding framework, leading the developments of 3D food printing technology. The literature reviewed informs that the uses and the users of 3D food printing, oftentimes intertwined with the future, are still in the preliminary phase waiting to be constructed.

2.1. About the Novel Food Technology—3D Food Printing

Digitally printing images or texts on two-dimensional surfaces have transformed the efficiency and quality of idea-transmission. Books that are digitally printed, for example, have been replicated faster than ever, allowing ideas to permeate more broadly. With printers prevalent at homes and offices, Digital 2D printing has offered greater chances to share ideas than transcribing with hands, movable-type printing and typewriters could ever achieve. Extending the dimensions of printing, the novel “three-dimensional printing” technology offers even more potentials than traditional printing in two dimensions. 3D printing, which was first applied in the 1980s for industrial prototyping (Savini & Savini, 2015, as cited in Brunner et al., 2018), has become a more rapid way to create prototypes than traditional modeling. Unlike traditional printers which can only print with ink on surfaces, 3D printers can print with various kinds of materials such as plastics, metal and even food ingredients. Materials are printed in a layer-by-layer manner, making 3D printing an additive manufacturing method to create an object (Yang et al., 2017).

Although 3D printing was already applied in the the 1980s, the application of printing with food ingredients did not occur until in the 2000s (Brunner et al., 2018). 3D food printing begins with digitally designing or scanning an object, and then the digital object will become a computer-aided design (CAD) file which allows 3D food printers to be digitally instructed to extrude food ingredients one layer after another, until the shape of the designed object is fully formed (Tran, 2016; Lupton & Turner, 2016). Extrusion-based printing, inkjet printing and binder jetting are the main three types of 3D food printing techniques available now, and each technique has different strengths and disadvantages when it comes to printing different properties of materials such paste, liquid and solid ingredients (Pitayachava, Sanklong &Thongrak, 2018). What distinguishes 3D food printing from traditional ways of making food creations is its digitalization. Not only do digital designs and instructions allow 3D food printers to make food shapes in high precision that are difficult or even impossible to make by hand or molds, but they also transform manual food creations into digital and mechanical food creations.

However, what 3D food printers can offer now is still limited. One can argue that getting food from a McDonald's self-oder kiosk is much faster and easier than from a 3D food printer. Getting a hamburger, for example, one might imagine selecting a hamburger on the interface of a 3D food printer or a computer, and voila, a hamburger appears ready to be eaten. It does not work as simple as that currently. With most available 3D food printers now, one needs to switch the cartridges of different ingredients for printing different parts of a hamburger if only one but not multiple extruders can be instructed at a time. Layers of dough, a layer of meat paste, a layer of cheese and a layer of sauce such as ketchup are printed respectively. Moreover, the ingredients have to be heated up with an oven or a pan if the heating platform and heated extruder of the 3D food printer cannot achieve the expected cooking results. Currently, most 3D food printers cannot operate all steps at once, and printable food materials are limited. 3D food printing still does not work as convenient as clicking on the interface of a self-service kiosk at McDonald's and picking at the counter where employees would bring you the food soon afterwards. It takes quite some amount of time and effort to make food with 3D food printers, longer and more efforts than ordering fast food.

3D printing a food creation has not exactly been an effortless task. What is more, what 3D food printers can make is highly limited by the materials that can be used for printing. In order to be printed and form certain shapes, the foodstuffs must be molten, flowable, pliable and viscous, so they can be extruded from nozzles and uphold the intended shapes after layers of printing (Yang et al., 2017; Khot, Lupton, Dolejsova & Mueller, 2017; Lupton, 2017). Consequently, edible materials such as chocolate, dough, batter, cheese, hummus, cake frosting, marzipan, and the like, are applicable for 3D printing desserts, pizza bases, pancakes, cookies, and so on (Cohen, Jeffrey, Cutler, Coulter, Vesco & Lipson, 2009, as cited in Sun, Peng, Zhou, Fuh, Hong & Chiu, 2015; Khot et al., 2017). While food ingredients that are universal in daily diets, such as rice, vegetables, fruits and meat, are not naturally printable with 3D food printers, they usually require to be turned into purees and pastes beforehand in order to be printed (Sun et al., 2015; Lupton & Turner, 2018). Moreover, hydrocolloids, such as xanthan gum, carrageenan, gum arabic and gelatin, are sometimes added as thickening and gelling agents to make ingredients like vegetables and meat more printable and to achieve certain textures and structures (Yang et al., 2017). Last but not least, different cooking times and temperatures of different food ingredients are also technical difficulties that 3D food printing has to find solutions to when mixing ingredients together, since different food ingredients have different heat resistance as well as cooking properties (Khot et al., 2017; Yang et al., 2017).

Despite technical limitations of 3D food printing at the moment, numerous companies and research labs have begun developing 3D food printers in food production. For instance, Choc Edge Ltd is a company that designs, manufactures and sells 3D chocolate printers. Unlike many other generic companies of 3D printers aiming at designers or hobbyists, Choc Edge targets at professionals like chocolatiers and confectioners (Choc Edge, 2018). Natural Machines has also been developing a 3D food printer called Foodini which is claimed to be the first 3D printer to print all types of real, fresh, nutritious savory foods to sweets, making Foodini the first 3D food printer kitchen appliance to contribute to to a healthy eating lifestyle (Natural Machines, 2018). The Barilla pasta company has also worked with TNO, a Dutch scientific research organization, on a customized 3D pasta printer; in addition, Barilla also held 3D modeling contests for designing unique shapes for pasta (Molitch-Hou, 2014).

Apart from independent companies and organizations, publicly funded research and innovation agencies have also taken part in developing 3D food printing. The company BeeHex that developed the “Chef 3D” printer was funded by a grant from NASA. The original purpose of the fund was hoped to allow astronauts to select and cook delicious food when they were on missions (Bindi, 2017) . Furthermore, BeeHex also received a grant from the U.S army to develop 3D food printers in regard to personalized nutrition (BeeHex, 2018). NASA has not been the only public agency interested in 3D food printing. In Europe, funded by the European Commission with up to 3 million euros, the PERFORMANCE (**PER**sonalised **FO**od using **R**apid **MA**nufacturing for the **N**utrition of elderly **C**onsum**E**rs) project has been developing 3D printed foods to help elderly people who have dysphagia tackle their swallowing problems (European Commission, 2015).

2.2. Recurring Themes of 3D Food Printing Technology

2.2.1. Increased Efficiency & 3D Food Printing

There are several attributes of 3D food printing that are often emphasized; for example, “increasing efficiency,” “contributing to health” and “promoting creativity” are frequently mentioned attributes of 3D food printing. First and foremost, how 3D food printing can increase efficiency is often talked about when it comes to the technology. Unlike traditional ways of making that are subtractive and require cutting and removing parts to form certain shapes, 3D food printing creates in an additive manner, which makes it easier to make food in intricate shapes, and it is in itself more efficient and economical since it does not require subtractive steps (Yang et al., 2017). Furthermore, digitally-instructed steps operated by 3D food printers can replace manual work and save labour costs for making food. (Campbell et al., 2011) claims that the reduced need for labour can benefit aging societies. In the study which identifies the promissory themes of 3D food printing in online news media, Lupton (2017) finds that 3D food printing is depicted to provide efficiency for home cooks, people in emergent conditions and even the food industry. Targeting at busy home cooks and people in emergent conditions such as soldiers and refugees who seek convenience and time-saving approaches to make food, 3D food printers are envisioned to provide a meal by simple downloading and printing, which parallels with other home kitchen appliances such as oven and waffle makers which make food preparation more convenient (Lupton, 2017). People who are in need of easy and quick ways of making food are imagined to be the beneficiaries of 3D food printing.

As for the food industry, Lupton (2017) finds that, in some online news, it is claimed that 3D food printing will make storage, transportation and preparation more efficient for food industry in general. The efficiency derives from the switch from offering food objects to offering digital food designs. In the future, what supermarkets sell can be digital food recipes that customers download and print at home rather than ready-made food products (Khot et al., 2017). This denotes the potential of the 3D food printing to reshape food industry, from the way people do grocery shopping, preparing food to cooking, because 3D printing will allow more localized food production near end customers. (Sun et al., 2015; Tran, 2016). From food assembly lines to the whole food supply chains can be reconfigured and become more localized with less carbon footprint and customized for users' preferences (Campbell et al. 2011; Sun et al. 2015). As promising as how 3D food printing can bring efficiency in certain aspects, it should be noticed that there are many preconditions for efficiency to exist. For example, 3D food printers should be able to print and cook a proper meal at ease, and 3D food printers should become prevalent appliances.

The intended uses and users of 3D food printing are, at this moment, preconceived. Currently, 3D food printing is more for decorating food than making a meal, and 3D food printers have not been universally applied in home kitchens and restaurants like ovens and microwaves.

2.2.2. Benefits to Health & 3D Food Printing

Other than the attribute of efficiency, benefiting health is another attribute of 3D food printing that is often underlined. Due to the reason that 3D food printers operate digitally and are capable of printing intricate shapes that are hard or even impossible to make by hand, the shaping capability is regarded as an invaluable contribution to health; for instance, children who dislike vegetables are more likely to eat vegetables in tempting shapes (Lupton, 2017). Combining with fresh and nutritious ingredients, the ability of 3D food printers to print customized shapes of food is seen as a contribution to healthy eating for users like children. Other than the customization at an aesthetic level that can be related to an healthy way of eating, customization can also be applied to achieve practical purposes such as to meet nutritional and textural requirements, which can help users to eat healthier. 3D food printing can provide customized needs and preferences for different users. Different age groups, people of different occupations, expectant mothers, children, people of different genotypes and health statuses require different nutritional intakes, and 3D food printers are expected to provide personalized food for them with a precise digital control of food printing (Dankar, Haddarah, Omar, Sepulcre & Pujola, 2018). Based on individual requirements of nutritions, 3D food printers can make food in personalized compositions and portions, printing food of tailor-made calories, added macronutrients and micronutrients in required amounts (Yang et al., 2017).

Other than nutritional customization, 3D food printing is expected to customize textures and shapes as well. For the elderly people who have trouble chewing and swallowing, 3D food printers can print reconstructed food that are easier to consume, such as puree (Pearse, 2014). For instance, fish can be reconstructed and printed with fish puree in the shape or fish or other appealing shapes. 3D food printing can provide the elderly and people with dysphagia with more appealing food options other than unappetizing mush. The customization that 3D food printers provide stems from digitalized information of nutritions, quantity, consistency and other food details. In an information-driven food culture, digitalized gastronomy provides easier access to make more precise nutritional and textural adjustments for healthy eating (Zoran & Coelho, 2011). With digital data, one can easily select nutritional properties and consistencies in the printed food for personal health.

Traditionally, manufacturing customized food can be pricey. However, operated in an additive manner and with digital control, 3D printing customized food does not require subtractive steps as in traditional molding, which can reduce the production cost for customizing food products in intended shapes (Sun et al., 2015). Consequently, 3D food printing is deemed as a technology that has the potential to democratize customized food products, transforming mass production to mass customization without much additional production cost (Campbell et al., 2011; Dankar et al., 2018). Campbell et al. (2011) claim that 3D printing has the potential to be a disruptive technology like personal computers and the internet have been. It should be noticed, however, the uses of 3D food printers for customization aim eminently at shaping capability. With users like children who dislike vegetables and people of dysphagia in mind, 3D food printers are targeted at printing in attractive shapes in order to make users eat what originally looked unappetizing to them. The space opened up for innovative and customized 3D printed food has been very specific so far.

Even though it is anticipated that 3D food printing can cater to customized nutritions, it is debatable whether customized nutritions can only be achieved via 3D food printing since nutritional customization is determined by what food ingredients are put in the tube for printing. That is to say, nutritional customization does not necessarily require 3D food printers to fulfill. Likewise, to what extent can 3D food printers customize food textures is still unclear. Not only is texture determined by the chosen food ingredients rather than printing process per se, but what can be extruded through nozzle is also very limited at this moment since only paste kind of texture can be extruded to form shapes. Consequently, with pricey 3D food printers which mainly have shaping capacity but not much more to offer at the moment, it is disputable whether 3D food printers will transform mass production to mass customization. It is also questionable whether the additional production cost saved is worth paying for expensive 3D food printers. However, regardless of the expensive costs of 3D food printers, the use of 3D food printers to customize with health benefit for certain users is often emphasized.

2.2.3. Promotion of Creativity & 3D Food Printing

Aside from customization with 3D food printers which can contribute to health, 3D food printing is also often associated with promoting users' creativity. Manufactured in an additive manner, whatever can be designed on a computer can be printed with 3D food printers, which liberates users to 3D-print food what they could not make via traditional ways of manufacturing (Campbell et al., 2011). In the work of Zoran & Coelho (2011), they mention that with digital instructions, it is anticipated that 3D food printers would generate not only new shapes of food but also new flavors, textures and scents of food creations which cannot be achieved via traditional ways of cooking. They think that digital gastronomy provides a new space for a faster and more capable fabrication of food, offering designers a more efficient access to experiments and new food creations. As Yang et al. (2017) point out in their research, 3D food printing has the potential to impact the process of food preparation and dining experiences, which might revolutionize the ways how food is prepared, food economy in general as well as food culture at large.

In the study of Lupton (2017), she discover that in many news reports, 3D food printing was often labelled as “innovative,” “novel” and “revolutionary” technology that could elevate haute cuisine in high-end restaurants. 3D food printing is expected to provide creative elements for fine dining experiences. Creative use of 3D food printers is not only applied in haute cuisine. A Japanese 3D-printing company “FabCafe” offered to 3D-scan the head of a person and then 3D-print the face with chocolate (Wainwright, 2013). One can customize their own chocolates by 3D-scanning and 3D-printing. Similarly, in the Edipulse project (Khot, Pennings & Mueller, 2015), 3D printed chocolate messages and emoticons were applied to make physical activities more engaging, converting data of physical activity into multi-sensory experiences. In the project, heart rate data measured by wearable devices were extracted to examine the duration and intensity of the monitored physical activities. Based on the duration of activity, if the duration did not match the goal, cheerful messages 3D-printed with chocolate would be incomplete (e.g. “well done, mate” appeared as “well” only), which incentivized the participants to keep exercising until meeting the set goal. Moreover, EdiPulse also printed emoticons based on heart rates. Chocolates in the shape of smiling face would be printed with fast heart rates from intense activities. Khot et al. (2015) utilized abstract physical activity data to 3D-printed chocolate, bringing visual, tactual, smelling and tasting sensory experiences together, offering a creative way to engage in exercises. EdiPulse was an example of 3D food printers used to promote user’s creativity.

2.2.4. Contribution to Sustainability & 3D Food Printing

The innovative applications of 3D food printers are not limited to printing new shapes, flavors, textures and engaging users in activities. 3D food printers are also inscribed to print with alternative food materials, such as insects, algae, duckweed, grass, lupine seeds, beet leaves and cultured meat (Gorkin & Dodds, 2013; Mims, 2013). With growing global population and the possibility of food shortage, the ability of 3D printers to form attractive shapes can be used to transform sustainable food sources like insects that are traditionally less acceptable to the general public into more appealing food (Yang et al., 2017). That way, the crops grown for livestocks such as cow, pigs and chicken can be reduced, and the crops can be used to feed more population. At the same time, greenhouse gas emissions can be reduced too. 3D food printing technology is expected to contribute to food and environmental sustainability by applying food resources like insects and algae to solve potential food shortage and environmental issues in the future.

Similarly, 3D food printers are inscribed to print cultured meat to tackle with growing population (Gorkin & Dodds, 2013). There are many substitute names for cultured meat; for instance, in vitro meat, cultivated meat, test tube meat, labchops, meat outside animal bodies, meat 2.0, cruelty-free meat, victimless meat (Jönsson, 2016). Apart from the sake of animals' welfare and no killings, some people choose the path of vegetarian or vegan for taking actions to alleviate environmental issues such as global warming. Livestock industries had negative impacts to our environment due to the energy use, water use and animals per se and so on caused by the industries. The crops grown to feed animals generated much CO_2, and the livestocks also produced methane and nitrous oxide, which intensify the greenhouse effect. As in vitro meat involves lower energy use and water use than beef, pork and so on produce (Jönsson, 2016), it might be an alternative to mitigate greenhouse effect, water pollution, and some other environmental problems. Moreover, as global population has grown rapidly, it is predicted that in the future there might not be enough crops to feed human beings, let alone animals. Meat supply that relies on killing livestocks will very likely not meet the demand for it. In vitro meat are likely to fill in that void if it will become inexpensive and universal. In the study of Lupton (2017), she finds that there are overlaps between 3D printed food and cultured meat in news reports when it comes global problems related to food and environmental sustainability. The application of 3D food printers in printing cultured meat in appealing shapes situates 3D food printing technology as a potential contribution to food sustainability and solution to environmental problems.

3D printing in general is often labelled as a contribution to environmental as well as economic sustainability. The materials that are removed in traditional subtractive processes become wasteful, but those wastes could be avoided in additive manufacturing processes of 3D printing, which renders 3D printing inherently green (Campbell, 2011). This can be narrowed down and applied to 3D food printing as well. In the case of confectionery, for instance, 3D printers can print a wedding cake in the targeted shape directly, without having to remove certain parts that would become wastes. In addition, 3D food printing is accredited with the potential to avoid food waste caused by throwing away ugly food produce (Lupton & Turner, 2016). When imperfect food produce are turned into food puree for 3D printing in attractive shapes, this can save ugly food produce from being thrown away, reducing food waste.

Moreover, 3D printing allows users to manufacture at home or closer to where they are, which can reduce or even skip the need for inventory, storage, packaging, distribution and even overseas transportation, turning a complicated supply chain into a more efficient one and reducing carbon emissions along the process (Campbell, 2011; Reeves, 2014). It is argued by Unruh (2018) that systematic level changes brought about by 3D printing technology in general, guided by circular economic principles, have the potential to transform current manufacture industry into a more circular economic manner, making manufacture industry more environmentally sustainable. The potentials of food sustainability and making contributions to the environment are recurrent remarks of 3D food printing technology, especially when it comes to applying alternative food sources such as insects and cultured meat for 3D food printing, the green nature of additive manufacturing and potential systematic change of food supply chain and industry.

2.3. Consumer Attitudes towards 3D Food Printing

2.3.1. 3D Food Printing As Another Way of Manufacturing Food

Promissory attributes of 3D food printing, such as providing efficiency for making food, customization for health, space for creativity and sustainable potentials, are emphasized to put the technology in the positive light. Nonetheless, as a novel food technology, the consumers' acceptance of 3D food printing is also pivotal to the development of the technology. In the cases of 3D printing pasta in rose shape by the renowned pasta brand Barilla, people are more acceptant, commenting on the 3D printed pasta as "looking tasty," "like normal pasta," "attractive" and even "beautiful," because printing pasta is not too different from mass-manufacture pasta in factories (Lupton & Turner, 2018). There have already been various kinds of pasta being manufactured without 3D food printers, from penne, elbows, cellentani to rotini pasta made from machines in factories, so rose-shaped pasta made from 3D food printer are not too alien for consumers to accept.

Similar responses are received when it comes to 3D printed chocolates. Participants in the study of Lupton & Turner (2018) comment on 3D printed chocolates as "really beautiful," "impressive," "delicious because they are made from real chocolate" and "just another version of making chocolate other than molded in different shapes." In the cases of pasta and chocolates, the application of 3D food printers in making them is generally positive for two main reasons. First, the shapes of pasta and chocolate have been played around and made creative for quite some time. New shape designs of pasta and chocolate would not be too bizarre to accept. Second, 3D food printers are seen as another choice of machines other than traditional machines or molds.

2.3.2. The Concept of “Being Natural” and 3D Printed Food

Although 3D printed pasta and chocolate generally receive more positive responses from consumers, positive responses are not universal. Some 3D printed food gain ambivalent feedbacks instead. 3D printed pizzas, for instance, some people consider them to be similar to real pizzas, whereas as some people regard them to be not the same as real pizzas because they are made by 3D printers (Lupton & Turner, 2018). Similarly, 3D printed carrots receive both positive and negative responses. There are people giving positive feedbacks to 3D printed carrots in appealing shapes for those who suffer from dysphagia, and they recognize printing with carrot puree as a natural and healthy choice like having a standard carrot (Lupton & Turner, 2018), but there are also people giving unfavorable remarks:

> *“It’s probably pretty expensive, and there might be extra artificial ingredients and additives in there that may not be the healthiest ... [It] can’t possibly be as healthy. It would either be the same, or worse. Like how can you beat a carrot with a printed carrot as far as nutrition goes? Impossible. Artificial ingredients and additives used that you don’t need in already natural products.” (Lupton & Turner, 2016, p.12)*

The response reveals the concerns that people have towards 3D food printing. It is worried that some additives are added during the printing process; furthermore, it is regarded that 3D printed food is worse or the same as the original food at best. The participant in the study reckons original carrots to be better than 3D printed carrots. The original food is seen as natural and better as opposed to 3D printed food that might be fabricated with additional artificial food materials or additives.

In the PERFORMANCE project funded by the EU, it is expected to apply 3D food printing technology to provide food that looks and tastes like real food to patients like those who suffer from dysphagia (European Commission, 2015). It is difficult for people with chewing and swallowing problems to eat a regular dish. The concept of the PERFORMANCE project is to reconstruct regular dishes and make them look like the original dishes with 3D food printers, making the food dysphagia-friendly. People with dysphagia can enjoy those visually pleasing food instead of unpleasant puree and mashed food, preventing them from getting malnutrition caused by unpalatable food. Although the project goal is promising, consumer attitudes towards mimicking food with 3D food printing technology should be taken into consideration too. A participant in a study expresses:

“[t]he bit about trying to make a non-natural food look like a natural food freaks me out a bit too. I think I would rather it not try to look like something from an actual animal and not pretend to be something it’s not.” (Lupton & Turner, 2016, p.11)

While cloning food for people with dysphagia is seen as a merit in the PERFORMANCE project, it might not be generally accepted to clone food for consumers. The opinion expressed by the participant suggests that 3D printing food to mimic original food shape and format is daunting to her. The participant views 3D printed to be unnatural, and it is even more creepy for the unnatural posing to be like the natural.

The quality of being natural is often put in inspection. One of the positive trait frequently highlighted of 3D food printing is its ability to efficiently make food in intricate and customized shapes. In the studies of Lupton and Turner (2016 & 2018), however, they find that intricate shapes that 3D printers make are regarded by consumers as processed, unusual, strange, artificial, highly manipulated, and non-edible:

“The geometric shapes, colors and apparently hard texture of the confections put people in mind of toys or decorations rather than edible products. Words like “plastic,” “weird,” “pretty,” “artificial,” and “unnatural” were employed to describe their appearance.” (Lupton & Turner, 2018, p.408)

In the cases of 3D printed confections in colorful geometric shapes, the confections are perceived more as decorative objects rather than tasty confections. Intricate shapes that were not possible to be made in traditional manufacture arouse unsettling feelings among some participants of the study. Appealing shapes of 3D printed food also has the impact on how people perceive the food-making process. A comment made by a participant elucidates the correlation between attractive shapes and unnaturalness:

“The pictures and the topic I find both fascinating and disturbing. I prefer my food to come from natural whole ingredients by a regular growing process, versus technological manufacture, and I feel that something inherently valuable is surely lost in this process.” (Lupton & Turner, 2016, p.12)

The participants pronounce that they feel unsettled by the 3D printed food despite they look fascinating. The “fascinating” look also leads her to the doubt about the nutritional value of 3D printed food and the comparison of natural food versus manufactured food. Despite the fact that certain 3D printed food is just the same food in puree form, due to the reason that the food is extruded from a 3D food printer, it falls into the category of being highly manufactured and unnatural.

The responses in the studies of Lupton & Turner (2016 & 2018) coincide with the research finding of Rozin (2005) on the meaning of “natural,” he finds that the process has great impact on the reduction of how natural people perceive the food to be; for instance, organic farming renders carrots to be seen more natural than carrots grown from commercial farming. The author also discovers that people view wild strawberries to be more natural than organic strawberries, whereas genetically modified plants to be the least natural due to its highest level of intervention. The more the human intervene, the higher the reduction of naturalness will be perceived. Applying the concept to the response of the focus group participant, even if the food is the same pureed food, coming out from a 3D food printer in intricate shapes makes the food more manufactured and less natural to the participant.

Despite providing the option of making food less processed, the name “3D printing” food make people relate the novel food technology with high manipulation and thus unnatural. Printing is often associated with marking on papers or surfaces, whereas 3D printing is often related to manufacturing objects using plastic, metals, and other non-food materials. 3D food printing technology derives from 3D printing in general which has been a non-food industry such as toys; consequently, it is hard for people to relate 3D printing with foodstuffs and to see 3D printed food as something natural (Lupton & Turner, 2016; Brunner et al., 2018). This is especially notable in the expressions of disliking 3D printed food observed in the study of Lupton & Turner (2018):

> “*Even though it’s made from real ingredients, it still makes me wonder about the lengths gone to, to achieve this. It actually looks visually pleasant, but I can’t get past the fact that it is printed,…” (p.411)*

> *“I don’t know how to feel about all this. It’s made from real food but what else is in it? It’s weird it’s being printed.” (p.412)*

The responses manifest the correlation between 3D food printers with unnaturalness, emphasizing that “printing” food is uncanny and very likely artificial. Despite making from real food ingredients, the participants cannot help but doubt what could have been done and tainted during the printing process. The participants express reservation towards 3D printed food out of neophobic tendency, since food usually is not “printed.”

While 3D food printing is recognized in its potential to contribute to food sustainability and solving food shortage by using alternative food sources such as insects and algae (Khot et al., 2017), whether the application of 3D printing food with insects and algae would be a solution to solving food shortage is highly relevant to consumers' attitudes towards 3D printed food made with sources such as insects that were conventionally viewed as not appetizing and edible by the majority of population. Nevertheless, despite the potential to contribute to food and environmental sustainability, 3D printed food made with insects tend to receive negative remarks:

> *"I saw the word insect and was instantly disgusted by it. Even if it was considered natural and edible by others I would wonder how it was put together. Very strange." (Lupton & Turner, 2016, p.10)*

> *"... may be good for you as a source of protein.... Anything made from insects would taste disgusting. The whole idea is totally disgusting and I would not serve it for anyone to eat." (Lupton & Turner, 2018, p.410)*

> *"I think it's very natural and probably healthy for you as it's ground insects, but I'm not sure if I would like the taste, I have never eaten insects before. I'm not sure if I could eat it, I could possibly try it but not really willingly. The idea of ground insect makes me squirmy."* *(Lupton & Turner, 2018, p.411)*

The application of insects in 3D-printing food tends to receive fierce oppositions. Interestingly, the insects are regarded as natural, healthy and a good source of protein, but despite the naturalness and nutritional value, they are thought to be disgusting and non-edible. The revulsion cannot be overcome even with the merit of being natural and healthy is identified. The sheer disgust of insects as food comes to the forefront when the idea of 3D printing food with insects is mentioned. The idea of 3D printing itself being unnatural and artificial no longer is the focus. Using insects to 3D-print food becomes the factor of rejection.

The detestation of eating insects is common in many societies and cultures. People in the west, for instance, have trouble with the entomophagy (Shalomi, 2015; Verbeke, 2015, as cited in Lupton & Turner, 2018). The idea of food made from insects is generally seen as repulsive. When a novel food technology like 3D food printing is subscribed with the use of insects for food printing, it inevitable would encounter resistance. The resistance, in this case, is not so much about the technology per se but more about the ingredients applied that are usually deemed as inedible. Users' attitudes towards 3D food printing, especially in the case of 3D printing food with insects is highly entangled with the social, cultural, geographical and historical contexts of what have been acculturated to be edible food (Lupton & Turner, 2016). When people are exposed to the food sources that they are not used to, resistances are to be expected.

People are generally skeptical towards the use and value of 3D food printing (Lupton & Turner, 2016), which brings up reevaluation of food in many aspects. 3D food printing technology makes people reflect upon “what food is essentially.” Naturalness is a recurrent assessment applied to 3D food printing technology. First and foremost, making food with 3D food printers is considered artificial, processed and thus unnatural. This underlies the fundamental question on how food should be generated. Due to the reason that food production with 3D food printers is still unknown to most consumers, Lupton & Turner (2016) find that people are usually concerned about the safety of food production done by 3D food printers in terms of potential allergens, bacteria or other containments and nutritional loss in the making process. This suggests that in order to receive more consumer acceptance of 3D food printing technology, those concerns about allergens, bacteria and containments should be avoided in the technological designs of 3D food printers. Furthermore, the communication should be better formatted to clear those concerns from the consumers.

Other than the unnaturalness and artificiality of making food with 3D food printers, food contents used to print are also scrutinized in regards to naturalness. Certain food contents printed with 3D food printers are considered highly abnormal. As a novel food technology, 3D food printing has been subscribed to print with insects to contribute to solving food shortages and benefiting environmental sustainability. Utilizing insects for 3D food printing receives much resistance due to its application of the food sources. Insects are traditionally not viewed as human food sources in many cultures. When it is subscribed to print with insects, it would inevitable be rejected due to the materials it applies. Interestingly, insects are actually considered natural and healthy source of protein, but they are considered as unnatural food mainly because of their appearance (Lupton & Turner, 2018). Other than the ingredients used to print, consumers are also worried about unnatural additives being added in the process of printing (Lupton & Turner, 2016). The research findings suggests that ingredients used for printing when promoting the technology has great impacts on the acceptance of 3D food printing. It is indeed a positive when naturalness is guaranteed, such as making with additives and using natural ingredients; however, not all naturalness can be accepted. The application of insects in 3D food printing, for instance, is viewed as natural but appalling.

2.3.2. Functionality, Users and Implications

Aside from the “naturalness” being questioned, functions of 3D food printers are also evaluated by consumers. 3D food printing technology is still under development, so the functions of 3D food printers are still being developed. With the shaping ability at the moment, the necessity of 3D food printers is in doubt:

> *“…and I wonder why you would serve this when you could make a real meal of pureed chicken and vegetables." (Lupton & Turner 2018, p.411)*

The person’s doubt about the necessity of 3D printers to print pureed food implies that food shapes are not as imperative as food materials themselves. The shaping function of 3D food printers are not seen as necessary. Therefore, it is important how the functions of 3D food printers can meet the requirements of users. The uses of 3D food printing require clarification and expansion. It also should be noted that even when 3D food printers become more multifunctional and competent, cooking manually can still be irreplaceable. Physical actions performed in the process of cooking, such as making dough or cutting vegetables can be therapeutic themselves, and the time spent manually making food together can also be valuable (Grimes & Harper, 2008). The degree of applying 3D food printers to digitally make food thus is highly related to the users’ conception of how food should be generated and what food making processes are meaningful to them.

Other than the uses of 3D food printers, the users of 3D food printers also require designations that take consumers’ opinions into consideration. For instance, instead of viewing 3D food printing technology for the high-end cuisine and fine dining (Sun et al. 2015; Lupton, 2017), 3D food printing can be seen as a food manufacture option for the homeless and the poor:

> *"I would not like to eat 3D food at all. The idea is not appealing to me. It might be good for the homeless…[i]t might be good for the really poor as it might in time be a cheap way to make food’ and...[i]t would probably need less material to make a meal.” (Lupton & Turner, 2016, p.12)*

Due to the expensive costs of 3D food printers, 3D food printing technology has been situated for users such as high-end restaurants. However, the response from the participant of the study suggests that possibility that to general consumers, 3D printing food might be ideal for those with limited options such as homeless and poor people. The consumers with open options are less likely to choose 3D printed food. For the disadvantaged, 3D food printing offers an alternative option of food manufacturing, whereas for the privileged, 3D printed food is regarded as a limitation or even threat to their individual options of food (Lupton & Turner, 2016).

From the 3D food printing itself, appearances of 3D printed food, materials used for 3D food printing, naturalness of food-making process, the naturalness of food ingredients used in 3D food printers to the functionality of 3D food printing technology, overall consumer attitudes towards 3D food printing technology is more negative than positive in the studies of Lupton and Turner (2016 & 2018) and Brunner et al (2018). Nevertheless, the negative attitudes of consumers towards 3D food printing offers reflections on how food is to us. The consumers' attitudes and responses suggest that people have cultivated ideas about how food should be made of, how food should look like and how food should be processed and prepared; thus, digital fabrication of 3D food printing and printing with unfamiliar ingredients are often contested (Lupton & Turner, 2016). Reevaluation of the current uses of 3D food printers, ingredients applied and inscribed users are required. Reformulation of uses as well as users of 3D food printing technology is mandatory for the further developments and broader acceptance of this novel food technology. In other words, the uses and purposes of 3D food printing technology are still open for being shaped until the technology per se and the food it make becomes normalized (Lupton & Turner, 2018).

Aside from further social-technical construct of 3D food printing technology needed, proper communication with users are necessary as well. In the research of Brunner et al (2018), they provide basic information and facts about 3D food printing and the applications of it to the participants, and study results show that the first impression consumers have towards 3D food printing technology plays a crucial role in how they think about the technology. Their research also discovers that those who have little knowledge about 3D food printing are more likely to form a positive take on 3D food printing technology with a well-designed communication about the novel technology. Nevertheless, they also notice that for those who were already informed about 3D food printing, they are less likely to change their attitudes, especially fears and reluctance to use 3D food printers. Among those who already formed their opinions, neophobia towards novel food technology like 3D food printing remains or even increases despite communication to remove the negative opinions are provided (Brunner et al., 2018). Well-formulated communication that takes general preconceived ideas about how food should be is thus indispensable to widen the acceptance of 3D food printing technology. The constant co-production of the technical designs and the social aspects of consumer attitudes that constantly redefines the functionality and meanings of 3D food printing is the path to a more widely-accepted version of this novel food technology.

2.4. 3D Food Printing: Novel Food Technology In the Making

2.4.1. Use Improvements & Regulatory Establishments Required

There are some 3D food printers available for domestic use as well as professional use on the market; however, the 3D food printers are mostly still under development (Lupton, 2017). There are two major disadvantages of 3D food printing technology. First, compared with other generic kitchen appliances, 3D food printers are still rather expensive. Therefore, 3D food printing is more applicable in haute cuisine sectors, since 3D food printers make more sense in high-value but low-volume food creations (Sun et al., 2015). Therefore, for 3D food printers to be more prevalent in home kitchen as well as professional kitchens, cost reduction and mass production will be necessary. The second disadvantage of 3D food printing technology is that 3D printers generally operate rather slow in comparison with traditional way of manufacture (Reeves, 2014). This renders 3D food printing technology time-uneconomical and cost-uneconomical in societies that view time in monetary terms. To increase the speed of 3D food printers thus is essential for a wider application.

Other than being expensive and slow at the moment, the ingredients that are suitable for printing is limited due to the reason that only the materials that can stick together to form shapes are ideal. In addition, even if available for printing with more than one cartridge, the 3D printers cannot print with too many cartridges at once, so the combinations of ingredients are not exactly diverse. Consequently, the textures of 3D printed food are currently monotonous (Sun et al., 2015), which requires improvement because for a broader application of 3D food printers, the printers have to be able to print more than just chocolate, dough, puree and the like. Apart from functionality confined by the materials for 3D food printing, the purposes that 3D food printers offer are narrow. 3D food printers now dedicate mainly to shaping. Some 3D food printers provide the heating option with laser, a heating platform or chamber; however, most 3D food printers focus on printing chocolate, dough or puree. If the ingredients need to be heated or baked, they require other kitchen equipments to do so, which indicates that 3D food printers has not been able to replace other kitchen appliances yet. The main specialty of 3D food printing technology at the moment is making intricate shapes that are difficult to be made by hand.

The fact that 3D food printing specialize mainly in shaping implies the technology is catered mainly for creative purposes. Even though 3D food printing technology is emphasized with its potential in solving social problems such as food shortage by printing with insects or ugly food that would be thrown away. Equipped with mainly the shaping ability, 3D food printing technology is portrayed as “a first world problem, not a third world solution," for it is mainly applied to print intricate and attractive shapes that are not achievable in handmade food, but it does not make new food (e.g. novel food from chemical compounds) that can alleviate social problems (Tran, 2016). Moreover, since 3D food printers offer mainly the shaping function with limited material textural options and that the printers are expensive, 3D food printing is situated for niche groups like the elderly, people with dysphagia or high-end confectioners or restaurants who seek novelty (Lupton & Turner, 2016). 3D food printing is viewed with the potential of reconfiguring a customized food supply chain due to its closer production sites to consumers (Sun et al., 2015). However, to reconfigure the food supply chain, users of 3D food printers have to be more than just the niche groups.

Aside from 3D food printing technology to be further developed, the regulatory aspect of 3D food printing also requires establishments. In the study of Tran (2016), he points out that since 3D food printing is still a novel technology and that legislations tend to progress slower than technological developments, there are no regulations regarding the safety and labelling issues of 3D food printing. He proposes that for 3D food safety issues, regulations should adapt from the current FDA regulations for food safety and allergens to fit 3D food printing. As for labelling issues, he argues that consumers are entitled to know whether the food is generated from a 3D food printer, which is analogous to the labelling issues of GMO food. By labelling 3D printed food and GMO food, it provides consumers the power to choose printed or non-printed food and GMO or non-GMO food, and it also passes down the responsibility to consumers to choose what food to ingest (Tran, 2016). To increase the acceptance of 3D food printing technology among consumers, regulations regarding food safety and labelling concerns should be tackled. Although from the consumers' perspective, regulations regarding food safety and labelling of 3D printed food are paramount, from the creators' perspective, legislations about intellectual property is important to give credit to creators of 3D digital designs. Nonetheless, intellectual property laws that favor the creators of digital designs also create legislative barriers, making the public unable to use the creations. Santoso & Wicker (2016) thus suggest that a balance between protecting creators' ownership and remaining flexibility of use will be beneficial to overall innovation and problem-solving of 3D printing.

2.4.2. Promises and Future As A Driving Force

Despite the insufficient functionality of 3D food printers and the lacking of legislation regarding 3D printed food safety, labelling and digital rights, Lupton (2017) finds that 3D printing technology is often emphasized with its benefits and promises rather than its potential disadvantages and danger in online news media. She notices that the online news reports about 3D food printing technology center around the values it can bring to consumers, restaurants, entrepreneurs, food industry in general and the environment. Moreover, she also discovers that most online news reports tend to present 3D food printing as an advanced technological invention that has both entertaining as well as promising purposes, such as providing creative and healthy options of food, efficient manufacture and sustainable possibilities for food supply and the environment. In online news, 3D food printing technology is presented with optimistic claims, and those positive depictions and promises tend to locate in the future instead of the present time; additionally, an intriguing resemblance often recurs when it comes to 3D food printing—the Replicator in Star Trek (Lupton, 2017). The Star Trek Replicator is a machine that can make synthesized meals from energy, which appears like magic since food come out of the air without any materials or manual interventions required (Tran, 2016; Zoran & Coelho, 2011). Making 3D food printers analogous to the Star Trek Replicator suggests 3D food printing is a futuristic technology that resembles the futuristic machine out of science fiction.

Novel food technologies involving new ways of food production or preparation can evoke people's resistance, especially when the novel food technologies are unfamiliar to the public and radically different from the conventional ways of producing or preparing food. GM (Genetically modified) foods, for instance, have been regarded as "Frankenfoods" and encountered many anti-GM movements despite their potential to enhance nutritions and quality of crops (Gusterson, 2005). Similarly, cultured meat often arouses uneasiness or disgust for it is not a culturally common way to generate meat and deemed as unnatural (Verbeke et al., 2015; Jönsson, 2016;). Regardless of its potential to offer cruelty-free, space-saving and sustainable meat option (Jönsson, 2016), in vitro meat has not been a universally accepted novel food technology. Contrary to GM foods and in vitro meat, 3D food printing, as a novel food technology, is often associated positively in online news (Lupton, 2017). The claims about benefits that 3D food printing can bring to users mostly are benefits in the future; for instance, convenient printed meals at home or food on the go for astronauts on space missions and soldiers from the military (Tran, 2016; Lupton, 2017). Promises are made to promote 3D food printing. It is notable that 3D food printing is presented as a rather novel food technology still in development, the claims and promises made about 3D food printers are not yet in the market; in other words, the optimistic claims and promises are located in speculative futures (Lupton, 2017). Most online news about 3D food printing focus mainly on the positives about how 3D food printers can or will contribute rather than critics, concerns and potential risks about 3D food printing (Lupton, 2017). The technological narratives can potentially impact how people perceive the future kitchen, and they can also shape the path of development towards the depicted future of kitchen (Zoran & Coelho, 2011). The promissory themes of 3D food printing technology serve as a framework of technological developments.

2.5. Uses and Users of 3D Food Printing to Be Configured

The literature reviewed shows that the recurring themes of 3D food printing tend to be positive and promissory, ranging from being efficient, healthy, creative and sustainable (Lupton, 2017). Manufactured in an additive manner, which can be more efficient and economical, 3D food printing is expected to reduce the need for manual work and labour cost and to provide an efficient way of making food by a simple download and print for users such as home cooks, refugees, soldiers and astronauts (Campbell et al., 2011; Yang et al., 2017; Lupton, 2017). Owing to its digital operation, the customization provided by 3D food printing is expected to benefit health by printing food that catered to individual need of nutritions and textures (Zoran & Coelho, 2011; Pearse, 2014; Dankar et al., 2018), for instance, personalized amount of calories, macronutrients and micronutrients (Yang et al., 2017) for patients such as people with dysphagia. The customization option of 3D food printing is also anticipated to boost creativity, since digital instruction and manufacture provides users with more space for novel creations that were not viable with traditional way of food manufacture (Campbell et al., 2011; Zoran & Coelho, 2011). Digital manipulation of data also allows 3D food printing to provide creative ways for users to interact with, e.g. printing chocolate in the shape of 3D-scanned face (Wainwright, 2013) or 3D printing chocolate messages and emoticons to motivate users to engage in physical activities (Khot, Pennings & Mueller, 2015). Last but not least, 3D food printing is anticipated to contribute to food as well as environmental sustainability, due to its additive way of manufacturing which is inherently green (Campbell, 2011), its potential to reduce inventory, storage, packing, distribution and transportation in the case when users can manufacture food at home (Campbell, 2011; Reeves, 2014) and its option to print with alternative food such as insects, algae and cultured meat in ways that are more appetizing (Mims, 2013; Gorkin & Dodds, 2013; Lupton, 2017; Khot et al., 2017; Yang et al., 2017).

Although there have been studies affirming or discovering the positive benefits and potentials of 3D food printing technology, the researches on consumers' responses and attitudes towards 3D food printing stir up reflections on the validity and practicality of the positive benefits and potentials of the novel food technology. Lupton & Turner (2016 & 2018) find in their researches that consumers deem the appearances of some 3D printed food as unnatural. While 3D food printing is expected to provide food creations in intricate shapes that were unattainable with traditional manufacture, the creative shapes arouses unsettling feelings since they look unnatural to eat, which suggests the formerly-expected beneficial use in intricate shaping is not what the users in the study want. Moreover, consumers do not find 3D food printers necessary (Lupton & Turner, 2018). The same applies to the ingredients. 3D food printing is anticipated to contribute to food and environmental sustainability by printing with alternative food materials such as insects, algae and cultured meat (Mims, 2013; Gorkin & Dodds, 2013; Lupton, 2017; Khot et al., 2017; Yang et al., 2017). As promising as applying alternative materials can be, consumer attitudes suggest otherwise. In the studies of Lupton and Turner (2016 & 2018) consumer are resistant towards accepting 3D printed ground insect snack, participants express disgust in ground insect snack despite finding them natural or even healthy. 3D printing with alternative food sources indeed can potentially contribute to food and environmental sustainability; however, to actualize it, consumer acceptance is mandatory. Without user acceptance, the expectation can be just a false hope.

It is regarded that 3D food printing might change the types and quantities of things we have in kitchens when it becomes a new way of food preparation and cooking (Zoran & Coelho, 2011). Some current kitchen appliances might be replaced. 3D food printers can be the new common appliances in kitchen. Digital fabrication with 3D food printers will potentially provide more food customizations and creative productions. The whole process of making food in kitchens can possibly be redefined. Nonetheless, still under development, 3D food printing remains rather expensive and slow (Reeves, 2014; Lupton, 2017). At the moment, the use of 3D food printing mainly focus on its shaping capability. For some consumers; however, the shaping function of 3D food printers is not deemed as necessary (Lupton & Turner, 2018). The use of the technology targets at the creative purposes, rather than to solve social problems. Using 3D food printing to alleviate or even end world food shortage problem remains a future benefit (Lupton, 2017). Notably, some uses subscribed to 3D food printers are reachable (e.g. using 3D food printers to print food in customized and creative shapes), but many other uses of 3D food printers remain in the future. For instance, the efficient use of 3D food printers to supply food on-the-go for refugees, soldiers and astronauts or the use of 3D printing insects to solve food shortage problems remain speculative (Lupton, 2017).

From the literature reviewed, intriguingly, both currently achievable uses and future uses of 3D food printing receive both positive and negative consumer responses. The inconsistencies between how 3D food printing is expected to be useful in certain uses and how consumers think about those uses indicate that the uses of 3D food printing require further configuration. Similarly, whom are expected to benefit from the uses of 3D food printing might not coincide with those users' perspectives. Although 3D food printing is associated with high-end fine dining and benefits for future home cooks, refugees, soldiers and astronauts, the study of Lupton & Turner (2016) shows that consumers think 3D food printing is catered for the homeless and the poor. Consumer attitudes towards 3D food printing provide developers fresh insights into the further configuration of the users. The literature reviewed cover from the recurring positive themes of 3D food printing, consumer attitudes towards the technology and the current state of 3D food printing technological development and legislative absence. The literature review shows that 3D food printing is still a novel food technology waiting to be further configured, both the uses and users are still being constructed. Particularly, the literature review shows that expected uses and users do not go hand in hand with how consumers think about the anticipated uses and users. Since the promissory themes are identified in the online news study on 3D food printing by Lupton (2017) and other technological development articles and researches of 3D food printing with optimistic perspectives, the nature of uses and users presented might be more promissory. Consequently, it would be interesting to investigate the perspectives of 3D food printing developers, especially on how they script the uses and users of 3D food printing to their potential customers when they already aim to sell the 3D food printers rather than future potentials of the novel food technology.

3. Sensitizing Concepts

3.1. Users and Uses in Design Practices of Technology

3.1.1. Configuration & Bi-Directional Configuration of Users

There has been research in the realm of science and technology studies (STS) that works on users and uses of technological designs. In the study of Woolgar (1990), for instance, he has collected data from an ethnographic observation in usability trials of a company that manufactured microcomputers. He discovers that in the course of designing and producing new technological products such as microcomputers, users are configured in the process. The configuration of users takes place in “coordinating the presumed user behaviors” as well as in “setting constraints upon users’ possible future actions”:

> *“The machine's task is to make sure these putative users access the company in the prescribed fashion: by way of preferred (hardware) connections or through a predetermined sequence of keyboard operations. The user will find other routes barred and warnings posted on the case itself. Labels bear warnings of the dire consequences of unauthorized boundary transgression: electrocution, invalidation of the warranty and worse (Woolgar, 1990, p.79).”*

By designing with presumed users in mind, guiding their operations and limiting their potential future behaviors, certain uses or prohibited uses of the technology are inscribed in the technology. In his case study, preferred hardware operations are inscribed in the machine. The same goes to the undesirable uses of presumed users. By putting labels indicating the consequent danger and invalidation of the warranty, users who concern and avoid the consequent danger and invalid warranty are configured by the uses. The designers configure the users by allocating the preferred uses as well as the prohibited uses, delineating users that access as well as avoid certain uses that have been designed in the machines. Since my research interests are in the uses and users of 3D food printing technology, the concept of configuring users in uses design of machines, proposed by Woolgar (1990), can be a helpful analytical tool of my analysis for two reasons. First, it can be applied to examine what uses are intended and what uses are hindered or even forbidden in 3D food printers. It helps to understand what 3D food printing technology is or is not designed for. Second, it provides a way to look into the expected users configured by the developers of 3D food printing technology. In cases when users are not explicitly specified, investigations on the intended as well as prohibited uses of 3D food printers might be helpful to learn more about the targeted users of the novel food technology configured by the developers.

Woolgar (1990) conceptualizes technological machines as texts to be read by users. That is, the process of “developers constructing a machine for users to use” corresponds to the process of “writers writing texts for readers to read.” Although regarding users of technological machines as readers of texts implies that there is flexibility for users to interpret what the machines are for, Woolgar (1990) emphasizes more on the power of designers to design machines that are used in a preferred way. In other words, designers “write” with potential users capabilities and behaviors in mind and then materialize those considerations in machines so that the users would “read” the machine in the way that designers intend machines to be “read.” How users “read” machines is therefore constrained because the users have already been configured in the design processes of machines (Woolgar, 1990, as cited in Oudshoorn &Pinch, 2003). The concept of constructing a machine as writing texts can come in handy analytically by looking into how much room there is for readers’ own interpretations in the texts. In other words, how flexible can the uses be freely exerted. The degree of uses flexibility would be an interesting perspective to explore, because as a novel food technology, 3D food printing might be subscribed with inexplicit uses and thus equivocal configured users. As for in the case when uses are rigid without flexibility due to technical constraints, underdevelopment, etc. It would be intriguing to see how developers of 3D food printing make sense of the flexibility or inflexibility. A reflection upon the implications of such flexibility or inflexibility might also be useful for my empirical findings.

To launch a successful product, the designers should make the machine appeal to as many users as possible in order to sell the machine. Consequently, designers should not limit the users to only a type of users and demands, but they should target at the overlap demands of various types of users so that the machine would meet as many users’ preferences as possible, keeping “users multiple” rather than “user singular” (Woolgar, 1990). Relevant to “the room for texts interpretation” or “the space for use flexibility” (Woolgar, 1990), the more uses as well as uses flexibility are in technical machines, the more users can be included in the applications of machines. However, as a nascent food technology, how many kinds of users can 3D food printing include is uncertain. Thus, it would be interesting to see how the composition of users, configured by the developers of 3D food printers, falls in the spectrum of “user singular” and “users multiple” (Woolgar, 1990).

Other than configuring users with intended uses, Woolgar (1990) also finds in his study that designers sometimes hold the view that users do not know what they want for future developments because they only know about what is available now; therefore, it is believed that the designers' or a company's visions of the future define users' future requirements. In this regard, users have less access to the future than designers do. Since designers have more control over the future requirements of users, designers have the power to define the uses of a machine and who the users are. In some technological cases, users did not actively ask for what they wanted since they were focused on what had been offered. For instance, certain 3D food printing developments were funded by public organizations such as NASA with the goal to 3D-print food for astronauts on missions (NASA Technology, 2019) . General consumers did not actively ask for 3D food printers. Instead, consumers are generally skeptical about 3D printed food and that consumers are not sure about why 3D food printers are necessary (Lupton & Turner, 2018). Therefore, an investigation into how the developers of 3D food printing make sense of their visions of the future: "how much they take users into consideration," "what users are considered," and "what visions of the future or future requirements of users are thought of" would be helpful lenses for understand how they make sense of the technology.

Woolgar's conception of texts focuses more on how the designers "write" the texts in a machine, rather than how the users "read" the machine (Woolgar, 1990), underlining the process of encoding technological machines done by designers, but it fails to notice the process of decoding technological machines performed by the users (Mackay, Carne, Beynon-Davies & Tudhope, 2000). In the work of Mackay et al. (2000), they argue that designers configure users; however, in turn, the users also configure designers, which makes configuration a bi-directional rather than a unidirectional process. When the agency of users are recognized, it would enrich Woolgar's conception of technological designs. By recognizing the influence of users on the uses of technological objects, it avoids the view that is designer-centric and technologically determinist. The concept of bi-directional configuration can help me reflect on how the users might in turn affect the uses design instead of focusing only on how designers configure users with uses. This would be especially helpful in cases when users like chefs or confectioners are involved to some extent in the developments of 3D food printers. As for in the case when configuration of uses by users are not evident, the concept of "how users read the machine" can be applied to learn how consumer attitudes might in turn affect the further developments of 3D food printing. If the consumer attitudes do not occur in the data, the concept can be utilized for discussion in regards to the studies that have been done on consumer attitudes towards 3D food printing.

3.1.2. Scripting Users and Uses

Similar to the concept of reconfiguration proposed by Mackay et al. (2000) which recognizes that users also configure designers, the script concept applied to technological developments also notes the agency of users. In the study of Akrich (1992), she introduces the concept of script as the end product of a technical object that defines the framework of action determined by the actors and the space of action:

> *"Designers thus define actors with specific tastes, competences, motives, aspirations, political prejudices, and the rest, and they assume that morality, technology, science, and economy will evolve in particular ways. A large part of the work of innovations is that of "inscribing" this vision of (or prediction about) the world in the technical content of the new object. I will call the end product of this work a "script" or a "scenario." …To be sure, it may be that no actors will come forward to play the roles envisaged by the designer. Or users may define quite different roles of their own….like a film script, technical objects define a framework of action together with the actors and the space in which they are supposed to act (Akrich, 1992, p.208)."*

Even though designers can inscribe their visions and intended uses in technical objects for their putative users, the users involved also take parts in acting in relation to the script manifested in technical objects. This means that the users do not necessarily utilize technical objects that way in which the designers intend them to use. The users can ignore the intended uses and come up with new uses, or they can also choose to refuse the technical objects. Therefore, the concept of script proposed by Akrich (1992) is not technologically determinist, but it acknowledges that both designers and users have agency in the development of technical objects.

In comparison with the concepts of configuring users with uses and the focus on designers' uses implants in technical objects proposed by Woolgar (1990) as well as the concept of bi-directional configuration of uses between designers and users proposed by Mackay et al. (2000), the concept of script introduced by Akrich (1992) reaches even further. The concept of script focuses not merely on the designers' role in defining users by determining the uses in technical machines, and it also goes beyond the roles of designers and users in forming uses of technical machines together. The script concept informs instructions in technical objects that guide users to perform in certain ways, but the users may act accordingly or not, acknowledging the flexibility of user behavior towards uses of technical designs as well as the space in which the users and technical objects are in. The concept of script can serve as an analytical tool; for instance, in the cases when 3D food printers are scripted as a home kitchen appliances, users at home does not necessarily have to act according to the script. Home cooks can choose not to use 3D food printers as home appliances for various reasons. For example, they might consider manual cooking process to be more effective or relaxing, so the scripted function and actions of the technical machines will not be performed as a consequence.

Applying the script concept to understand the relationship between designers, technical objects and users, users are allowed to have their own interpretations of texts written in technical objects by designers, to make new uses prescribed not by designers or to refuse the usage of the technical objects. Nevertheless, even though the script concept recognizes users' agency in the development of technical objects, if the uses of the technical objects do not deviate too much from the prescribed uses anticipated by the designers, the script becomes the major force to form actions (Akrich, 1992). This indicates that technical machines are not just passive objects used to serve humans; instead, the machines are active in directing actions of users. For instance, a speed bump would slow down whoever passes through, and in comparison with a porcelain cup, a plastic coffee cup would make users more likely to not reuse it (Verbeek, 2006). The script inscribed by designers in artifacts drives the behaviors of users in certain direction and limits them to certain actions, although users can also choose not to follow the script by refusals of usages or changing the intended uses. Consequently, the script of technical objects are not deterministic but a mediating concept (Jelsma, 2003). Users' behaviors can be mediated by the scripts of technical objects but are not entirely determined by them.

Adopting the notion of script proposed by Akrich (1992), the analysis of my data can be augmented, because the concept goes beyond the designer-centric of uses and users as well as the focus in the bi-directional formation of uses between designers and users. By conceptualizing technical machines as scripts that serve as frameworks for acting and driving-forces for acting in certain ways, it allows the analysis to heed and incorporate users agency as well as the space in which users are located. The concept of script recognizes "the stage" where the users perform as well as "the spontaneity of uses" by users as actors on stage. The script can be utilized analytically to provide more attention towards the users' agencies and the environment where they are in. For instance, in the study of Lupton & Turner (2016 & 2018), they find consumers are generally disgusted by 3D food printing insects. By applying the concept of script, it admits that consumer attitudes towards 3D printed insect food might differ from user to user. Users can have their own interpretation of the script. Based on their backgrounds, they might have different takes on the script, so they might see 3D for printing insects differently. People in the west are more likely to be against the idea of insects as food (Verbeke, 2015, as cited in Lupton & Turner, 2018). The same script of 3D food printing insects might receive different users' reactions from other regions or cultures. Overall, the script concept can serve as an augmented analytical tool for analyzing the relationship between 3D food printing developers, uses of 3D food printers and the users of 3D food printing.

Scripts prescribed in technical artifacts by designers mediate the actions of users, which means technical artifacts do not exist passively but actively in directing users' practices. According the script concept of Akrich (1992), technical objects define both actors and the relationships between actors, and they also have political strength that may change, stabilize, naturalize and depoliticize social relations. In other words, scripts go beyond functionality of artifacts; other than delivering functions, they also shape users' practices and influence users' behaviors (Verbeek, 2006). Since it is not just the functions but also the shaping of users' actions when it comes to technical artifacts, designers of scripts are thus important because the scripts they write have profound impacts. Particularly, when encountering ethical concerns, the script approach would allow evaluations of whether technical objects direct users to behave ethically. For instance, in comparison with metal utensils, plastic utensils are more likely to be thrown away right after use. As a consequence, even though both users and designers have agency in the development of technical objects, as inscribers of scripts, designers bear more responsibility to consider contexts of uses in relation to ethics (Verbeek, 2006).

Although the script concept does not emphasize the agency of designers as much as the concept of user configuration proposed by Woolgar (1990), the concept of script still views technical objects as an active existence that makes users perform in certain directions. Users can have their own interpretations of the script, but the script also serves as a framework and directs users to act in certain ways, which recognized the responsibility of designers, especially the political impacts caused by the script that designers create (Akrich, 1992). For instance, when a coffee capsule machine is designed to conveniently make coffee with one-time use capsules that are made hard to recycle due to multiple combined materials, then inevitably, it scripts the users to act in the direction of throwing it away right after use without recycling the capsules and thus creates more wastes. Surely, users can hack ways to reuse the capsules or find other ways to operate, but the technical design has the impact to direct users to use the machine in certain manners. The concept of script thus notes the political power of the script as well as the responsibility of the designers to design for an ethical outcome of the script's political impacts. The fact that the political impacts of the script and that designers are held responsible for the designs makes the concept of script a useful tool for analysis. As a novel food technology, the use of 3D food printing is often associated with promising benefits. The concept of script can be a tool for analyzing what the political impacts of 3D food printing are induced by the script of the

3D food printer designers; additionally, the concept provides an analytical perspective on the interactions between designers and their responsibility of the consequences caused by their scripts.

3.1.3. Conceptualizing Users as Consumer-Citizens

In the concept of script proposed by Akrich (1992), designers are the inscribers of scripts and thus have more responsibility when it comes to ethical uses of designed objects. Nevertheless, users as consumers can also actively take up responsibilities of ethical uses of designed objects. In generic economic or political understandings, a “consumer” is someone who seeks individual pleasure and cares merely about self-interest, whereas a “citizen” is someone who values the public common goods as well as collective welfare and takes responsibility to secure that social and ecological commons (Mol, 2009; Johnston, 2008; Soper, 2006). These two terms are usually reckoned in opposition. Consumers who prioritize pleasure and self-interest cannot go hand-in-hand with citizens who value common goods. In the study of Mol (2009), however, she presents the idea of a “consumer-citizen” whose pleasure does not clash with doing good; rather, individual pleasure incorporates with the public good.

In the study of Mol (2009), she discovers that public health campaigns in the Netherlands, especially those related to obesity, have the tendency to portray eating healthy food as a devotion towards the public health as well as a civic duty rather than a way to gain pleasure. After researching on various food packages from the Netherlands, she explores the food products that exemplify how bodily pleasure can be fostered by purchasing certain products that are perceived to be good for the public health, suggesting that the normativities of a consumer and a citizen can be integrated into the normativity of a consumer-citizen (Mol, 2009). On the food packages of *Twisted Organic* fruit juice, yoghurt with “good” bacteria of *Vifit* (vitality and fit or well) or *ACTIVIA* (active life), the texts, images on the products or even the brand names tend to suggest a consumer-citizen who drinks or eats with pleasure and simultaneously remain healthy, which contrasts with the public discourse about being healthy for the common food but at the same time having to tame the body and forsake pleasure (Mol, 2009). The consumers of the products are configured by the products’ designers as consumer-citizens. The scripts of the food products are also inscribed by the designers to make the consumers value not only tastiness but also health. The normatively of consumer-citizen can be a useful analytical concept for examining the users configured by the developers of 3D food printing, because 3D food printing is a novel food technology that involves foodstuffs. The incorporation of health and pleasure might be present in the designs of 3D food printers.

By the same token, Mol (2009) also studies the packages of Faire Trade products like Fair Trade original chocolate sprinkles of *Hagelslag*, learning about the success of the product to combine deliciousness and fairness together, even though testiness and fairness are two very different types of good. The concept of consumer-citizen that purchases for both sensory pleasure and fairness of society can be utilized to analyze the script of a technical object that directs users to seek not only bodily enjoyment but also for the care of social fairness. In particular, 3D food printing is often related as a solution to social problems such as food shortage (Lupton, 2017). The consumer-citizen who purchases for the novelty in 3D food printing as well as the solution towards societal problems can be an angle for analysis. In her study, Mol (2009) demonstrates that food products can be “healthy and yummy” as well as "fair and delicious.” Appetizing taste does not have to conflict with other types of good such as health and fairness. Studying the features of consumer-citizens configured by the food products and analyzing the various kinds of good that are appreciated, Mol (2009) concludes that good taste is not innate but cultivated by shared social-material practices; therefore, newspapers, televisions, the internet, and so forth are all influential in conveying the values of goodness to consumer-citizens. She thus proposes to experiment with “good taste” as a positive normative category instead of “aesthetic that is not subject to the rational mind.” By viewing “good taste” as a positive norm to be cultivated, it allows critical evaluations of how the good tastes, such as health and fairness devoted to the common good of the public, are formed. Regarding the good taste as a positive norm may come in handy in the analysis or the discussion related to the literature reviewed.

Similar to the concept of consumer-citizen, several papers mention or utilise the concept of “citizen-consumer (Soper, 2006; Johnston 2008; Davies, 2014) ” or “consumer as citizen (Ricci, Marinelli & Puliti, 2016)” instead. Generally, a “citizen-consumer” or a “consumer as citizen” is depicted as an individual who purchases and respects sustainable developments of the society, such as environmental conservation, social responsibility and labour rights. The hybrid of consumer and citizen indicates the action of “voting with your dollar” for something good (Johnston, 2008). This comes down to what is considered as a good and quality life for individuals as well as the public. Soper (2006) claims that “alternative hedonism” is important in understanding the issues of consumer as citizen or citizen as consumer, for alternative hedonism highlights the enjoyment of consumption that concedes to its own undesirable consequences (noise, pollution, health problems, risks, waste, destruction, and so forth) and thus stimulates the reevaluation of what it means to have a good life and then initiate changes in consuming practices. The synthesis of consumer and citizen evokes reflections on what’s good for society and initiates changes in consumption to contribute to the societal good. The synthetic concept can be applied to examine how designer and users of 3D food printing consider what to be common good for the society and how they can incorporate the uses of 3D food printing into the devotion of the common good.

It is noticeable that the approach of Mol (2009) to consumer-citizen does not mark the proportion of consumer to citizen. That is, she only addresses the diverse goods but does not dig deeper into whether citizenship only receives superficial attentions and serves consumerist interests. Nevertheless, in the study of Johnston (2008), she looks into the case of Whole Foods Market and studying the ideological tensions of the citizen-consumer. She explores the citizen-consumer hybrid in the case from three aspects: culture, political economy and political ecology. In the culture aspect, she finds that Whole Foods Market, as a corporate actor, maximizes consumer choices yet minimize citizenship responsibilities. Furthermore, in a political economic sense, the citizen-consumer delineated by Whole Foods Market contains divisions of social class to some extent, because the concept of citizen-consumer framed by the corporate makes those with more economic capital more ethical than those who cannot afford the same food choices due to the economic status, which implicitly draws and legitimizes class boundaries. Lastly, the author also finds that the framing of citizen-consumer by Whole Foods Market, in a political ecology sense, is about conservation through consumption, rather than asking citizen-consumers to reduce consumption. Consequently, she concludes that the citizen-consumer hybrid in the case of Whole Foods Market only gives superficial concerns to citizenship and focuses mainly on serving consumerist interests, which makes a true and balanced citizen-consumer difficult to attain in a growth and profit-oriented corporate background. An analysis of not only the synthesis of consumer and citizen but also the ratio of consumer to citizen can enrich the research findings. That is, an analysis of users falling in the spectrum between consumer and citizen would provides deeper understandings of the constructed complex between consumption and public good.

3.2. Sociology of Expectations

As identified by Virilio (1999, as cited in Brown & Michael, 2003), time has become equivalent to money, which has made speed some sort of power, and this has pushed competitive developments from the present further and further into the future, despite the fact that the developments towards future are speculative ones constructed by expectations, visions or imaginaries. Since the last half century, scientific and technological investments have turned from discovering by chance into planning for particular goals, and this “strategic turn” is relevant to the tendency to see the future as a better version of the present, which makes technological development and scientific knowledge become paramount for societal developments towards an improved future (Borup, Brown, Konrad, & van Lente, 2006). As the contemporary culture has become more future-oriented than ever before (Giddens, 1998, as cited in Brown & Michael, 2003), science and technology in contemporary times are prone to innovate in a future-oriented manner; consequently, to better understand scientific and technological developments, studying expectations would be a prolific start, because expectations carry images of the technical as well as the social future (Borup et al., 2006).

Studying expectations is to see the future not merely as a neutral time and space but as an analytical object that has the power to influence the present by arranging resources, organizing activities and handling uncertainty across boundaries between different communities, times, levels and scales (Brown & Michael, 2003; Borup et al., 2006). Expectations of science and technology can be identified in various forms, ranging from scientific texts, policy documents, legal documents, think tank's publications, commodified knowledge of specialist consultants, actions of various stake holders, news media, bodies, materials, objects, machines, and so forth (Borup et al., 2006; Horst, 2007; Wilkie & Michael, 2009; Pollock & Williams, 2010; Beaulieu, 2016). For instance, expectations of using cord blood for future imagined treatments are embodied in the deposited cord blood (Brown & Kraft, 2006, as cited in Borup et al., 2006). In other words, the imaginations and expectations of future treatments are inscribed and materialized in cord blood samples. In the field of science and technology studies, many researchers have studied the roles that expectations play in shaping novel technologies and science. There are several recurring central themes and findings about expectations in the studies of expectations. Other than materiality and embodiment, expectations are oftentimes studied and correlated with their "performativity,""unfulfilled expectations" and "temporal and socio-spatial variances" (Borup et al., 2006).

3.2.1. Performativity of Expectations & Unfulfilled Expectations

In the early stages of technological or scientific developments when new technologies or scientific findings have not yet been substantiated, the expectations of novel technologies or scientific changes already pre-exist before the novel technologies and scientific changes themselves, which makes expectations wishful enactments of a desired future (Borup et al., 2006). In other words, the pictures of future potentials carried by technological or scientific developments work as promises that require actions in order to be enacted as the promised future. As expectations are not only the causes of technological and scientific substantiations but also the consequences of such substantiations, expectations are constitutive or performative as discussed by Borup et al. (2016):

> *"First and foremost expectations are "constitutive" or "performative" in attracting the interest of necessary allies (various actors in innovation networks, investors,*

regulatory actors, users, etc.) and in defining roles and in building mutually binding obligations and agendas…the dynamics of 'promise and requirement', i.e. of promissory commitments that become part of a shared agenda and thus require action…Pronouncing an expectation does not necessarily create accountability, but does prompt responses and the expectation that the enunciator should justify their future-oriented claim…Expectations are, in this sense, obligatory and open up the potential for present-day promises to be held to future account (p.289)."

For example, when it is expected that 3D food printing technology will dedicate to reducing food waste, the expectation of reducing food waste is not only the real-time representation of the future when and where food waste is alleviated, such expectation is also the constitutive force that makes the desired future happen. The expectation of food waste reduction with 3D food printing technology might prompt developers to design printed food that caters to the goal, e.g. using unappealing or bruised food that would have been thrown away for printing. It might also attract investors and users who see the potential of using the technology to reduce food waste to infuse capital for developments and purchase 3D food printers to make it happen.

Through setting expected future, an expectation enrolls various actors in the development of technology and science, and it also guides as well as shapes the development to its own desired outcome (Pollock & Williams, 2010). An expectation is therefore performative, for it is both the cause and the consequence of the expected future. When it is promised that a technology can achieve a certain function or goal, the requirements to make the promise a reality ensue in the form of agenda that needs action-taking. In the development of a novel technology or scientific breakthrough, it usually consists of a series of promise-requirement cycles (Geels & Smit, 2000). In a series of promise-requirement cycles, expectations are profoundly influential in shaping novel technologies and scientific changes in various ways:

"Such expectations can be seen to be fundamentally 'generative', they guide activities, provide structure and legitimation, attract interest and foster investment. They give definition to roles, clarify duties, offer some shared shape of what to expect and how to prepare for opportunities and risks. Visions drive technical and scientific activity, warranting the production of measurements, calculations, material tests, pilot projects and models (Borup et al., 2006, p. 285-286)."

As expectations provide scripts which shape the developments of technologies and science, it is important to study the performativity of expectations. By looking into the performativity of expectations, the generative force of expectations to enroll human and non-human actors and activities can be identified so that the determinist understanding of technology and science are more likely to be avoided. Expectations and promises serve as strategic resources in the promise-requirement cycles of technological and scientific developments (Geels & Smit, 2000), making the developments of technology and science inherently social rather than technologically determinist. By examining the performativity of expectations related to 3D food printing, learning how the promissory expectations enact themselves develop towards the expected realities, it would help the analysis identify that the technological developments enacted by the expectations of 3D food printing is intrinsically social.

Despite the fact that expectations are the representations of the future that guide the present and shape the future, expectations are not dependable; as a matter of fact, the past is filled with failed futures (Brown & Michael, 2003). First and foremost, expectations of technological or scientific developments tend to focus on technologies to be the main or only solutions to problems or routes to a better future. Such technologically deterministic future imaginations neglect the co-evolution of techno-science and society, overlooking society's impacts on policy, managements of demands and removal of barriers that are crucial to technological and scientific developments (Geels & Smit, 2000; Brown & Michael, 2003). In many cases, expectations tend to expect new technologies will take over and replace old technologies; nonetheless, old technologies and new technologies often coexist for different markets and social groups rather than disappear as soon as new technologies become available; for instance the access to the Internet does not replace the usage of paper and turn into a paperless world; instead, the Internet has generated even more printed papers (Geels & Smit, 2000).

New technologies do not necessarily replace old technologies. Nowadays, letters, paper books, paper magazines, newspapers, vinyls, CDs, petrol cars and physical stores coexist with e-mails, e-books, online magazines, online newspapers, music streamings, electric cars and online shops. Expectations of new technologies completely taking over from old technologies are not necessarily fulfilled. Such failed expectations are often caused by purely functional thinking that only takes functions into consideration yet neglects the social and psychological factors; for instance, despite online shopping can provide more convenient and efficient shopping experience, some people might still prefer shopping at physical stores because they like social interactions with sellers or simply enjoy spending time together with friends or family in physical stores (Geels & Smit, 2000). Expectations that are based on purely functional thinking are prone to be naively optimistic about future developments and ignorant of social influences.

Another reason why technological or scientific expectations often fail to meet their original promises is related to their performativity. Technological and scientific expectations guide and shape the developments. In particular, at the early stages, new technologies or scientific breakthroughs usually require developers to foster protected spaces or niches to nurture the technologies for further developments, and the developers usually do so by attracting money as well as effort investments that look forward to the future potential of new technologies (Geels & Smit, 2000). This means that when new technologies or scientific breakthrough are still in early developments or niche markets, their actual functionalities or capabilities tend to fall behind their expectations or promises, as mentioned in the work of Geels & Smit (2000):

> *"New technological options often emerge as 'hopeful monstrosities'. They are 'hopeful' because they have demonstrated that they can fulfill some societal function, but they are "monstrous" because their performance characteristics are low (p. 879)."*

Despite the fact that novel technological or scientific developments oftentimes fail to deliver what they first expected or promised, it is still important to recognize the mobilizing ability of those expectations, because the expectations of the future have constitutive impacts on the present.

Noting that the expectations assemble the technical and the social towards the promised future, but at the same time, the social aspects can drive the technological development into a future that is not the same as the promised one would be an intriguing point for analysis. In particular, consumer attitudes towards 3D food printing can differ much from what the developers of 3D food printers expect and have much driving force towards further developments. Even if the consumer attitudes are not manifested enough in the research findings, the social aspects such as consumer attitudes can still be reflected upon for discussing about how the research findings can be further incorporated into future studies, or the empirical findings can be related to the existing researches on consumers' attitudes towards 3D food printing.

3.2.2. Temporal & Socio-Spatial Variances of Expectations

Due to the reason that expectations and promises are strategic resources, the future projected in the expectations and promises are usually set high in order to attract investments and impact the agenda-setting process in technological and scientific developments; however, they do not necessarily intend to foresee the future accurately (Geels & Smit, 2000). Since early expectations are usually set high to gain momentum for developments, hype and disappointment occur in turn during the course of developments; in other words, expectations have temporal variability at different stages (Borup et al., 2006). Hype and disappointment can be identified in the variances of expectations. At the early stages of developments, expectations are the most intense, because they are set high in order to enroll as stakeholders and mobilize as many resources as possible, which resulting in hype that is created by investing in the expectations instead of the fundamentals (Borup et al., 2006). When the expectations fail to meet what they claim a technology would bring, expectations would drop, and the investments might only continue if the providers can further improve and deliver something that satisfies the early adopters, and expectations might gradually increase again if mainstream users accept the technology (Gartner, 2018).

Particularly, when it comes to emerging novel technologies, the potentials, properties, meanings, and so forth are still undefined, those technologies will thus go through a process of learning and co-evolving with the society, resulting in variances of expectations (Geels & Smit, 2000). In the case that temporal variances of expectations can be identified in research findings, the temporal variances provides analytical lenses to see how expectations and other social actors are at play. While in the case in which the temporal variances of expectations are less likely to be evident from the research data, since 3D food printing is still a nascent food technology and that the time span of the research data might not be long enough to identify obvious temporal variances of expectations, the concept of temporal variances can be applied to reflect on the research and identify the opportunities for future researches.

Other than temporal variances, expectations also have socio-spatial variances. Technologies are prone to go through the process of "societal embedding" in which technologies reconfigure users and are reconfigured in use; consequently, the final technological outcomes tend to end up not the same outcome as originally expected (Geels & Smit, 2000; Borup et al., 2006). It should be noted that during the process of technological development and societal embedding, many different social actors are involved; therefore, expectations also have social-spatial variances due to the reason that different social actors might have different expectations and different levels of trust in expectations in the course of technological developments (Borup et al., 2006).

For instance, in the study of Horst (2007), she finds that different groups of people hold different expectations towards gene therapy used to cure cancer. For the same gene therapy, in the assemblage of consumption which focuses on patients' rights, it regards expectations of gene therapy as future cure to be unproblematic and that the expectation will be realized by medical science sooner or later; in the assemblage of comportment that centers around doctor's responsibility, expectations should be credible about what can be delivered because expectations represent the future of gene therapy and cannot be a false hope that jeopardize the scientific inquiry to cure cancer; in the assemblage of heroic action that emphasizes the last hope, expectations are also unproblematic regardless of whether gene therapy will really cure cancer, because false expectations can be justified as patients' last hope for curing cancer (Horst, 2007). The three different assemblages in this case study highlights the social variances of expectations for gene therapy.

Expectations might also vary based on an actor's closeness to the actual technological or scientific developments due to the reason that technical capabilities, technical uncertainties and the gap between scientific experiments and expected future results tend to be invisible to the general public such as entrepreneurs and policy makers (Brown & Michael, 2003; Borup et al. 2006). People who are closer to the site of knowledge or technology production tend to be more prudent and realistic about what to expect than those who are further away from the site of knowledge or technology production. The reserved expectations is highly relevant to accountability; for instance, entrepreneurs are not necessarily accountable for long-term promises, and they tend to move to the next new innovation fast and create another inflated expectations for investments (Brown & Michael, 2003). The less the accountability to the claimed expectations, the less reserved the claimed expectations are.

Other than social variances caused by different social actors and distance from the site of production, the same social actors might also express different levels of trust on different occasions. For example, in order to attract interests and investments for developing, when scientists are in public and play the roles of entrepreneurs, they might express high expectations and promises of a technological or scientific developments; nevertheless, when they talk to the experts in their fields, the expectations might not be as high, and the promises might not be as bold as claimed to the public (Borup et al., 2006). Expectations in the scientific community differ from the expectations in the public, showing that expectations also have social-spatial variability. Oftentimes, the differences of expectations among different communities are induced by the unequal accesses to the knowledge and information (Brown & Michael, 2003; Borup et al. 2006).

The socio-spatial variances of expectations can serve as a useful analytical tool. It would be interesting to look into how different social groups hold various expectations towards 3D food printing technology; for instance, professional cooks might expect differently from how home cooks expect 3D food printers to be, or the developers might construct different expectations for different social groups, depending on how the research data manifests. Additionally, depending on how close the person is to the technical development, they might also hold different levels of expectations towards 3D food printing.

The developers' expectations might differ from the end users'. Even if the different level of expectations caused by different distance from the development are not present in the research finding, this concept can be used for suggesting the direction for future researches. Last but not least, it would also be intriguing to investigate whether the same social actors, both the developers and users, might express expectations differently at different sites when they play different social roles; for instance, the developers might express expectations differently when they are at different sites. When they are preaching broader visions, the expectations might be set high, whereas when they are actually selling 3D food printers, they might have to set the expectations more down to earth. The socio-spatial variances of expectations concept can be utilized to better understand the interactions between social actors, the place where they are located and the expectations towards 3D food printing.

3.3. Uses, Users and Sociology of Expectations

When it comes to design practices of technology, it usually involves configuring putative users with uses. In the study of Woolgar (1990) for instance, he discovers that designers define the identities of putative users and set limits on users' potential future actions. Characterizing putative users and predicting their future behaviors both involve envisaging the future that is constructed by expectations. This is where sociology of expectations can work as augmentation for social studies of users and uses in design practices of technology. While developments in science and technology has become more and more strategic and future-oriented (Borup, Brown, Konrad, & van Lente, 2006; Giddens, 1998, as cited in Brown & Michael, 2003), expectations have become significant existences that guide developments. Expectations are inscribed in technology designs as well as in the promotions of them. Other than being inscribed in design objects, expectations can also appear in policy documents, legal documents, think tank's publications, news media, grant proposals, research or development agendas, and so on (Wilkie & Michael, 2009; Pollock & Williams, 2010; Beaulieu, 2016). The expectations and visions inscribed in technology designs tend to relate to the expectations appear in those sources. In particular, the expectations in development agendas tend to overlap with the developed objects with intended users and uses designed by developers. Consequently, combing social studies of users and uses in design practices of technology with social studies of expectations can be not only compatible but also prolific in generating more findings.

In the script concept proposed by Akrich (1992), designers have certain visions about how the techno-social world should evolve and then inscribe those visions into the designed objects; that is, with the objects designed with certain visions and expectations, designers provide scripts to shape users' practices and behaviors. To inscribe the visions and expectations, it usually requires designers to picture users with certain tastes, capabilities, intentions, desires, political preferences, and so on (Akrich, 1992). Therefore, a social study of expectations can provide deeper understandings in design practices of technology, because expectations are oftentimes inscribed in technological designs. For example, when designers envision and expect the techno-society to progress towards a more eco-friendly space with less air pollution, they might design technical objects that reduce the emission of polluted air. Other than having expectations of future with green technologies, designers also expect users to share the same visions. They expect users to be the consumers that also value the environment and have the will to take actions by adopting the technological inventions. Users are configured as consumer-citizens whose consumer practices also contribute to ecological sustainability, although the ratio of citizen to consumer requires further inspection. The designed objects are scripted to deliver those visions and expectations by shaping users' actions. In this regard, expectations are closely intertwined with technological designs.

Furthermore, the concepts of "bi-directional configuration" and "script" also recognize the agency of users. The concepts would be helpful in analyzing how users' preferences or inclinations would in turn reconfigure technical objects or have impacts on the scripts prescribed by designers. In addition, a social study of expectations also pays attention to the social-spatial variations of expectation induced by different social actors, which could provide an analytical approach to understand how different users have disparate expectations for certain technologies and how those varied expectations can in turn influence the designed objects or scripts of designs. Other than demonstrating social-spatial variations, the sociology of expectations also offers a social approach to explain why expectations often fail, which can be useful for providing explanations with social contexts to why some technologies designed with certain expectations fail. This approach is more likely to avoid technological determinism. What is more, since my study subject is 3D food printing technology which involves food cultures that have been deeply rooted traditions for long, it would be productive to apply the sociology of expectations as analytical start point to understand why 3D food printing is accepted or not or how 3D food printing is developed in certain directions rather than others. For instance, 3D food printing can be related to the Slow Food Movement. Certain developments of 3D food printing technology cater to the Slow Food Movement that promotes local food and localization, whereas some developments of 3D food printing might not. Therefore, to study why certain expectations of technological designs does not fulfill what they have promised from social perspectives can be prolific in generating findings. In this sense, the sociology of expectations and a social study of design practices in technology are inseparable from each another.

4. Research Questions

In my study, rather than focusing on the online news discourse of 3D food printing technology like Lupton (2017) does in her research, I focus specifically on the developers of 3D food printing technology. Even though online news on 3D food printing technology also includes 3D food printing developers' perspectives, those perspectives would appear as second-hand sources, and it is inevitable that the news might also incorporate journalistic views and visions of 3D food printing. Consequently, 3D food printing technology in online news might not be identical with developers' views on the technology or how they promote 3D food printing, since the journalists do not have the pressure to strike a balance between promoting 3D food printing technology and delivering products that meet the statements made in promotion. Although news on 3D food printing does contribute to broader sociotechnical conception about this novel food technology (Lupton, 2017), it might not directly overlap with developers' perspectives on 3D food printing. As a consequence, to get closer to the development and production sites to learn how 3D food printing technology is constructed and introduced by the developers, I will look into how the developers configure the uses of their 3-D food printing devices as well as potential users and reach out to consumers. Accordingly, my research will be guided by the following main question and subquestions:

4.1. Main Research Question

How are the uses and users of 3D food printers scripted and configured by the developers of 3D food printing technology on their official websites and in their promotional videos in order to make sense of the novel food technology?

For novel food technologies, the uses and users are relatively undefined in comparison with mature food technologies. Consequently, before the novel food technologies are adopted by users and perhaps repurposed the uses inscribed by developers, developers have the power to script the uses and users. How the developers of the technologies inscribe certain uses and potential users is thus influential in the further developments of the technologies and the user acceptance of the technologies. While printers are usually associated with marking papers with chemical inks or manufacturing 3D objects made of plastics, the idea of 3D food printing can stir up uncomfortable feelings and distaste (Lupton & Turner, 2016). Since foods are commonly correlated with cooking and baking which involves mixing and heating ingredients with cooking stoves, ovens or the other kitchen appliances, preparing food with a 3D printer can be unsettling to some people.

Owing to this, how the developers make sense of 3D food printing has a great impact on whether this novel food technology will be accepted. To understand how the developers make sense and convey the idea of 3D food printing technology, my main research question is formulated centering around two main foci. The first focus is about how the uses and users of 3D food printing constructed by the developers, and the second focus is about how expectations and the future interact with the present time.

4.2. Research Subquestions

In the course of finding answers to the main question, subquestions are formulated to make the research direction stay in focus:

(1) How are the uses of 3D food printers framed in relation to conventional food preparation by the developers of 3D food printing technology?

This question aims to learn about how the developers frame 3D food printing technology. First and foremost, "how should 3D food printers be operated and applied according to the developers of this technology?" The practicality and functionality of 3D food printing presented by the developers will be the main focus of inquiry. While novel food technologies tend to provide new ways of generating or preparing foodstuffs, consumers might not find them acceptable, for the new ways might be completely different from the conventional ways which they have been accustomed to generate or prepare foods. Therefore, it is important how the developers of 3D food printing situate the technology in relation to conventional ways of food preparation, since it would have profound effect on how consumers react to it.

When a novel food technology is placed as radically revolutionary, it might face polarized degrees of acceptances, eventually turning into a failed technology. Likewise, a novel food technology has much overlap with already existing food technologies, consumers might see no points to adopt them at all. As a consequence, to make a novel food technology successful, it is essential that the developers of novel food technology find their way to weave their technology into the existing food culture and food industry. "How 3D food printing technology is positioned by the developers in relation to conventional ways of food preparing such as cooking and baking" will be examined. In my study, I will look into how the developers position 3D food printing technology and how they make 3D food printing technology interact with the existing food culture and food industry.

(2) How are the users of 3D food printers conceived by the developers of 3D food printing technology?

In the process of developing innovative technologies, developers usually have certain visions about how the social and the technical world should be like in the future, and these visions encompass future users whom they expect to use the technologies. As a result, other than the uses of 3D food printers, I would also like to find out how the users are conceived by the developers, because this would reveal another aspect of 3D food printing technology that the developers consider or expect it to be. Potential users are parts of the visions. Therefore, to develop novel technologies, developers also have to imagine and define their potential users with certain tastes, capabilities, and so forth (Akrich, 1992). In my study, I will look into what kinds of people are envisaged as users by the developers in 3D food printing technology. Who they are, what they value will be the main focus of inspection.

Additionally, I will also pay attention to what competences users should possess and what performances users should make in order to operate 3D food printers, e.g. affluent finance to purchase 3D food printers, digital literacy, manual food preparation before printing, and so on. Last but not least, in relation to the second subquestion about how developers expect 3D food printing can contribute to the society, I would like to identify which users are expected to be benefited from the uses of 3D food printing.

(3) How do the developers of 3D food printing technology expect or promise 3D food printers to contribute to the society?

Novel food technologies are usually assigned with certain contributions to the society, because developers of novel food technologies are prone to expect their technologies to bring purposes to the society, whether as selling points or not. Take GM foods, for instance, they are expected to provide nutrition-enhanced crops to provide improved diets, stop hunger and save lives (Gusterson, 2005). In vitro meat is also bestowed with expectations. It is seen as a solution to animal slaughter, environmental issues caused by animal farming, and so forth (Jönsson, 2016). Novel food technologies tend to be introduced as solutions to solve certain problems. For this reason, I am interested in learning what contributions the developer of 3D food printing technology expect 3D food printers to make. In particular, I will look into "what problems the developers expect the uses of 3D food printing technology can solve or alleviate," and "what uses of 3D food printers are applied to solve those problems."

(4) In the developers' depictions about uses and users of 3D food printing, how does the future interact with the present time?

As novel food technologies are innovations that are still developing, the contributions that developers wish the technologies to bring to society tend to be futuristic. That is, the contributions of novel food technologies usually appear in the forms of expectations or promises to be actualized in the future. However, positioning novel food technologies in intangible and far-away future is hard to attract attention, interests and investments and approvements for the developments of the technologies. Developers thus might play around between the future and the present to obscure the time line, making the developments more visible and persuasive. Therefore, I am intrigued how the future interact with the future time in the developers' depictions.

In relation to this, when contributions are expectations of the future, both uses and users will be placed in the future as well. To better understand how the developers of 3D food printing technology shape the development of it, examining how the developers position the uses and users of 3D food printers in the temporal spectrum would be helpful. Therefore, I will scrutinize how uses and users of 3D food printing technology are situated, whether they are placed in the present, the future or constantly shift between the now and the future.

5. Materials & Methods

5.1 Material Selection & Materials

To look into how the developers of 3D food printing technology configure uses and users of the technology, the most direct way is to examine the companies' websites and promotional videos of 3D food printing technology. For the hobbyists and professionals alike, when they intend to engage in a new technology or upgraded their appliances, official websites of new technologies tend to be the places where the first-hand information and resources regarding the technologies are provided. Likewise, online videos are also resources to learn about new technologies nowadays. Companies tend to promote their concepts, service and products via online videos, whether their service or products are still developing or developed. For this reason, I consider that choosing official websites and promotional videos of the developers of 3D food printing technology would be a fruitful way to learn how the uses and users of 3D food printing technology is scripted and configured by the developers.

To select the materials in the year of 2018, I first went through the websites of major companies and organizations that dedicated to 3D food printing technology, including Natural Machines, BeeHex, Robots in Gastronomy, Print2Taste (Procusini), byFlow, Food Ink, 3D Systems, PancakeBot, Choc Edge and WASP. After checking their official websites, several were eliminated from the list of study materials. First, Robots in Gastronomy, which was a research and design group focusing on digital gastronomy, was also left out from the list of research materials, for Robots in Gastronomy did not specifically advertise 3D food printers. The official website only had little introduction and links to press release, and it was last updated in 2014. Therefore, I also decided to delete it from the list of research materials. Similarly, on the official websites of 3D Systems and WASP both focused on 3D printing technology in general, 3D food printing was not the focus, and there was no specific advertisement on 3D food printers. Consequently, I also excluded these two websites from my list. As for PancakeBot and Choc Edge, which targeted at printing pancakes and chocolates respectively, I also decided to omit these official websites, because I wanted to keep the focus on printing food in general rather than specific type of food. After the selection, the online websites that I would use for analysis were the official websites of Natural Machines, BeeHex, Print2Taste (Procusini) and byFlow. These four websites all contained ample information about what 3D food printing was and how the developers expected 3D food printing could do as well as how users could and should utilize 3D food printers. Other than these four official websites, I also included the official websites of Food

Ink as research material. Food Ink was a gourmet experience which consists of pop-up dinning series that featured 3D-printed food, utensils and furniture[2]. Owing to the reason that on the website of Food Ink, 3D-printed food was situated in the intersection of fine cuisine, art, philosophy and technology, I reckoned that it would be beneficial to include it for analysis, because it provided a specific context of how developers of 3D food printing technology imagined and shaped the technology.

Additionally, I also looked up whether these companies had promotional videos of 3D food printing technology on their own websites or on YouTube. After checking, I found two videos that were especially fitting for my research interests and analysis. The first one was a promotional video of byFlow on YouTube called “byFlow in High Tech Stories February 2018.” The format of the video was also like an interview and introduction. One of the founders talked throughout the video, and it was occasionally accompanied by a narrator’s introduction. The entire video lasted 2 minutes and 51 seconds. As for Food Ink, on their official website as well as YouTube channel, it also had a video called “The World’s First 3D-Printing Restaurant” which I found abundant for analysis, because it provided a context of how 3D food printing could and should be; moreover, it also emphasized “to taste tomorrow today,” which was highly related to my research question about the interaction between the present and the future and my research interest in the sociology of expectations. The video lasted 2 minutes and 40 seconds.

1	**The official Website of BeeHex** http://beehex.com/	-
2	**The official Website of Print2Taste (Procusini)** https://www.procusini.com/	-
3	**The official Website of byFlow** https://www.3dbyflow.com/home-en	-
4	**The Official Website of Food Ink** http://foodink.io	-
5	**The Official Website of Natural Machines** https://www.naturalmachines.com	-
6	**The video “byFlow in High Tech Stories February 2018” by byFlow** https://www.youtube.com/watch?v=EatSq5YKY3Q&t=39s	0:00-2:51
7	**The video "Food Ink - The World's First 3D-Printing Restaurant” by Food Ink** https://www.youtube.com/watch?v=UWOVvSfSjCM	0:00-2:40

After the selection process, the research materials of my case study consist of 5 official websites and 2 promotional videos of developers that dedicate to 3D food printing technology. I consider these websites and videos to be proper amount of materials for a

[2] http://foodink.io

study of master's degree. The synopsis of each promotional video are introduced in the following sections.

- **Video 1 : "byFlow in High Tech Stories February 2018" by byFlow**

The video begins with a female narrator bringing up byFlow's 3D printers which can print more than fifty ingredients, including chocolate, sugar, butter, vegetables, fruits and meat. One of the founders of byFlow, Nina Hoff, goes on mentioning the potential of the technology to help against food waste, since 3D food printer can provide a second life for the spotted or unappealing food that would have been thrown away. The narrator goes on with the statement that 3D food printing has more important benefits, then Nina Hoff comments on how 3D food printing can provide fun and appealing food for people with swallowing problems. Additionally, it is mentioned that the Dutch food company "Verstegen" developed the world's first edible filing for 3D printers. Nina Hoff then explains that this would make it easier for the middle segments such as hotels, restaurants and cafes to start with 3D food printing. Verstegen has developed a vegetable puree with Jan Smink who is a chef at the Librije. The puree for 3D printing is made of red beets and cardamom. In the video, it also covers that byFlow is a family business and that Nina Hoff won the award for "Woman Tech Entrepreneur" at the Technionista Awards. She has initiated "Woman in Tech" and conveyed the idea that many women are needed to build great technology and tell the story if necessary. The video ends with the concept that "future is happening now." Nina Hoff concludes that they are able to build this future, because they know they have to live here for another fifty to sixty years, so they'd better be a part of it right now instead of waiting for something great to happen, and that is why she finds it fun to be at byFlow.

- **Video 2: "Food Ink - The World's First 3D-Printing Restaurant" by Food Ink**

There is no single narrator or speaker in the video; rather, it is accompanied by background music throughout the video and some texts on top of the video images. The video starts with a shot of a modern building in the background and the caption "FOOD INK presents" in the foreground, accompanied by Luigi Boccherini's the string quintet in E major, Op.11, No.5 as the background music. Then, it quickly moves on to the inside of the building as the background image to foreground Alan Kay's quote—"The best way to predict the future is to invent it." The video images then shift to people in workshops and a man with a lab coat opening an oven. Soon afterwards, the music switch to the instrumental version of "Winning" by Fingazz. The sudden change from classical music to electronic music in the background, along with the caption "let's hack fine-dining," bring up a whole new and high-tech ambience for viewers. The electronic music plays throughout the video until the end, and the video images focus on people attending workshops, 3D food printers printing food, food designs on computers, professional chefs preparing food along with 3D food printers, and presenting several exquisite dishes and delicate desserts that could be associated with haute cuisine. There is a caption highlighting "the world's first 3D-printing pop-up restaurant." Additionally, the convenience and simplicity of digital kitchen are emphasized through captions such as "you've got meal," "pixels to printer to plate," "download something delicious" and "3D-printed dessert? piece of cake." Near the end of the video, cities around the world and online are accentuated; then, it ends with the caption "taste tomorrow today."

5.2 Preliminary Preparation for Analysis

The five official websites were saved as PDF files, including the home pages and links to other pages within navigation bars. These PDF files of the official websites were treated as information source where raw data in the form of units for analysis was generated from. There were two reason for saving the websites as PDF files. First, it was easier to analyze than browsing online websites; second, it was better for the study to settle for a particular version of the research data. Since online websites could be updated regularly, saving a particular version would make more sense for research analysis, fitting better for the scope of a master's thesis. Updated versions could be utilized for further studies in the future.

After saving those PDF files, I read them several times until I become immersed in the contents. This step is crucial because researchers need to be completely familiar with the contents in order to gain meaningful insights of the contents (Elo & Kyngäs, 2008). After completely familiarizing the contents of the official websites, I begin to define the units of later analysis. A unit of analysis is a fundamental sample of text that would be coded and categorized in the process of content analysis, and a unit can consist of a word, a half sentence, a full sentence, a paragraph, paragraphs, a document, an image, an item or feature in an image, a shot in a film, an entire film, and so forth (Schilling, 2006; Elo & Kyngäs, 2008; Zhang & Wildemuth, 2009; Schreier, 2012). Depending on the contents of written texts or visual texts, the sizes and scales of units for analysis are determined by individual themes, ideas and meanings. When defining a unit by a theme or meaning, it ensures that a segment of written or visual text contained an idea or information (Schilling, 2006; Zhang & Wildemuth, 2009), which would help me avoid encountering useless analysis when I strictly apply word-by-word or sentence-by-sentence coding. At this stage, I define the units on the website for analysis, and the units can be a framed section on a webpage, a caption, a paragraph of written text, an image, a pair of written and visual texts, and so on. These units are marked and stored as raw data for later analysis.

As for the videos, each video is transcribed into written texts and treated as preliminary source of data for analysis. It should be noticed that one of the two videos in my materials does not have a narrator or speaker; however, the messages are conveyed in animated captions. Even though there is no verbal sound to be transcribed, I still find transcribing the texts in the captions for analysis necessary, for the animated captions function the same way as verbal utterance does to convey messages. After the transcripts are finished, I first immerse myself in the written texts of the transcripts. As soon as I become familiar with the contents of the two video transcripts, I start to determine the units for analysis. A unit can be a word, a sentence, a paragraph, and so forth, depending on the theme or meaning that was formed within the unit (Schilling, 2006; Zhang & Wildemuth, 2009). These units are also be marked and stored as raw data for later analysis.

5.3 Qualitative Content Analysis

To fit the scale of a master's thesis study, analyzing all the websites and videos of 3D food printing developers is simply not a feasible task. Consequently, to conduct a research that is viable for a master thesis, I choose to analyze five official websites and two promotional videos created by the developers of 3D food printing technology. Since I do not begin with a presumed theory or concept and that my research questions are difficult to be answered in numerical terms, a qualitative research method would be more applicable. Particularly, a qualitative content analysis is ideal as my methodological approach. Being the research approach where qualitative content analysis stems from, quantitative content analysis is a methodological approach that provided objective and systematic description in quantitative terms of studied samples (Schreier, 2012). However, since meaning is often complex, context-dependent and that meaning frequency is not always proportional to the importance in the studied subjects or materials, a qualitative approach to content analysis can be more fruitful in some researches due to the reason that it is not confined by manifest contents and frequency counts (Kracauer, 1952; Schreier, 2012). Qualitative content analysis is a systematic research method that allows manifest as well as latent meanings, themes and patterns to arise from verbal, visual or written data by condensing broad phenomenon with categorizations, which enables researchers to construct social reality with their own interpretation in a subjective but scientific manner without impetuous quantification (Schilling, 2006; Elo & Kyngäs, 2008; Zhang & Wildemuth, 2009; Bengtsson, 2016).

Unlike a quantitative research method that collects data from a large number of samples so as to remain as unbiased as possible (Jensen & Laurie, 2016), a qualitative content analysis usually is conducted with "purposively selected materials" that could be related to the research questions (Zhang & Wildemuth, 2009). Instead of reaching a generalization or stating a single truth as in quantitative approaches, a qualitative content analysis focuses on in-depth understanding of certain materials and a specific context, which renders a qualitative content analysis case-oriented (Bengtsson, 2016). I reckon a qualitative content analysis would be useful for two reasons. First, my materials are "purposively selected" official websites and videos produced by 3D food printing developers in order to answer my research questions; second, my research questions that ask about the uses and users of a novel food technology constructed by the developers require in-depth analysis that cannot be generalized and answered in numerical terms. A case-oriented qualitative content analysis is ideal for my study.

In addition, to understand how the uses and users of 3D food printing are constructed by the developers in my research materials, a manifest analysis of what are being said might not be enough to answer my research questions; therefore, a latent analysis of how things are being said is equally important for the overall content analysis. In other words, to answer my research questions with an analysis of my chosen materials, interpretations are indispensable. As qualitative content analysis is interpretive and suitable for the research materials without obvious meanings and requires some degree of interpretation (Schreier, 2012), it fits my study well. Nevertheless, the importance of interpretation in the qualitative content analysis also underlines the co-production of data and the researcher's background knowledge, contending that data does not speak for itself, but meanings are constructed by researchers (Schreier, 2012). In the process of qualitative content analysis, researchers have to constantly keep the research questions in mind, always go back to the questions, delete the information in the raw data that are not relevant to the goal of the study (Schilling, 2006; Elo & Kyngäs, 2008; Bengtsson, 2016). Consequently, with the same research materials, when different research questions are asked, the final categories and results of qualitative content analysis would end up differently. Qualitative content analysis provides one in-depth aspect of the research data rather than a comprehensive overview of it, since meanings are always constructed and that different questions accentuate different meanings of the same research data.

Despite interpretations are at the core of qualitative content analysis, it is a systematic and scientific research method to be applied to verbal as well as visual texts. By coding materials and classifying research data as instances of categories of a coding frame, it ruptures data and adjusts condensed data in the form of categories to draw and verify conclusions (Schilling, 2006; Schreier, 2012). Therefore, in the process of qualitative content analysis, even though certain information at the individual level is forsaken, the information at the collective level is gained in the analysis results (Schreier, 2012). To initiate a qualitative content analysis of my own, I first read through the texts of transcripts and the units of the official websites many times so that I do not feel pressured going into the analytical phase.

Soon after having a sufficient grasp of the materials, I move on to the open coding phase. I applied open coding on both verbal as well as visual texts. An example of how open coding phase is conducted for video transcripts is shown in table 1. On the left side of the table are original textual units in transcripts, and on the right side of the table are the notes and headings generated from the texts during open coding process.

Table 1. An example of how open coding is conducted.

Original Texts in Transcript	**Notes and heading generated in open coding phase**
Chocolate, sugar, butter, vegetables, fruit and even meat, with a 3D food printer, startup byFlow can print more than fifty different ingredients. Besides the fact that it's awesome, it can also help against food waste.	**Printing with chocolate** **Printing with sugar** **Printing with butter** **Printing with vegetables** **Printing with fruit** **Printing with meat** **Printing with more than 50 different ingredients** **Helping against food waste**
With this food, the food that has been thrown away because it has a little spot on there, or because it doesn't look appealing enough, we can give it a second life with 3D food printing, so we can put it in our 3D food printer and print some beautiful dish for it.	**Providing a second life for unappealing food by printing beautiful dishes**
And 3D food printing has more important benefits: Can you imagine that there's people that has swalloing problems, so they cannot even eat food. They always are litmited to NutriDrinks or to puree….and all look disgusting. These people don't have fun anymore with eating. Umm with 3D food printing, we can print that fun back.	**Helping people with swallowing problems** **3D-printed food as replacement of NutriDrinks and puree** **3D-printed food as fun food for people with swallowing problems**
And thanks to byFlow's printer, the well-known Dutch food company "Verstegen" developed the world's first edible filling for 3D printer. Smart, because not all the restaurants have the time to make the fillings themselves.	**Developing food cartridges for 3D printers** **Saving time with food cartridges** **Using food cartridges in restaurant**

They want to make it easier for let's say, the middle segments of the Horeca, to also start with 3D food printing. So they came up with the vegetable puree. It is made out of red beets and cardamom which is a herb. It tasted amazing, so they just found the perfect recipe togerther with Jan Smink who is a chef at the Librije, umm to always be able to 3D-food print.	**Using3D printing food in Horeca** **Using food cartridges in hotels** **Using food cartridges in restaurants** **Using food cartridges in cafes** **Printing with vegetable puree** **Using red beets as ingredients** **Using cardamoms as ingredients** **Vegetable puree for printing is tasty** **Developing cartridge recipe with professional chef**
For byFlow, Nina has a lot of plans, because the future is happening now.	**Future is happening now**
We are able to build this future. We know we have to live here for another fifty to sixty years, so we'd better be part of it right now instead of waiting for something great to happen, so I think that's also the fun of being at byFlow.	**3D food printing is the future** **Building 3D food printing future now** **Being part of 3D food printing future now** **3D food printing as something great** **Not waiting for 3D food printing to happen** **byFlow builds the future now**
Turning Technology into Business	**Turning 3D food printing into business**

To facilitate the coding process, I conduct open coding with the help of MAXQDA. MAXQDA is a software designed for qualitative and mixed methods research[3]. It is very helpful for collecting, organizing and analyzing research data. The open coding phase of the video transcripts is conducted on MAXQDA, because it allows me to retrieve coded segments at ease, which can save me much time trying to find the original texts of certain open codes. I can easily retrieve the original text by simply clicking the code. Moreover, for the upcoming phase to create categories based on open coding results, it would be much easier to manage the grouping process.

Other than verbal texts from the video transcripts, I also apply open coding to the written texts as well as visual texts from the official websites. The process of open coding is also conducted with the help of MAXQDA. During the preliminary preparation phase, I have already determined the units on the official websites. Each unit has been saved as a picture file for analysis. At this open coding phase, I simply code on each picture. Working with MAXQDA, I can freely delimit the part I want to code and then assign a code to it. To retrieve the original visual or written texts, I only need to click on the codes, which is also helpful for writing final results of the study. All the codes created during open coding phase are automatically saved under the same project for later analysis. Two examples of open coding

[3] [What is MAXQDA?] (n.d.). MAXQDA. Retrieved July 28th, 2018, from https://www.maxqda.com/what-is-maxqda

applied to units on official webpages are shown in figure 1 and figure 2. Open coding is the stage where categories emerge from data; in other words, data is extracted, reduced and decontextualized (Bengtsson, 2016). After notes and headings emerge from the written and visual texts of all units, I start to group the codes. These codes are grouped together in the categories they are sorted into. With constant comparison and contrast, the categories are created based on the contents of the coded units as well as my research questions. It is very important to keep the research questions in mind and leg go of irrelevant information so that researched materials are re-contextualized and that the final analysis can answer the questions this study wants to learn about (Elo & Kyngäs, 2008; Bengtsson, 2016).

Figure 1. A coding example of texts

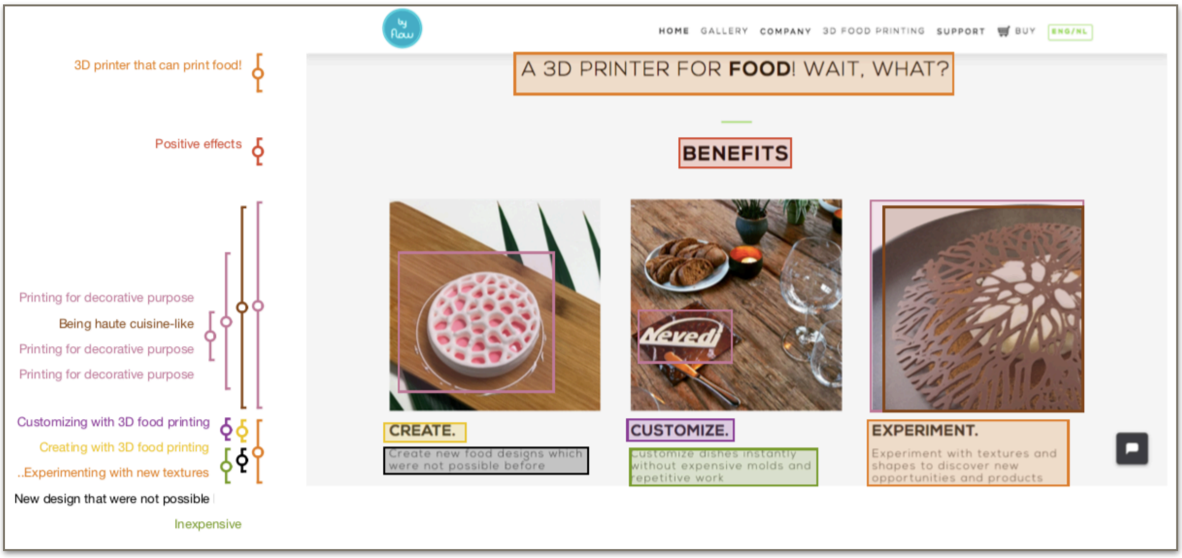


Figure 2. A coding example of images

Examples of how the process of grouping and categorization works is demonstrated in table 1. All the codes of video transcripts and official websites created during open coding phase are saved and managed in the same project which is organized on MAXQDA.

The codes are grouped into subcategories, and then the subcategories converge into main categories which are to be developed into themes. After subcategories, main categories and themes are generated, a coding frame is completed. The completion of the coding frame allows me to move into the phase to draw a first conclusion and write the results of my first analysis. The conclusion and results of video transcripts and official websites at this stage will be combined with the conclusion and results of multimodal critical discourse analysis applied to the videos in order to gain deeper and more holistic understanding. It should be noticed that qualitative content analysis conducted with coding and categorization is not a entirely linear process (Elo & Kyngäs, 2008); rather, the process is a combination of linear and cyclic paths (Schreier, 2012). The stages of qualitative content analysis from defining units, open coding, categorizing, building coding frame, drawing a conclusion to writing final results are indeed semi-sequential. However, I sometimes go through some stages more than once in order to revise my coding frame to make the conclusion and final results more inclusive, then inevitably, I have to adjust to include or exclude some data and go through the phases of open coding, categorizing and modifying the coding frame again. When a proper and sufficient explanation can be generated from the coding frame to answer my research questions, it is the point when saturation of the data is achieved and categories are good enough for the coding frame (Bengtsson, 2016).

Table 2. An example of grouping and categorization

Digital kitchen	WiFi connection		
	Digital gastronomy/ production	5 preset food designs	
	Finding the best settings (temperature, speed, sieving)		
	Software (+ free downloads)		
	Other equipments needed, e.g. iPad		
	Procusini club provides numerous applications		
	3D printer is future-proof	Upgradable printheads and software	
	Easy and practical in use	Emphasizing “guaranteed success”	Files of 3D objects and be found in databases on the Internet
			Files of 3D objects and be found in databases on the Internet
			Operating on its own
			Entering and printing names = child’s play
			No cleaning necessary
			Can be cleaned in a dishwasher

5.4 Multimodal Critical Discourse Analysis

Since qualitative content analysis alone used to study the video transcripts neglects the visual and some audio contents that are not transcribed in the video transcripts, applying a multimodal discourse analysis, especially a multimodal critical discourse analysis as a supplementary methodological approach, it can complement qualitative content analysis which focuses only the verbal contents of the videos. Applying multimodal critical discourse analysis to the videos can benefit the overall results and make it more comprehensive. There are two folds in multimodal critical discourse analysis. The first fold is in its multimodality, and the second fold is about critical discourse analysis.

Regarding multimodality, oftentimes, written and transcribed spoken texts tend to be the center of analysis; however, language is not the only social semiotic that produces meanings; rather, there are many other social semiotics such as speech, dance, music, images, layout, gesture, moving images, soundtrack, clothing and 3D objects that are sources for communication (Jancsary, Hoellerer & Meyer, 2015; Roderick, 2016). These social semiotic resources are modes of meaning-making that are socially and cultural shaped (Kress ,2010, as cited in Jancsary et al., 2015). In everyday encounters, there are various modes involved. For instance, watching a youtube video may involve speech, music, images, moving images, and so forth at play. Therefore, to address the deficiency of only focusing on written and transcribed spoken texts, multimodality is then proposed to offer a way to see meaning being produced by various semiotic modes altogether (Roderick, 2016). In a multimodal analysis, it does not focus on only one semiotic source, assuming the other modes are just auxiliary; instead, a multimodal analysis sees communication to be achieved by the interaction of modes which is a “meaning-materiality complexes” generated in the process of resemiotization (Roderick, 2016).

Owing to the development of new technologies, the communication has turned from being monomodal to multimodal, making communication involve different modes to express complex ideas (Machin, 2013). Nowadays, individuals, groups, companies, organizations and policy makers also use means other than texts, such as visual images and videos to get their ideas across. In particular, to promote novel technologies, a multimodal presentation like texts with visuals and videos are often applied to make new technologies more tangible and appealing. This also applies to 3D food printing technology. Since it is still developing, 3D food printers are still evolving and changing. Visuals and audio-visuals thus can help people have more concrete ideas about what 3D food printing is about. The multimodal trend of communication is especially typical in communicating about 3D-printed food and 3D food printers. Other than written news, much information about 3D food printing are available on official websites and videos. On the official websites produced by developers of

3D food printing technology, other than written texts, there are many images, animations, layout designs and even videos. These different modes all play a role in communicating information about 3D food printing technology to the viewers. As for in the videos produced by the developers or review videos on 3D food printers made by professionals or amateurs reviewers, images, moving images, background music, sound effects, speech, gesture, and so forth combined together are also important for getting ideas across. Since a multimodal analysis recognizes each mode and its contribution to the overall “meaning-materiality complexes” (Jancsary et al., 2015; Roderick, 2016), I think applying multimodal critical discourse analysis which combines modes is an advantageous way to generate useful and insightful results.

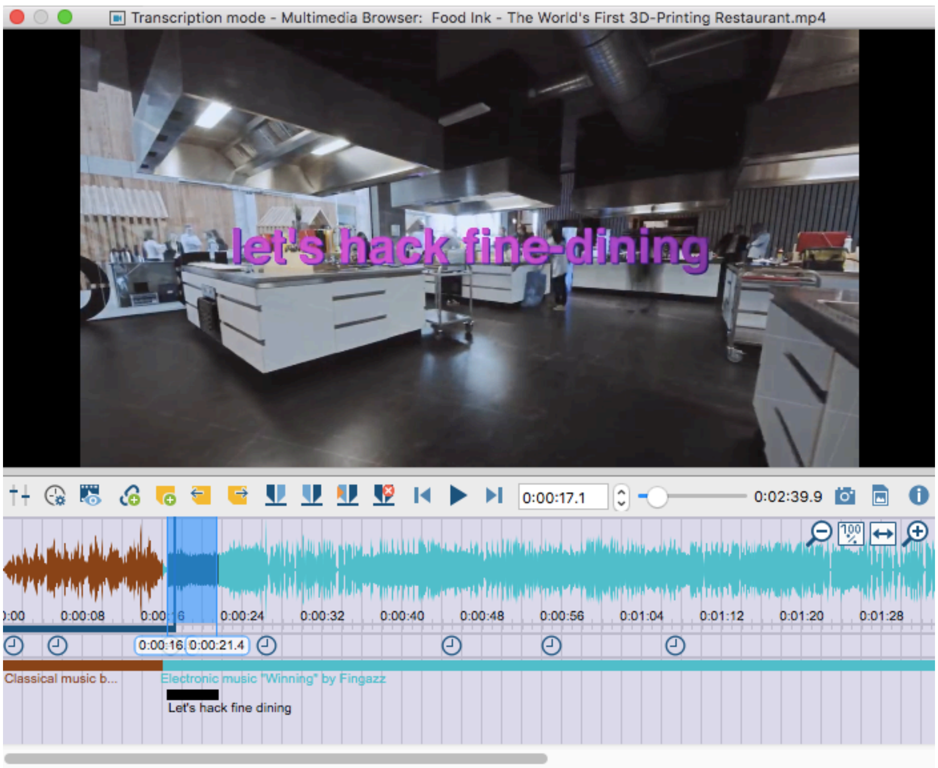
Apart from multimodality, multimodal critical discourse analysis is special for being critical. It is important to combine multimodality together with critical discourse analysis because power, truth and interest are oftentimes represented in semiotic modes other than language; multimodal critical discourse analysis thus aims to discover how power or persuasiveness is established in a multimodal design (Machin & Mayr, 2012, as cited in Jancsary et al., 2015). In the work of Fairclough (2003, as cited in Machin, 2013), he notes on what critical discourse analysis concerns:

> “The analysis in CDS (critical discourse studies) typically draws out these discourse showing what kinds of identities, actions, and circumstances are concealed, abstracted, foregrounded in a text, pointing to the ideological and political consequences of these.” (p.352)

Multimodal critical discourse analysis also pays attention to the process of concealment, abstraction and foregrounding in discourses, but it does it with keeping different kinds of modes in mind, trying to identify how the modes contribute to the process (Machin, 2013). In the developers’ multimodal discourse of 3D food printing technology, certain identities, actions and circumstances could be hidden, simplified or accentuated. For instance, despite many applications of printing chocolates or sugar with 3D food printers, when trying to sell the benefits of 3D food printing, developers have the tendency to emphasize more on the applications of 3D food printers to print with natural ingredients such as fruits and vegetables, identifying 3D food printing as being healthy. In the video, the audio might be talking about utilizing natural ingredient, while the visual images in the video show 3D printers printing chocolates. Consequently, applying multimodal critical discourse analysis can be beneficial for gaining richer study results, because multimodal critical discourse analysis looks into why certain meanings are naturalized or legitimized in certain contexts and what such naturalizing and legitimizing results achieve (Machin, 2013).

It should be noted that critical discourse analysis per se is not “the” research method but an analytical approach that asks critical questions and takes modes of communication into account, which means that there are no standardized methods for conducting critical discourse analysis (Jancsary et al., 2015). Depending on the respective study materials and goals, multimodal critical discourse analyses can differ from one another. To assemble an approach of multimodal critical discourse analysis for my own research, I have used the methodological approach proposed by Jancsary et al (2015) as reference, outlining five steps (identifying the genre, recognizing the manifest content, reconstructing latent elements, learning the overall composition and evaluating critically) in three layers (individual modes, integrated analysis and broader discourse) for my analysis. Like qualitative analysis of websites and video transcripts, multimodal critical discourse analysis of videos is performed on MAXQDA too. When analyzing the videos on MAXQDA, I first try to identify the genre of the verbal, visual and audio texts respectively. For example, when the genre of the audio texts change from classical music to electronic music, I code the time frames where different background music plays, as shown in figure 3. After identifying the genre, I move on to the contents. The manifest verbal, visual and audio contents are identified individually. The next step is to look into the latent elements of these contents. They are coded or written down in memos. Then, I move on to the integrated analysis, trying to recognize the interplay of verbal, visual and audio contents to see how they relate to one another. Afterwards, I impose an critical evaluation on the multimodal analysis, reflecting upon what the analysis imply about broader social context and issues.

Figure 3. A coding example of an video



5.5 Design of the Analysis

As my research materials consist of five official websites and two videos produced by the developers of 3D food printing technology, this study combines qualitative content analysis and multimodal critical discourse analysis. Qualitative content analysis is applied to study the video transcripts of verbal contents. This provides a preliminary and general understanding of the video contents. Official websites are also studied with qualitative content analysis, because it can provide in-depth understanding of both written and visual texts. However, in the videos, communication is not achieved merely in verbal terms. Video transcripts of verbal contents alone are not adequate to generate in-depth understanding of meanings constructed in different modes, such as sound, images and moving images. Combining multimodal critical discourse analysis can be fruitful for enriching the analysis results. Nevertheless, I only attempt to apply multimodal critical discourse analysis to the videos. I do not conduct multimodal critical discourse analysis on the websites. Even though the websites also consist of various semiotic resources, weighing the considerable amount of time needed to conduct multimodal critical discourse analysis on the websites and the amount of results it could add to my study, I have decided not to conduct it on the websites. The results generated from qualitative content analysis are rich enough. I reckon that applying multimodal critical discourse analysis on the websites' contents will not yield extra results that can answer my research questions.

6. Results & Analysis

The chapter of results and analysis was based on the data collected from the websites and videos of five companies: “BeeHex,” “Procusini,” “byFlow,” “Food Ink” and “Natural Machines.” Regarding the five companies:

- **BeeHex**[4]

Located in the United States, BeeHex was funded by NASA to develop 3D food printer system for deep space missions. In addition, it was awarded a project by the United States Army. The company situated their 3D food printers as machines that allowed people to customize and personalize food on the spot.

- **Procusini**[5]

Procusini was a German company that develops 3D food printers for professional applications, such as for hotels, catering, event gastronomy and confectionary. The 3D food printer they sold was named “Procusini.” The company also provided the options of food refills for 3D food printing, allowing users to print food such as chocolate, marzipan, fondant and pasta right away.

- **byFlow**[6]

byFlow was a Dutch company that specialized in developing 3D food printers for professional use. The product they provided was the “Focus 3D food printer.” They also worked with the food supplier “Verstegen” to provide fillings for 3D food printing.

- **Natural Machines**[7]

Natural Machines was located in Spain. The company focused mainly on professional kitchen users. The launch product of Natural Machines was the 3D food printer “Foodini.” Foodini was an open capsule model, allowing users to place freshly-prepared ingredients to print food.

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[4] BeeHex. Retrieved August 3, 2018, from http://beehex.com/

[5] Procusini. Retrieved August 6, 2018, from https://www.procusini.com/

[6] byFlow. Retrieved July 28, 2018, from https://www.3dbyflow.com/home-en

[7] Natural Machines. Retrieved August 18, 2018, from https://www.naturalmachines.com

- **Food Ink**[8]

Initiating the world's first 3D printing restaurant in London, Food Ink focused on creating edible art with 3D food printing. Food, utensils and furniture in the restaurant were all 3D-printed. Food Ink also collaborated with restaurants in various countries to offer 3D-printed dining experiences.

6.1. Digitalized Food Production: Replicating Human Skills?

6.1.1. Scripting Digitalized Food-Making Process

As opposed to handmade food which involved human skills, kitchen utensils and equipments, 3D food printers were often emphasized with their features of digitalization. In the study data, digitalized food making process was always the aspect that surfaced to the forefront when it came to 3D food printing:

> *"Foodini is a connected device, meaning it's connected to the Internet. It has a built in touch screen on the front that provides the user interface for printing food. Once the user chooses the recipe they want to print (from the onboard touchscreen, or from a user's tablet, laptop, etc.), Foodini will instruct what food to put in each capsule, and then printing can begin."*
>
> *(The Website of Natural Machines_Q&A)*

The transformation from "hand-making food" to "printing food" led to the focus on digitalized features. To turn a recipe into a dish, instead of preparing and cooking ingredients by hand, it became "printing" with a "device." Owing to "the Internet connection," the "connected device" allowed users to choose the recipe they desired via the "user interface" on "touch screen of the device," "tablet" or "laptop," then the 3D food printer would be instructed to print the selected dish. 3D food printing rendered the process of making food digitalized and simplified as selecting and clicking print.

Other than simple operation, updatability was another focus often related to when it came to digital production of 3D food printing. Due to the connection to the Internet, the 3D food printers could stay up-to-date, just like most electronic products nowadays:

> *"Foodini comes with Foodini Creator software. You will also get free updates to Foodini Creator, similar to how you get free updates to your phone OS"*

[8] Food Ink. Retrieved August 6, 2018, from http://foodink.io

(The Website of Natural Machines_Q&A)

> *"Quickly and easily update your assortment with seasonal items. Stay up-to-date with the latest trends and meet the needs of the market without changes to your standard methods of production and large investment in new molds or machines."*

(The Website of byFlow)

Just like updating the operating system of phones, the software of 3D food printers was updatable too, allowing the users to stay up to date instantly and effortlessly. As updatable digital devices, 3D food printers were designed to be future-proof. As long as the updated functions could be instructed by the 3D food printers, the functionality and value of the devices could stay up to date. The users who use the Internet to update and the updated future uses were scripted in the 3D food printers. Additionally, since food could be 3D-printed, traditional molds and machines were no longer in need. On the website of byFlow, the depiction showed that for business owners, 3D food printing was catered for following the needs of the market and able to save money for making new molds or machines. The use of 3D food printers to keep up with the trend of the market without investing in new molds or machines was scripted in the 3D food printers, and the users who value keeping their business up to date were configured by the use of the 3D food printers as well.

Digitalized food making process also put focus on the consistency and formula of food materials as well as the settings of 3D food printers:

> *"The secret of successful 3D food items lies in the right consistency and formula in combination with the settings. Vary for instance the temperature, speed and layer height in the Procusini Club and find the settings suitable for your foods."*

(The Website of Procusini)

It was not about cooking for how long, which order of cooking steps, but it was about finding the ideal consistency, formula the settings in temperature, speed, layer height. The focus was on the printing inputs and the factors that would affect the printing outputs, identical to printing on surfaces with regular office printers. It was about the ink for printing, printing factors and the print result. The conventional cooking was transformed and simplified as in and out factors and results of 3D food printing. Moreover, the developer of the company offered users to find what they need in Procusini Club, an online club, just like the developers of smartphones offered users find what they wanted for their phones at the

APP store. To make food with 3D food printers, the food making process was turned into the operations of digital devices.

The technical machines tended to work as a script, serving as a framework for uses to be practiced; consequently, users would be led by the driving force of the script to act in certain ways (Akrich, 1992). The digital features and devices required for 3D food printing made users to prepare food in digital ways. The designers of 3D food printing instructed the users to make food digitally with “3D food printers,” “computers” and “screens with user interfaces.” The users were configured by the developers as users who utilized digital devices and operations to make food. Therefore, the users would pay attentions to the consistency of printed food materials and settings of 3D food printers. Moreover, with the updatability of 3D food printers, the designers configured users who updated the 3D food printers like they updated their phone operating systems so as to stay up-to-date. The users who would benefit from the simplicity of digital food-making and updatability to stay up-to-date were configured by the developers. Notably, the focus of food-making shifted from the food objects to digital food designs. In the study of Zoran & Coelho (2011), they presented the concept of digital gastronomy, indicating that the distribution, purchases, sharing and sampling of recipes would be as easy and diverse as the consumption of the digital music today, so the economic model will be different. Although the future of reshaped food industry with 3D food printing has not yet arrived, the direction of shifting to digital designs with 3D food printing could be identified in the research materials.

6.1.2. Easy, Convenient, Time-Saving & Money-Saving Uses?

Due to digitalized operations, making food with 3D food printers was reduced to simple steps of operating 3D food printers. Consequently, 3D food printing was often described as being easy to use. For example, to make intricate food objects, one simply needed to access the databases on the Internet:

> *“3D templates are available for most objects. Today, before market launch all products are designed in 3D, so that your customer can easily provide you the file. Other objects can be found in numerous databases on the Internet - from the Christmas tree to the special Cobra oldtimer - almost everything can be found.”*
>
> *(The Website of Procusini)*

Making food in shapes no longer required hand-shaping or molds. All that was required was to find 3D templates in databases online, then food objects in intricate shapes such as

Christmas tree or Cobra oldtimer could be manufactured by 3D food printers, which was similar to finding required document files online and selecting to print. The process of making intricate food objects was condensed into the actions of selecting 3D templates and print. Therefore, the easiness of operation was often accentuated in the research data. The designers of 3D food printing configured users as someone who would use 3D food printers to make intricate food shapes by accessing the databases on the Internet, rather than forming food shapes by hand. Furthermore, the designers configured the market uses of 3D food printing for the business owners. Business owners applying 3D food printing could satisfy customers by making objects that came from the files the customers found on online. The technical operation of 3D food printing was configured as easy uses of finding 3D object files and printing the objects.

3D food printing was often depicted as easy and convenient. In figure 4, for example, to print food with the 3D food printer Procusini 3.0 was portrayed as an easy operation that could be achieved with a computer, laptop or tablet with WiFi connection. Moreover, like printing documents, the operation steps of the 3D food printer were assimilated to the steps of changing ink for printing on papers, simplified in four steps: “open the cover,” “insert the Procusini refill,” “close” and “let’s go!” The steps were expected to be finished in less than 15 minutes, and no prior knowledge about the 3D food printer was required for operations. The easiness and convenience were also emphasized by highlighting “no cleaning necessary” as a contrast to traditional food preparation and cooking that required cleaning afterwards. As for the parts that were chosen to be cleaned, it was pointed out that the cartridge, stainless steel masher and stainless steel tip were dishwasher-safe. Overall, the depictions of easiness and convenience were foregrounded when it comes to 3D food printing.

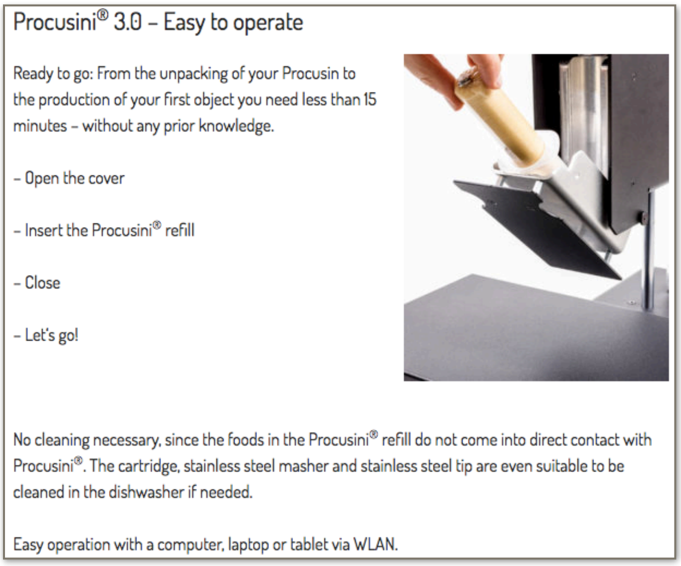


Figure 4.
Procusini 3.0 - Easy to operate
(Procusini, n.d.)

In relation to 3D food printing being easy and convenient, automation was also frequently highlighted in the research materials. The fact that 3D food printers could automate some food-making process was often brought up as a positive feature:

> *"The good thing about the Procusini is that I don't have to be there the whole time. It is operating on its own." -Benedikt Momm, Konditorei Monn*
>
> *(The Website of Procusini)*

Figure 5.
Saving time and money by automizing repetitive tasks and replacing customized molds (byFlow, n.d.)

As a digital device that could be instructed by computers, 3D food printers could operate on their own. Consequently, 3D food printers were used for automizing tasks. The testimony from the confectionery chef, Benedikt Momm, was highlighted by the developers of Procusini to emphasize the automating capability of the 3D food printers. The chef gained convenience and time due to the automation process. Likewise, the automating function was presented as a time-saving & money-saving feature by the 3D food printing developer "byFlow," as shown in figure 5. Repetitive works that required human involvements could be performed by 3D food printers instead. In addition, since 3D food printers manufactured additively, customized molds were no longer in need, which saved costs. The image of identical 3D-printed chocolates with alphabets on them were presented to illustrate automated repetition that could be completed by 3D food printers.

3D food printing could be applied not only to making confections and snacks, but it could also be used to print savory food such as ravioli. Instead of making food by hand, the 3D food printers could automate the making process:

> *"Take an example of ravioli. How often have you made homemade ravioli? Rolling out the dough to a thin layer, adding the filling, adding the top layer of dough, and then cutting it to size takes time. Let Foodini do it for you. Simply load the dough and filling into Foodini, and Foodini will print individual raviolis for you. The 3D printing of*

food – in this case, creating a layer of pasta, a layer of filling, and covering it with a layer of pasta again – is assembling the ravioli. The same as you would do by hand, except Foodini automates it: you don't have to manually do all the work... Foodini does it for you: less mess in your kitchen; more time to do other things."

(The Website of Natural Machines_Q&A)

"Design new creations or automate your production. Boost your operation with the tireless hands of BeeHex machine."

(The Website of BeeHex)

3D food printers were utilized to automatically assemble ravioli and make designed food creations. Instead of making those food by hand, 3D food printers served as "tireless hands" to make the food. The use of 3D food printers was for the purposes of replacing manual works, reducing mess in the kitchen and making use of the time saved by automation to do other things. 3D food printing was presented as a device that replaced manual works, made life easier and saved time.

Due to the easiness and convenience brought by digital operations & automation, 3D food printing was often depicted as an evolution that could replicate human skills:

"3D food printing is the natural evolution to hand-crafting."
-Charly Eisenrieder, Conditorei Münchner Freiheit

(The Website of Procusini)

"BeeHex designs and builds 3D food printers and robots to replicate the talent of a skilled individual"

(The Website of BeeHex)

The quote from the confectionery chef of Conditorei Münchner Freiheit, Charly Eisenrieder, conveyed the idea that automation performed by 3D food printers was evolved from hand-crafting. Although he did not suggest whether it was a better or progressive development, the quote disclosed the idea of hand-crafting being replaced by 3D food printing. Similarly, the 3D food printers of BeeHex was designed to replicate human skills. The developers of

3D food printing had the tendency to depict 3D food printers as replacements for human skills such as hand-crafting.

In the study of Lupton (2017), by studying online news media about 3D food printing, she found that 3D food printers were envisioned to be the devices that provide meals by simple download and printing for those who seek convenient and time-saving ways to make food. Potentially, the visions of seeking convenience and time-saving approach of making food in online news might involve the perspectives of not only developers, but also reporters', entrepreneurs', investors' views. In this research that focused on the developers' views on uses and users, the finding that 3D food printers were depicted as easy, convenient, time-saving devices matched the findings of Lupton (2017). By designing 3D food printing as easy operation, the developers scripted the users to make food in simple steps as inserting printing cartridges and printing. Additionally, by designing refills that did not come in direct contact with 3D food printers and thus required no cleaning with 3D food printers, the developers scripted the easy uses for the users who sought easy and convenient food-making. Likewise, by designing dishwasher-friendly cartridges, stainless steel mashers and stainless steel tips, the convenient uses scripted users to save time from washing manually.

Sun et al. (2015) indicated in their work that 3D food printing could increase manufacture efficiency and reduce the cost for making customized food. In my study materials, it could also be identified that the developers tended to emphasize the automating aspect of 3D food printing to highlight efficient production. With automation, the developers configured users that could save time since 3D food printers could automate on their own. With the tireless hands of 3D food printers, the users were also scripted to avoid manual works, produce less mess in the kitchen and have more time to do other things. The testimonial quote of the confectionery chef, Benedikt Momm, was cited by the developers as a successful user example of automation. Moreover, 3D food printing not only saved time for users, since it was printed in additive manner, it also saved the users the costs of making customized molds. The uses of printing without having to purchase molds were scripted in 3D food printers, allowing users to save costs. Consequently, due to automation, the developers scripted 3D food printers as devices that replicated human skills and the natural evolution of hand-crafting.

6.1.3. Users Who Had No Time & Not Good at Making Food

While the uses of 3D food printing was presented as being easy, convenient and time-saving, the users that utilized 3D food printing were configured to be the ones who valued those features:

"Today, too many people eat too much convenience foods, processed foods, packaged foods, or pre-made meals - many with ingredients that are unidentifiable to the common consumer, versus homemade, healthy foods and snacks. But there is the problem of people not having enough time to make homemade foods from scratch. Enter Foodini. Foodini is a kitchen appliance that takes on the difficult parts of making food that is hard or time-consuming to make fully by hand. By 3D printing food, you automate some of the assembly or finishing steps of home cooking, thus making it easier to create freshly made meals and snacks."

(The Website of Natural Machines_Q&A)

"So 3D food printing can take over the shaping and the food forming, without making a flour mess on the work surface. We can go and do other things = time saving. Now maybe you are great at making gnocchi. This particular example isn't for everyone. But for those of us who aren't gnocchi making experts, it definitely saves time."

(The Website of Natural Machines_Q&A)

The social background of convenience, processed, packaged or pre-made foods overflowing was imagined by the developers. The users who wanted homemade and healthy foods and snacks were constructed as well. 3D food printing was declared as an easy solution to eat healthier for those who did not have time. 3D food printers were designated as a kitchen appliance to do the tasks that were difficult and time-consuming to do by hand. The users were configured as people who appreciated homemade fresh food and as people who utilized 3D food printers to automate some steps of home cooking, because 3D food printing made making fresh meals and snacks easier. 3D food printers were catered for the users who did not have enough time to make homemade foods. In particular, users who felt like to save time by not getting the work surface messy and users who were not great at making food were configured by the easy and convenient uses of 3D food printing.

Other than automation of 3D food printing that provided users with easy ways to make homemade foods, the other technical designs were also catered to users who looked for easiness and convenience, e.g. simple control interface and effortless work to clean:

“EASY TO USE: No technical background required due to simple control interface”

(The Website of byFlow)

“If food does get on the walls of the inside of the machine, it's very easy to just wipe it down with a damp cloth or sponge. The capsules and glass plate can be put in the dishwasher or hand-washed, and the capsules are designed to come apart in certain sections for easy cleaning. For example, the nozzle comes apart from the capsule body. We don't like kitchen appliances that are hard to clean, and we're sure you don't either. So we are very determined to design Foodini to be as easy to clean as possible.”

(The Website of Natural Machines_Q&A)

The 3D food printers of byFlow was designed with simple control interface. The technical design of the 3D food printers were scripted with the users who had no technical background in mind. With uncomplicated control interface, users with no technical background could operate 3D food printers easily. The design of 3D food printer Foodini made by Natural Machines also configured users who looked for easiness and convenience of cleaning. Therefore, the food would not get inside the machine walls, and the materials used to make 3D food printers were made to be easy to clean. The capsules and glass plate were even designed to be easily washable by hand and even by dishwashers, making it easier for those who did not like to do the dishes. Due to the reason that the developers of Natural Machines disliked kitchen appliances that were hard to clean, the technical designs worked on the features of being easy to clean. The users who also disliked kitchen appliances that were difficult to clean were configured by the designers.

Other than convenience brought by printer automation, simple operating steps and easy cleaning achieved by uses design, the developers of 3D food printers even extended the easiness and convenience to the food materials for printing:

“As an added ease of use for consumers, we are looking into working with retailers that can prepare pre-packaged food capsules made freshly in-store as an alternative option for consumers. Imagine going to a store, picking up a 5 capsule pack of ravioli ingredients pre-made in the store using fresh ingredients, going home and popping them into Foodini to print.

(The Website of Natural Machines_Q&A)

“And thanks to byFlow’s printer, the well-known Dutch food company “Verstegen” developed the world’s first edible filling for 3D printer. Smart, because not all the restaurants have the time to make the fillings themselves.”

(The Website of byFlow)

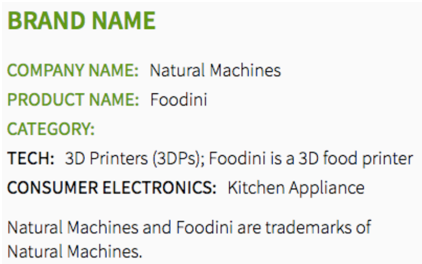
To provide consumers with more convenience, the developers of Natural Machines were working on the opportunity to collaborate with retailers to provide pre-packaged food capsules for printing. The idea was to offer the users of 3D food printers with the option of purchasing food ingredients in capsules ready for printing in stores. Likewise, the developers of byFlow cooperated with the Dutch food company, Verstegen, to develop fillings for 3D food printers, giving 3D food printing users such as restaurants the option to print with ready-made fillings. The pre-packaged food capsules and ready-made gilling for 3D food printers were catered to those who searched for convenience and those who did not have enough time to prepare food ingredients themselves for printing.

In the research data, from simple control interfaces, easily cleaned parts of 3D food printers to the options of pre-packaged capsules and fillings, easy and convenient uses were scripted in the technical designs of 3D food printers, instructing users to prepare food at ease. Users who did not have enough time to make homemade foods and users who were not good at making food were configured by the developers of 3D food printing. In the study of Lupton (2017), she found that 3D food printers were portrayed to be helpful for busy people that had not enough time to make meals in online news, and she also discovered that online news reports about 3D food printing tended to accentuated the utilitarian and functional aspects of 3D food printers. In my research data obtained from the official websites and videos of 3D food printing developers, the same useful and practical attributes of 3D food printing could be identified too. Understandably, the utilitarian and pragmatic features were emphasized to attract the intended users and to sell. Moreover, it was mentioned in the study of Khot et al. (2017) that 3D food printing would reshape the food industry, since business like supermarkets would sell in the future would be digital food recipes rather than ready-made physical food products. The availability of buying pre-packaged food capsules in stores for printing at home would signify a step closer to reshaping the food industry.

6.1.4. 3D Food Printer as a Kitchen Appliance

Despite the claims about using 3D food printers to replicate human skills and that 3D food printing was an evolution of hand-crafting, 3D food printers were not depicted as replace-it-all devices. Rather, 3D food printers were situated as a kitchen appliance by the developers. In figure 6, for instance, other than being categorized as a technology, 3D food printer “Foodini” was positioned as a kitchen appliance in the category of consumer electronics. In figure 7, Foodini was displayed on a spotless kitchen counter with the other kitchen appliances such as an oven, a microwave and a dishwasher, signifying that a 3D food printer was just like any other kitchen appliances that people were familiar with. The

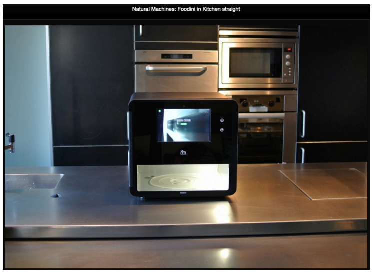
Figure 6.
3D printer as consumer electronic & kitchen appliance (Natural Machines, n.d.)


BRAND NAME

COMPANY NAME: Natural Machines
PRODUCT NAME: Foodini
CATEGORY:
TECH: 3D Printers (3DPs); Foodini is a 3D food printer
CONSUMER ELECTRONICS: Kitchen Appliance

Natural Machines and Foodini are trademarks of Natural Machines.

Figure 7.
3D printer along with other kitchen appliances (Natural Machines, n.d.)



developers of Foodini scripted the 3D food printer to be a kitchen appliance catering to consumers who would use it in their kitchens, just like an oven, a microwave, and so forth were used. A 3D food printer was regarded as a reduced food manufacturing facility designed to be put in kitchens:

> *“If you eat anything from a food manufacturer, like packaged food you buy in a supermarket, then you practically are already eating 3D printed food: a food manufacturer takes food, pushes it through machines, shapes it, forms it... we’ve taken that same concept and shrunk the large food manufacturing facility down to a stylish kitchen appliance that sits on your kitchen counter. But the big difference is with our open/empty food capsule system, we allow you to use your own fresh ingredients to print. This is real food, 3D printed.*
>
> *(The Website of Natural Machines_Q&A)*

Just as manufacturing machines that shaped and formed food ingredients to make packaged food bought in supermarkets, the developers of Natural Machines viewed 3D printed food to be similar to the packaged food made in larger manufacturing facilities, but the concept of food manufacturing in food factories was transformed into 3D food printing at home. The food manufacturing process was shrunk and relocated in kitchens. Additionally, with the capsules that allowed users to fill in fresh ingredients, 3D-printed food could be fresher than packaged food sold in supermarkets.

However, just like any other kitchen appliances, 3D food printers were designed to operate certain tasks. Although 3D food printing was often related to replacing manual works, they did not do all the tasks:

> *"Home kitchen users: Think about your favourite packaged foods that you buy, that if you were to make by hand would require forming, shaping, or layering. From simple pretzels or breadsticks, to ravioli. That's where 3D food printers shine. Professional kitchen users print with their own fresh, real, wholesome ingredients. Sometimes printing a plate decoration, sometimes printing a part of a dish that is then completed by hand, and some printing entire dishes."*
>
> *(The Website of Natural Machines_Q&A)*

3D food printers were specialized in forming, shaping and layering. Instead of buying packaged food that had been manufactured some time ago, 3D food printing was designed to be use in kitchens where users could print fresher food not long before eating. 3D food printing was scripted to be used as a localized manufacturing site for making fresher foods that substituted packaged foods. Nonetheless, 3D food printers could be applied in various ways. They could be utilized to print plate decorations, a part of dishes or entire dishes, depending on what made the most sense:

> *"We always ask ourselves before printing something if it's easier/faster/better to print it versus doing it by hand. Sprinkling some cheese and spices on a pizza is definitely faster by hand versus printing. Hence, our part printed/part hand made pizza. One of the reasons we decided to print only the dough and sauce is because those are the two most difficult parts of making a pizza by hand. But of course, if you want to print the entire pizza using Foodini, you can... as long as the ingredients are of a Foodini-approved consistency."*
>
> *(The Website of Natural Machines_Q&A)*

> *"At the end of the day, Foodini is a kitchen appliance to help people make fresh foods. We are certainly not proposing that every food you eat needs to be 3D printed, just like every food you eat now doesn't come out of an oven. A stew? You don't need a 3D printer for that. But think about foods that if you were to make by hand would require food shaping, or forming, or repetitive food assembly tasks, or layering... that's where Foodini can help."*

(The Website of Natural Machines_Q&A)

Even though one could use a 3D food printer to print the entire dish as long as the ingredients were of printable consistency, the suggestions from the developers were that 3D food printers made it easier to shape, form or do other repetitive food assembly chores, but not every task was better or faster operated by 3D food printers. For example, to sprinkle cheese and spices on top of a pizza worked faster than printing cheese and spices. To make a stew, 3D food printing was not the method that made the most sense, either. Just like any other kitchen appliances, 3D food printers had their strong suits and shortcomings. Defrosting made more sense to be done by a microwave than an oven. Baking a bread worked better in an oven rather than a microwave. Not all dishes should be made by an oven or microwave. Likewise, not all dishes should be manufactured by 3D food printers. In figure 8, for instance, the dish applied 3D food printing to form the arcade-inspired geometric blocks to make beef tartar, since the shaping capability of 3D food printers to form geometric blocks worked better than manual making. Notably, 3D food printing was not applied to print the whole dish.

Figure 8.
Steak Tartris: Beef tartar in 3D-printed arcade-inspired geometric blocks
(Food Ink, n.d.)

As opposed to handmade food, 3D-printed food can be seen as less loving due to automation. Some people regarded "love" as an important factor for making good and tasty food. Nevertheless, since 3D food printers automated some tasks, the handmade food that came from heart-warming love could be replaced by food made by cold machines. The love factor was put in doubt:

> *"Some people believe that the most important ingredient in food is love. Whether or not you agree with that statement is another topic, but let's assume here you do agree. Then, you may believe that when someone takes the time to prepare food – whether it's you or someone else – the food is also made with love and the resulting food just simply tastes… better. But what about when a 3D food printer is used to prepare food? Is the love automatically removed? Where is the love? We ask you to consider this: if you or anyone else cooking food (with added love!) uses any other*

kitchen appliance – whether it's a stove, an oven, a food processor to make doughs, a blender to make sauces, etc. – is that food made with any less love? Would the food not taste as good? Is the love gone? Of course not. That person is simply using kitchen appliances to prepare food. A 3D food printer (at least the way we are making 3D food printers) is a kitchen appliance. So that love going into food is still very much there."

(The Website of Natural Machines_Q&A)

The developers of 3D food printing argued that cooking with kitchen appliances did not cause the love of making food to disappear. Just like using a stove, an oven or a food processor in the process of making food, the food made did not contain less love. The kitchen appliances were just applied to make food, without losing the amount of love going into making the food.

In the study materials, the developers of 3D food printing scripted the use of 3D food printers as a kitchen appliance, just like the other consumer electronics, which resonated with the discovery of Lupton (2017) that 3D food printers were often assimilated as kitchen appliances such as ovens, sparkling water makers and waffle makers in news reports. Particularly, 3D food printers were scripted to serve as the reduced manufacturing facility that sit in kitchens as a modish kitchen appliance, allowing users to make fresher foods at home, since users could replace pre-packaged foods with 3D food printing. Understandably, the developers script the 3D food printers as a kitchen appliance to normalize the novel food technology as a part of kitchens. In the research materials, more details about 3D food printers as a kitchen appliance that were not highlighted in the literature were discovered too. First, since the uses of 3D food printers were limited at the moment, the uses were scripted for certain functions that made the most sense with 3D food printing. The functions such as forming, shaping, layering, and the other repetitive assembly tasks were scripted to be the uses that would replace manual works were emphasized by the designers. Notably, like any other kitchen appliances, 3D food printers were not scripted as all-in-one devices that could complete the whole dish on their own. Another intriguing finding was that the developers regarded the use of kitchen appliances such as 3D food printers, did not undermine the love that went to the food. Even though the developers also emphasized the advantages that, with the automation of 3D food printing, people could not be present while printing and thus save time, it was also affirmed that 3D food printing did not let love disappear because people were just using the appliances to prepare food. The developers tried to enroll multiple user types as users of 3D food printing in order to include more users. The spectrum of users fell from the users who wanted convenience from automated food tasks to the users who wanted to make food with love and use kitchen appliances at the same time.

6.1.5. Human Involvement: 3D Food Printing as Augmentation

Despite 3D food printing was depicted as easy, convenient and could replicate human skills and automate production, 3D printing food actually required human involvements. The aspect of human involvements were often diluted in the depictions from the developers:

> *"It depends on the recipe you are printing. For example, if you are printing chocolate, it is edible at any stage of the process (you can safely eat the chocolate before and after printing.) Other ingredients can be printed raw. For example, a meat-based hamburger can be printed using raw ingredients, and cooked after printing."*
>
> *(The Website of Natural Machines_Q&A)*

For food ingredients such as chocolate, after printing, the printed chocolates were already edible. However, if one prints meat or hamburger, without heating function built in a 3D food printer, one would have to cook the meat separately after printing. Depending on the 3D food printer used, one might have to print the food and then cook the food with a stove or oven. A 3D food printer might not be a one-stop manufacturing device for all food creations. Instead, human involvements for food preparation or other cooking devices were required to complete the food creations. For instance, the pasta refills prepackaged in bags required to add water and oil before printing, as shown in figure 9. A handheld mixer was used by someone to mix the ingredients well. Human involvement was required to prepare for 3D

Figure 9.
Required to add water and oil to pasta refills (Procusini, n.d.)

food printing. For speeding up and making food ingredients preparation easier for printing, other kitchen devices were required as well:

“You can prepare the ingredients by hand, or with the help of a hand-held blender, a countertop blender, a food processor, or other similar device. All ingredients can be prepared by hand, but machines (food processors, etc.) could make the process faster and easier, depending on the ingredient. Note that Foodini is not a food processor and will not prepare your ingredients for you. You'll need to prepare ingredients outside of Foodini.”

(The Website of Natural Machines_Q&A)

It was recommended by the developers of 3D food printers to use other kitchen devices such as blenders or food processors to prepare food ingredients for printing. 3D food printers did not have the functions of a food processor; therefore, they could not prepare food ingredients within the 3D food printers themselves.

Requirements for human involvements and other kitchen devices in food ingredients preparation were related to the food ingredients and textures for 3D food printing. As a kitchen appliance, there were certain food ingredients for printing and certain food dishes that could be printed with 3D food printers, just like any other kitchen appliance, with certain functions and limitations. In table 3, the food materials utilized for printing mentioned in the research materials were listed. Notably, the food materials that could be applied for printing were the viscous and malleable food ingredients, such as chocolate, marzipan, cheese, cream, and so on. The other food materials required to be pureed to be printable; for example, meat, vegetables, fruits, and so forth. Even though a paste consistency was not the only thing that was printable, textures for 3D printed food were still rather limited:

Also know that it is not mandatory to print only with a paste consistency. With our nozzles available in several different sizes, you can print things like whole couscous, or burgers with chunks of cranberries and walnuts, etc.”

(The Website of Natural Machines_Q&A)

What could be 3D food printed depended on the consistency for printing and nozzles sizes. Even though printing paste was not the only option, what had been offer were limited to whole couscous, chunks, and the like. Since 3D food printing was limited by what food materials could be utilized for printing and what textured could be achieved, 3D-printed foods were not diverse in the research materials, as shown in table 3. The majority of 3D-printed foods were dough-based, e.g. pizza, quiche, pastas, bread, cookies and brownies.

Table 3.

Food materials for printing & 3D-printed foods appeared in the research materials

Food Materials For Printing			3D-Printed Foods	
	Chocolate			Chicken nuggets (Chickpea nuggets for vegetarian)
	Sugar	Fondant in 5 colors		Pizza
	Marzipan in 5 colors			Fish & chips
	Pasta in 4 colors			Burgers (veggie & meat)
	Meringue	Royal icing		Quiche
	Cheese	Cream cheese		Pastas (e.g. Ravioli)
		Goat cheese		Simple pretzels or breadsticks
		Mozarella		Hash browns
		Mascarpone		Cookies and crackers
	Cremeux	Oreo yoghurt cremeux		Brownies
		Ganache		Chocolate
		Hazelnut cream		Guacamole
	Butter			Egg
	Meat	Chicken		Potato
		Beef		Butter
	Vegetables	Cardamom		Tangyuan
		Broccoli		
		Celery		
		Tomato		
		Red beets		
	Guacamole			
	Hummus			
	Fruits	Cassis (blackcurrant liqueur		
		Mango (fruir caviar)		
		Avocado		
	Cookie dough			

Overall, 3D food printing was not an all-in-one stop for making food. Since 3D food printers required certain consistencies for 3D food printing, it usually needed human involvements in preparing food ingredients for printing or other kitchen devices such as blenders to help make the food printable or ovens to cook dishes. The food ingredients that were available for 3D food printing were limited, and 3D printed foods were limited too. 3D food printers mainly served as shape-formers. However, human involvements and the need for other kitchen devices to complete a dish were oftentimes equivocal in the presentations. In figure 10, for example, the natural food ingredients such as carrots, potatoes, tomatoes, garlic and onions and cooking utensils like a spoon and knives were displayed alongside a 3D food printer printing a dish. It was not stated that whether the ingredients required further processing before printing. Similarly, in figure 11, two 3D food printers were put to forefront, whereas a chef-like man was in the background. It was not clear whether 3D food printers were replacements of human labor works or just served as augmented equipments for the cook. The dilution of human involvement or requirements for other device or the ambiguity between the relationship between cooks and 3D food printers were identified in the research materials.

Figure 10.
Cooking utensils and ingredients lying next to a 3D food printer (byFlow, n.d.)

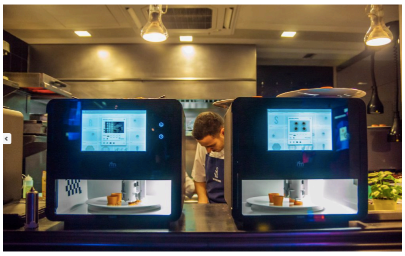


Figure 11.
A man working in the kitchen with two 3D food printers foregrounded (Food Ink, n.d.)

Notably, in the research materials, the technical designs of 3D food printers focused mainly on forming shapes. Consequently, in order to complete a dish, 3D food printing required human involvements for food preparation and other kitchen appliances such as a stove for cooking or a food processor for grinding and mixing food. Users who would prepare food ingredients for printing manually and use other kitchen appliances such as a mixer before 3D printing food were configured by the developers. Understandably, the requirements for extra efforts outside 3D food printers stemmed from the immature functionality of a novel food technology. However, in some cases, in order to normalize 3D food printing, the developers would blur the requirements for human involvements and other kitchen appliances. The ambiguity left room for interpretation that in stead of being an augmented kitchen device, 3D food printers could be an all-in-one solution. The vagueness between augmentation and all-in-one solution provided space for expectations and further developments. Regardless of the limited functions at the moment, as mentioned in Sun et al. (2015), 3D food printing was still being developed; consequently, the technological progress and applications of 3D food printers would keep changing in order to meet user's requirements and reshape their lifestyle. The meaning and role of 3D food printers being a kitchen appliance might keep expanding.

6.1.6. Oversimplification of Food-Making Process with 3D Food Printing

Nonetheless, despite the requirements for human involvements or processing with other kitchen devices, 3D food printing was often depicted as something easy and effortless. The steps of manual preparations and applications of other kitchen devices were often diluted or overlooked. In other words, the food preparation process of 3D food printers were oftentimes oversimplified. Due to the digitalization, the process of making food was reduced to download, printing and printed food ready to be enjoyed. In figure 12, figure 13 and figure 14, from food ingredients to a dish, the process was simplified as the actions of downloading something delicious, converting pixels of a 3D object to outputting the 3D printed food object on a plate with a printer, and voila, the dish was ready to be digested. At the background of figure 12, there were chefs preparing for dishes, which formed a contrast of the simplification. In particular, "you've got meal" was analogous to "you've got mail." Printing a meal was comparable with sending a mail. Clicking send, then you've got mail; likewise, clicking download, then you've got meal.

Figure 12.
Download something delicious (Food Ink, n.d.)

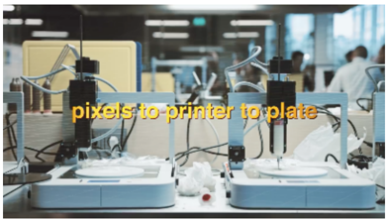


Figure 13.
Pixels to printer to plate (Food Ink, n.d.)

Figure 14.
You've got meal (Food Ink, n.d.)

Although 3D food printers are kitchen appliances that required manual preparation or other kitchen devices to prepare food for printing in many cases, the parts of extra work needed were often overlooked when highlighting that 3D food printing was easy. In the video of Fook Ink, for instance, 3D-printing dessert was regarded as effortless and thus a piece of cake, as shown in figure 15. Nevertheless, the emphasis on easiness generated confusion when the second after the image accompanied with the tile of "3D-printed dessert? piece of cake" was shown, what occurred was a 3D printed chocolate in the shape of a cake, leaving room for interpretation whether it was really easy to 3D-print a dessert. Regardless, the developers of 3D food printing tended to highlight the easiness and convenience brought by 3D food printing. In particular, the effortless and convenient operation were correlated to digitalization. In figure 17, for instance, 3D food printing a dish was reduced to downloading the design, choosing food materials and sending to the 3D food printer for printing. It was presented as an easy connect as 1, 2, 3, accentuating the easy steps from connection to a 3D-printed dish.

Figure 15.
3D-printed dessert? piece of cake
(Food Ink, n.d.)

Figure 16.
3D printed chocolate in the
shape of a cake (Food Ink, n.d.)

Figure 17.
Easy to connect:
easy as 1, 2, 3!
(byFlow, n.d.)

Even though to complete a dish, 3D food printers tended to require human involvements in food ingredients preparation or other kitchen devices for processing, 3D food printing process tended to be oversimplified by the developers when they were presenting the technology. One common simplification was rendering 3D food printing process as merely a digital process, overlooking requirements for manual preparation or other kitchen devices. The process of making food became “downloading food designs,” “selecting food materials on a computer,” “easy connection between a computer to a 3D food printer,” “clicking print on the screen” and “pixel data to food objects, ” Understandably, by highlighting the simple digital steps, the developers simplified the process of 3D food printing in order to present 3D food printers as easy and approachable devices. The simplified 3D food printing process also configured users as people who looked for simplicity, convenience and efficiency. In the research materials, the oversimplification of food-making process rendered the process a seemingly efficient one. The efficient process presented by oversimplification in the research data overlapped with the depictions in news reports that 3D food printing could provide efficiency for users (Lupton, 2017). Furthermore, in online news, 3D food printers were often seen as resemblance to the Star Trek Replicator which was a machine that could synthesize meals from energy and make food appear magically out of nothing (Zoran & Coelho, 2011; Tran, 2016; Lupton, 2017). By oversimplifying the process of making food with 3D food printers, it blurred the gap between what 3D food printers could achieve and the magical machines that they were expected to be. 3D food printers were expected to be easy and simple so that users could enjoy the convenience and save time. Nonetheless, the reality was that 3D food printers were not all-in-one devices. They might require manual preparations and other devices. As a novel food technology, 3D food printers' functionality had a gap between expectations. However, it was a common case, since the functionalities of a nascent technology tended to fall behind the expectations in the early stages of developments (Geels & Smit, 2000).

6.2. 3D-Food Print to Be Creative, Fun & Attractive

6.2.1. 3D Food Printing & Creativity

As a kitchen appliance, 3D food printers also had limitations. 3D food printing required manual preparation of food ingredients for printing, and what could be printed were limited at the moment. Nonetheless, 3D food printing was often emphasized with its potential to be creative:

> *"INNOVATIVE PRODUCTS AND ARTISTIC SHOWPIECES: Let your creative ideas become reality. Develop new products, dishes and showpieces to amaze your customers and stand out from competitors. You can experiment with different ingredients and achieve shapes that were not possible before by hand or mold. Visit our gallery for inspiration or download ready-to-use designs to see how it works.*
>
> *(The Website of byFlow)*

3D food printers were seen as devices to make creative ideas come true. Food-making was rendered a space to experiment with ingredients and make food in shapes that were not achievable by hand or molds. 3D food printing was related to innovating food products, in particularly with shapes of food. 3D food printers were positioned to provide the creative control that users needed, as shown in figure 18. To 3D-print food became a process of thinking, designing and creating. 3D food printers were applied to make beautiful food creations. Rather on focusing on the food manufacturing, 3D food printing shift the focus on thinking and designing, highlighting the creative potential, as presented in figure 19.

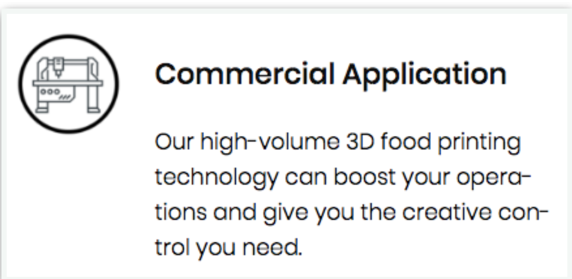


Figure 18.
Commercial application: Creative control
(BeeHex, n.d.)

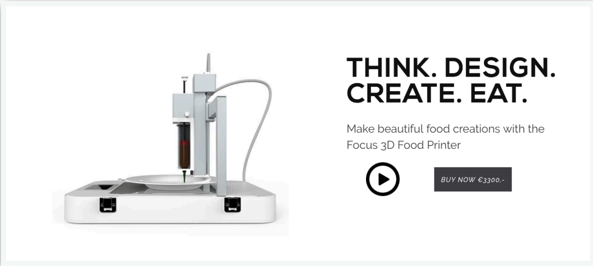


Figure 19.
Think. Design. Create. Eat: Making beautiful food creations with the Focus 3D Food Printer
(byFlow, n.d.)

3D food printers required digital instructions from computers. As long as the consistencies of food ingredients for printing and designs on computers were printable, the shape designs for printing were boundless. Therefore, 3D food printing were often accentuated with it creative potentials. In the research materials, the manufacturing ability of 3D food printers were often boosted by the creative capability, since designing on computer offered many more possibilities than making by hand or molds. As a consequence, the focus on the attributes of 3D food printing became "innovative creations," "experiments with new shapes and ingredients," "creative control for commercial application" and "thinking, designing and creating." Zoran & Coelho (2011) mentioned in their work that digital gastronomy provided a new space for food fabrication, allowing designers to experiment more and create more food designs. It is discovered in the research materials that the developers of 3D food printing tended to emphasize the creative potentials of the novel food technology. Furthermore, 3D food printing was often labeled as an "innovative technology," "novel technology" and "revolutionary technology" in the news reports (Lupton, 2017). The findings about 3D food printing and creativity in the websites and videos of 3D food printing developers resonated with the depictions about 3D food printing in online news accounts. Noticeably, the developers of 3D food printing configured users who utilized 3D food printers to experiment, create and innovate. However, whether the configured users would be the majority of the users was worth reflecting. In the works of Lupton & Turner (2016 & 2018), for instance, intricate shapes of 3D printed food objects made consumers feel unsettled, and some consumers found "printing food" intrinsically unnatural. Whether the creative aspect of 3D food printing was as an appeal to consumers might not align with what developers configured in the uses design and configuration of users.

6.2.2. 3D Food Printing Is Attractive and Fun

Owing to the ability to print food in the shapes that were difficult or impossible to make by hand, 3D food printing was often seen as a technology to inspire creativity. With 3D food printers, people were no longer confined by the capability to form shapes by hand; rather, imagination became the limit, which allowed food designs to become more creative than ever before. Due to the creative potentials to make unprecedented food designs, 3D food printing was often emphasized by the developers as being fun and attractive. 3D food printing was positioned as an innovative technology that could attract publicity and stand out among competitors. In figure 20, a man photographed the plate of 3D-printed food suggested that 3D food printing could be special and attract attention like an art piece; particularly, because 3D food printing was innovative, it could boost publicity and attract new customers.

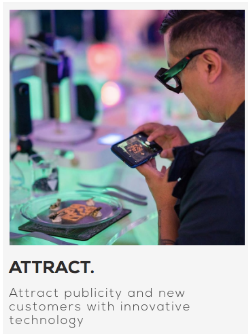


Figure 20.
Attract new customers with
the engaging 3D food printing experience.
(byFlow, n.d.)

Especially, for retail business, with the creative capability of 3D food printing, it could attract customers' attention to engage them in the process of watching and listening to the machines printing food creations, as shown in figure 21. Rather than watching a person preparing for food, 3D food printing allowed people to watch and listen to how a machine created food. Since it was different from the traditional way of food preparation which relied on human labor, people could watch and listen to how 3D food printers made food. One did not have to make food on his or her own or watch other people cook but only had to pay attention to the machine printing the treat, which was entertaining and changed the way people experience food. Moreover, with 3D printed food in shapes that were difficult to be

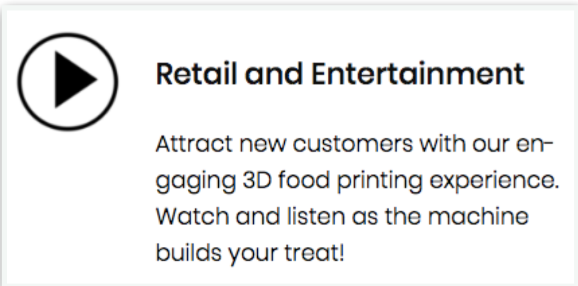


Figure 21.
Attract publicity and new customers
with innovative technology
(BeeHex, n.d.)

made by hand, retail business could utilize 3D food printing to differentiate their products from their fellow competitors. In figure 22, for instance, a dish accompanied with a savory crispy waffle was aimed to attract attention and stand out in competition. The testimonial quote of Charly and Max Eisenrieder from Münchner Freiheit Cafe and Catering was presented on the website of Procusini as a verification that 3D food printing could attract attention for business (see figure 23). It did not take a long time for the attention on the business to increase. 3D food printing could attract attentions from customers.

Figure 22.
Differentiate your self from competition
(Procusini, n.d.)

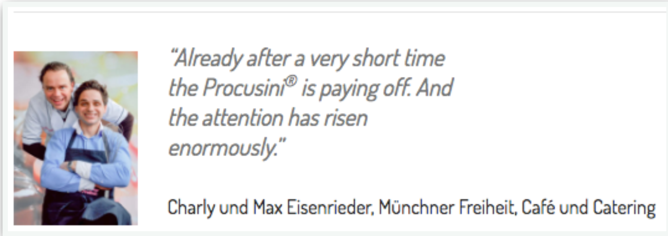


Figure 23.
The attention has risen enormously
(Procusini, n.d.)

Other than the ability to attract attention and make business stand out, 3D food printing was portrayed as being fun as well by the developers. 3D food printing, with its ability to craft or present food in shapes that would be difficult to make by hand, was regarded to make food fun:

> *"There are too many processed and "convenience" foods in the market, many with ingredients that are unidentifiable to the common consumer. Foodini can help replicate these convenience foods that people have become accustom to, but making them with fresh ingredients. And taking it a step further, Foodini can help craft/present food into shapes that would be difficult by hand... this makes food fun!"*
>
> *(The Website of Natural Machines_Q&A)*

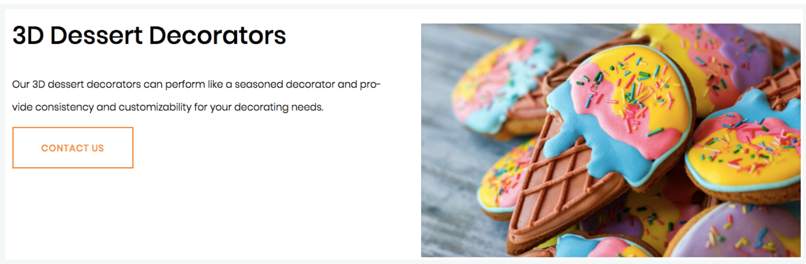


Figure 24.
Serving as 3D Dessert Decorators
(BeeHex, n.d.)

3D food printing was positioned to provide fun by printing shapes that were unconventional. Consequently, to be fun, the main feature of 3D food printers was the shaping ability. They were able to create shapes that had been difficult to achieve manually or by molds. What 3D food printing could excel was in forming intricate shapes to generate interests, attract and provide fun. 3D food printers thus were catered for the purpose of decorating. Due to the shaping capability and the customizability, 3D food printers were situated as 3D food decorators that could be used to provide new designs regularly. For instance, 3D food printers could serve as 3D dessert decorators for seasonal creation demands, as shown in figure 24.

Since 3D food printers could print creative shapes, 3D food printing was scripted by the developers to attract and provide fun experiences in commercial settings for business users. With commercial uses of 3D food printing, retail businesses were configured by the developers of 3D food printers as users. In the research materials regarding applying 3D food printing to attract and provide fun, the configured users were in fine dining, retail business, restaurants and catering business. The finding of applying 3D food printing to attract customers in fine dining matched the finding of Lupton (2017) on applying 3D food printing to elevate haute cuisine for fine dining experiences depicted in online news. However, regarding using 3D food printing to attract, it might not always work. In the work of Lupton and Turner (2018), they discovered that consumers were not always acceptive towards 3D printed foods in attractive shapes; for instance, 3D printed pasta in intricate shapes usually received more acceptance than 3D printed carrots, and some 3D printed foods in intricate shapes were seen as unsettling. In the case of 3D food printing for attracting customers and providing fun, it could be noticed that designers had more control in defining the uses and users (Woolgar, 1990). Nonetheless, it would be important for developers to take consumers' acceptance into consideration when configuring users.

6.2.3. Professional and Amateur Users Looking for Special Things

In the research materials, with the uses of 3D food printing to be creative, attractive and fund, both the professional as well as the amateur users who were looking for special things were configured by the developers. Nonetheless, in the findings, the developers of 3D food printers were more pronounced in professional users. 3D food printers were presented to be useful for professionals, for 3D food printing allowed the professionals to turn their creative ideas into real 3D food objects:

> *"3D Food Printing for Professionals: 3D Food Printing System Procusini 3.0 is an universal Plug & Play printing solution for the creative and personal creation of food in professional kitchen, catering and event-gastronomy, as well as bakery and confectionary."*
>
> *(The Website of Procusini)*

> *"We also have a lot of interest from chefs that want to make intricately designed foods with Foodini. This is where the shaping capabilities of Foodini come into play."*
>
> *(The Website of Natural Machines_Q&A)*

The shaping capabilities of 3D food printers were deemed useful solutions to make creative food objects by the developers of 3D food printing. Particularly, for professional kitchens, catering, event gastronomy, bakeries and confectionery shops, 3D food printing could help make their food products more creative. Furthermore, the developers of 3D food printing emphasized that 3D food printers existed to boost operation and creativity for the professionals rather than hindering or replacing their specialty:

> *"Q: When making many foods, the creation of those foods is almost an art form in itself. Is there a risk that the use of Foodini could be a barrier to a chef's artistry? No, if anything Foodini is another tool for a chef to create something artistic."*
>
> *(The Website of Natural Machines_Q&A)*

> *"Let's start with helping the chefs sleep peacefully - the printer is not there to steal your jobs!….3D Food Printers are not a new enemy. In fact, in contrary, they can become a very helpful friend. From a food professional's perspective, 3D Food Printing is nothing else than a food preparation process. However, the process is new, unique and offers outstanding applications, not known to any other kitchen tool or device. The 3D Food Printer makes it possible to create almost any kind of shape with almost any kind of food. Yes, normal & fresh food. Yes, so simple and mind-blowing at the same time."*
>
> *(The Website of byFlow)*

It was assured that 3D food printers would not render the food creations of a chef less artistic. The role of 3D food printing was to assist the professionals to achieve their artistic ideas. 3D food printing was not supposed to be a barrier or replacement to the specialty of chefs. Instead, 3D food printers were to help chefs do better. Therefore, 3D food printing was not considered as an enemy of chefs, but it was recognized as a food preparation process. It was depicted as a food preparation process that helped form creative shapes.

To promote the use of 3D food printing as an enhancement rather than a replacement of professional skills, the endorsements from professional users were presented in the research materials:

> *"To surprise my guests with a new and unique experience, I want to be open to innovative technologies. By using the Focus 3D Food Printer I'm able to experiment with traditional, local ingredients and serve them in forms and shapes that otherwise*

would not be possible. I'm excited that my restaurant will be the first in the Netherlands to do so."

-Jan Smink
(The Website of byFlow)

3D food printing was endorsed by the restaurant chef, Jan Smink, as an innovative technology that allowed him to experiment with ingredients and served those in forms and shapes that were unattainable before 3D food printing. Smink expressed his excitement that 3D food printers provided him with the chances to surprise his guests with a new and unique experience, and he was thrilled that his restaurant would be the first in the Netherlands to utilize 3D food printing.

Aside from the use in a professional restaurant kitchen, 3D food printing was depicted to be useful for chocolatiers and pastry chefs too. The developers of 3D food printers suggest the application of 3D food printing to personalizing chocolate and desserts (see figure 25). 3D food printing was recommended for printing personalized shapes, e.g. logos, texts or other artistic designs. Nonetheless, the "personalization" catered more to the purpose of attraction. Instead of printing the whole chocolate bar, cakes, cookies, and so on, it was suggested to print personalized shapes on the bar, cakes and cookies. Generally,

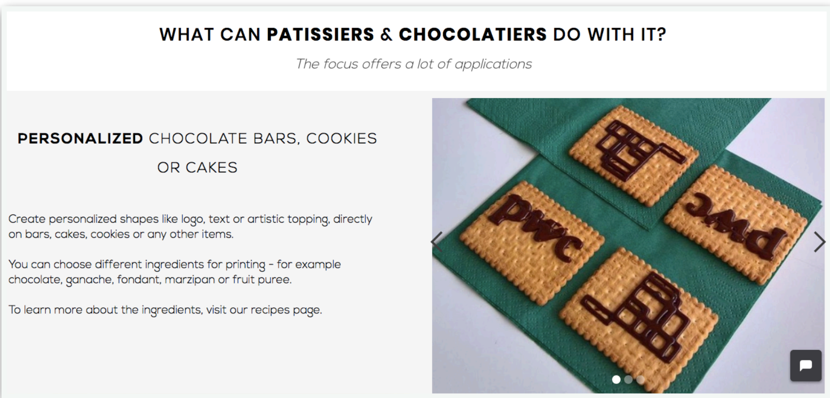


Figure 25. 3D food printing for pastry chefs & chocolatiers (byFlow, n.d.)

what was often emphasized by users like chocolatiers or pastry chefs about 3D food printing was that 3D food printing provided new experiences with the products they made:

"With the 3D chocolate printer, we can combine our rich legacy in chocolate making with the technologies of tomorrow. It is a very exciting venture to be able to create new experiences with one of Belgium's most famous product: chocolate."

-VP Global Gourmet at Barry Callebaut
(The Website of byFlow)

"The 3D Food Printer opens a whole new world of possibilities within my field. I believe in the innovative technology. It allows me to bring my showpieces to an extraordinary level."

-Hidde de Brabander
(The Website of byFlow)

As a Belgian manufacturer of chocolate and cocoa products, the representative of Barry Callebaut commented that 3D food printers could create new experiences for the conventional and world-famous chocolate of Belgium. Similarly, 3D food printing was endorsed by the celebrity pastry chef, Hidde de Brabander, as a gateway to a new world of possibilities in making all sorts of desserts and baked goods. 3D food printing was regarded as an innovative technology which allowed him to level up his pastry showpieces to the level of extraordinary. Notably, 3D food printing was seen as an enhancement.

Food professionals from "chocolate and cocoa industry (Callebaut)," "special food service and catering industry (Maison van den boer)" and "spices and sauce industry (Verstegen)" were listed on the website of byFlow to show that they had bought the 3D food printer (see figure 26). Other than food professionals from industries, 3D food printing was also utilized by "Inholland University of Applied Sciences" and "Radboud University." The testimonial quote of Inholland University of Applied Science was listed on the website of byFlow:

"The Focus is a very approachable and easy to use 3D printer, which gives our students of Food Commerce and Technology the capability to research the potential of 3D food printing for diverse companies."

-Inholland University of Applied Sciences (The Website of byFlow)

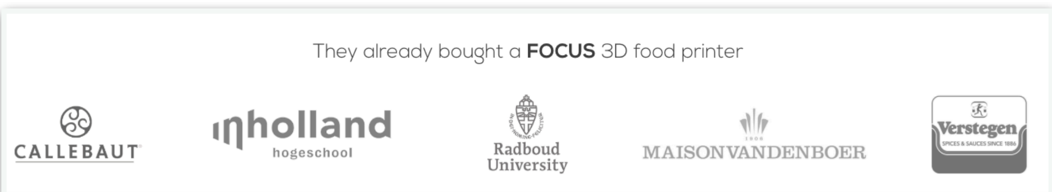


Figure 26. Highlighting professional users of 3D food printers (byFlow, n.d.)

The university revealed that the Focus 3D food printer was easy to use, so it provided the students of Food Commerce and Technology the means to research on 3D food printing potentials for different companies.

From the professionals of food industries to universities, 3D food printing was applied to generate food products in new and creative ways and provide new experiences with food. Other than configuring professionals in food industries and universities as users, amateur users were also configured in creative uses. Generally, 3D food printing catered to customers who were looking for something special. For example, instead of having a traditional or generic wedding cake, some might choose a wedding cake with 3D-printing bridal couple modeled with marzipan placing on top of it (see figure 27). 3D food printing targeted at the group of people that looked for uniqueness. Consequently, the businesses that utilized 3D food printers were more likely to got business opportunities from customers who were looking for special things.

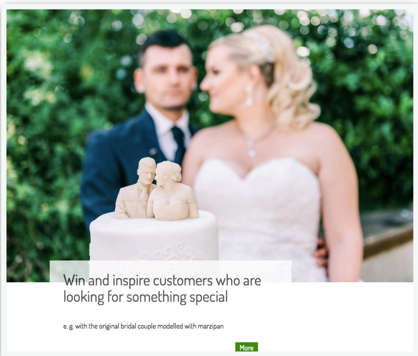


Figure 27. Win and inspire customers who are looking for something special (Procusini, n.d.)

Noticeably, even though 3D food printers were positioned as kitchen appliances, the developers of 3D food printing also correlated 3D food printers with innovation. For example, on the website of Procusini, the news about Procusini 3.0. made it to the finalist of the World Food Innovation Awards was posted (see figure 28). Procusini 3.0. was categorized as “best foodservice” and “catering product.” Likewise, on the website of

Figure 28.
Procusini 3.0 is finalist of the World Food Innovation Awards (Procusini, n.d.)

BeeHex, it was highlighted that the BeeHex had won various awards, from “Best New Tech from Vice Magazine,” “Best Tech in Silicon Valley of Timmy Award” and nomination of “ Best New Technology from Taste Talks Food and Drink Awards,” as shown in figure 29. Next to the description about winning awards, a picture of crowds gathering to look at a 3D food printer printing food at an exhibition setting. 3D food printers were showcased in an exhibition in which people looked for something new or special. In other words, 3D food printing was situated as an unique and innovative technology to be introduced in an exhibition.

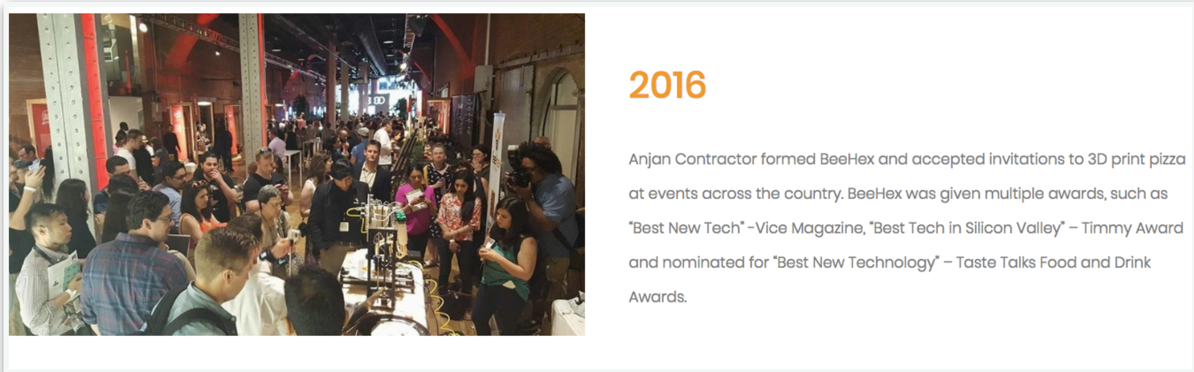


Figure 29. BeeHex was given multiple awards (BeeHex, n.d.)

Similar to BeeHex showcasing 3D food printing in an exhibition-like setting, byFlow also participated in Horecava, an Dutch annual hospitality trade fair in the Netherlands (see figure 30). They set up an InnovationLAB at the fair for participants to experience with 3D food printing. Notably, to manifest their presence at the hospitality fair as an InnovationLAB, it conveyed the idea that 3D food printing was a novel innovation for people to get to know to and learn about how it was. In particular, on the right side of the figure, the catch-phrase “the future is here” on top of the booth suggested that 3D food printing was futuristic.

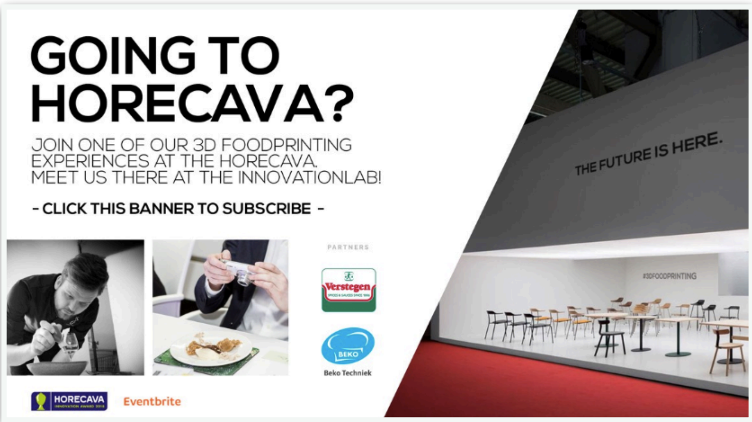


Figure 30. InnovationLAB (byFlow, n.d.)

Furthermore, byFlow also joined the Dutch Design Week, which was an event that brought exhibitions, workshops, and so forth together, in order to provide a workshop and interactive demonstrations with 3D food printers, as shown in figure 31. By participating the Dutch Design Week, it signified that the developers of byFlow situated 3D food printers as design-related devices.

Figure 31.
Dutch design week
(byFlow, n.d.)

3D food printing appeared not only in fairs and exhibitions being introduced as innovative technological devices, 3D food printers were also related with high-end dining:

> *“FRUIT CAVIAR: Do you want to try molecular cuisine and 3D food printing at the same time? Combine them today and make your own fruit caviar!….Perfect to amaze even the most demanding foodies!.*
>
> (The Website of byFlow)

3D food printers were applied to combine with molecular cuisine in order to make fruit caviar. By incorporating 3D food printing with molecular cuisine which was often associated with fine dining to make dish like fruit caviar, it was targeted to amaze the users such as foodies. Fine-dining experiences with 3D food printing were also accompanied by high-tech or scientific elements. For instance, the fine-dining even arranged by Food Ink utilized colorful lights and 3D printed furnitures, decorations, utensils to enhance the fine-dining experience. Colorful lights were applied to create ambience, making the dining experience unusual (see figure 32). Moreover, the furnitures and decorations used for dining were 3D-printed as well (see figure 33), and the same applied to the utensils for consuming food, as shown in figure 34. Accompanied by 3D-printed furnitures, decorations and flatware, the experience of having 3D-printed dishes were enhanced to be more unique and technological. Last but not least, to infuse more scientific vibe into the dinging experience, lab supplies, such as beakers, graduated cylinders and volumetric flasks, were used as containers for liquids and drinks (see figure 35).

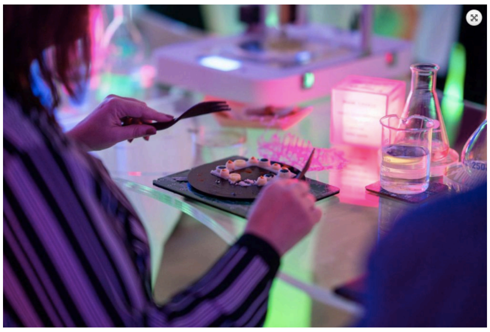


Figure 32.
Applying colorful lights
(Food Ink, n.d.)

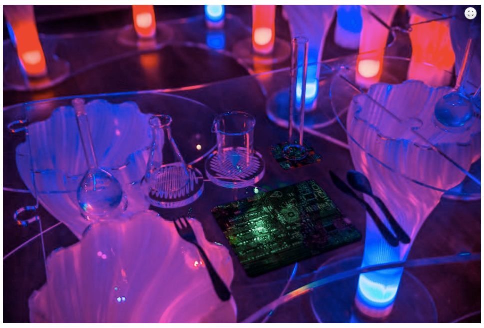


Figure 33.
3D-printed furnitures
& decorations
(Food Ink, n.d.)

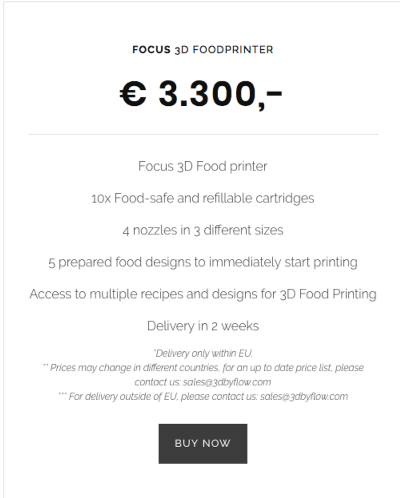
Figure 34.
3D-printed utensils
(Food Ink, n.d.)

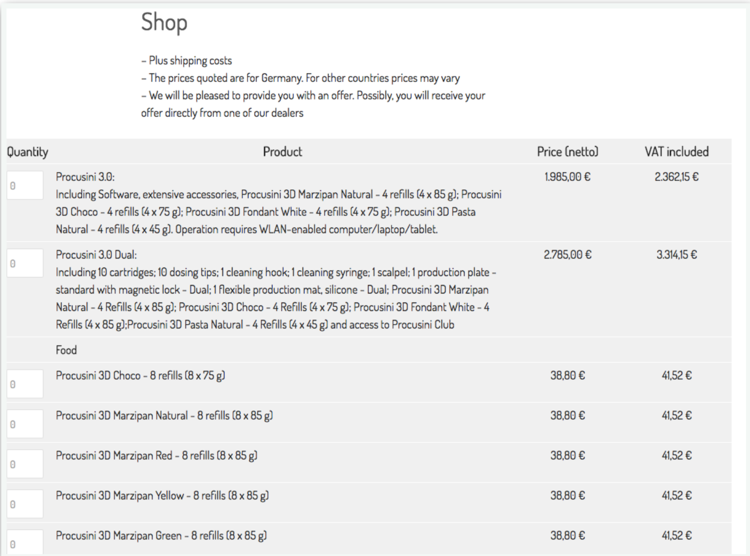
Figure 35.
Using lab supplies
(Food Ink, n.d.)

Other than situating 3D food printing as a technological innovation and relating it with high-end dining, 3D food printing was also presented as a high-end product. In figure 36, for example, the fillings in the cartridges for printing were packaged as a high-end product like consumer electronics. 3D food printing fillings were showcased similar to how a launch of a new technological product would be presented. Since 3D food printing was positioned as a high-end product, the prices of 3D food printers were not as approachable as regular kitchen appliances. Take the Focus 3D Food printer of byFlow for instance, the cost of the printer plus cartridges, nozzles and multiple recipes as well as designs for printing was up to 3300 euros (see figure 37). The cheaper Procusini 3.0 package option also cost around 2342 euros, and the eight refills package for printing cost more than 41 euros, as indicated in figure 38. The refill package already cost more than some common kitchen appliances.

Figure 36.
Selling in the form of designer goods (byFlow, n.d.)

Figure 37.
The Focus 3D food printer costs 3300 euros (byFlow, n.d.)





Shop

– Plus shipping costs
– The prices quoted are for Germany. For other countries prices may vary
– We will be pleased to provide you with an offer. Possibly, you will receive your offer directly from one of our dealers

Quantity	Product	Price (netto)	VAT included
0	Procusini 3.0: Including Software, extensive accessories, Procusini 3D Marzipan Natural - 4 refills (4 x 85 g); Procusini 3D Choco - 4 refills (4 x 75 g); Procusini 3D Fondant White - 4 refills (4 x 75 g); Procusini 3D Pasta Natural - 4 refills (4 x 45 g). Operation requires WLAN-enabled computer/laptop/tablet.	1.985,00 €	2.362,15 €
0	Procusini 3.0 Dual: Including 10 cartridges; 10 dosing tips; 1 cleaning hook; 1 cleaning syringe; 1 scalpel; 1 production plate - standard with magnetic lock - Dual; 1 flexible production mat, silicone - Dual; Procusini 3D Marzipan Natural - 4 Refills (4 x 85 g); Procusini 3D Choco - 4 Refills (4 x 75 g); Procusini 3D Fondant White - 4 Refills (4 x 85 g);Procusini 3D Pasta Natural - 4 Refills (4 x 45 g) and access to Procusini Club	2.785,00 €	3.314,15 €
	Food		
0	Procusini 3D Choco - 8 refills (8 x 75 g)	38,80 €	41,52 €
0	Procusini 3D Marzipan Natural - 8 refills (8 x 85 g)	38,80 €	41,52 €
0	Procusini 3D Marzipan Red - 8 refills (8 x 85 g)	38,80 €	41,52 €
0	Procusini 3D Marzipan Yellow - 8 refills (8 x 85 g)	38,80 €	41,52 €
0	Procusini 3D Marzipan Green - 8 refills (8 x 85 g)	38,80 €	41,52 €

Figure 38.
Prices of 3D food printing products printer costs 3300 euros (Procusini, n.d.)

Noticeably, the developers of 3D food printing were more pronounced about applying 3D food printers for professional uses. The professionals from professional kitchens, catering businesses, bakeries and confectionery shops were configured as users that could benefit from the creative uses of 3D food printers. It was also emphasized by the developers that 3D food printing was merely a food preparation process that could boost the operation and creativity for the professionals rather than hamper their creativity or even replace their specialty. The testimonial quotes from the professional users were listed by the developers to demonstrate that 3D food printers enabled the professionals to experiment, create new experiences, provide new possibilities and innovate, especially for traditional products and ways of making food, which resonated with the idea about how 3D food printers could liberate users from traditional ways of making food (Campbell et al., 2011). Nevertheless, it could be noticed that the experiments, new experiences, and new innovations centered around the shaping aspects of 3D food printers. In the work of Zoran & Coelho (2011), they discussed about the potentials 3D food printers to generate not only new shapes but also achieve new flavors, textures and scents of food. The aspects of coming up with new flavors, textures and scents of food with 3D food printing were not visible in the research materials. Furthermore, other than professionals in food industries, universities were also listed as users. In particular, universities were users that were researching on the potentials of 3D food printing for companies. The business applications of 3D food printing were rather prominent in the research materials, especially when it came across the creative aspect of the novel food technology. 3D food printing was scripted to revolutionize businesses by providing new ways of making and creating food objects.

Other than professional and university users that were configured in creative uses, people who were looking for something special in general were configured as users of 3D food printers too. The developers of 3D food printing associated 3D food printers with winning technology and innovation awards, situating 3D food printing a worthy technology and innovation. By presenting winning technology and innovation awards on the websites to appeal to users, the developers also configured users who were looking for something novel, innovative and special. Similarly, by setting up an InnovationaLAB at a hospitality trade fair with the catch-phrase “the future is here,” it suggested 3D food printing was a futuristic food technology, and the users who sought novel and futuristic technology were configured. Moreover, by attending a design event that brought exhibitions and workshops together, 3D food printers were positioned as design-related devices, the users who utilized 3D food printers to design food objects were configured.

Besides the associations with technology, innovation and design, 3D food printing were also related to fine dining experiences such as molecular cuisine, high-tech vibes of dining setting and environments to satisfy foodies. The users who looked for high-end fine dining experiences and high-tech vibes were configured by the developers too. Notably, even though 3D food printing were situated as kitchen appliances in some cases, the developers accentuated not only on the functionality and the pragmatics. While most kitchen appliances such as food processors were underlined with their pragmatic uses only, 3D food printers were emphasized with their creative, innovative and design potentials. 3D food printers were positioned not only as kitchen appliances but also as novel technological devices that were able to create, design and provide novel experiences with food. Consequently, 3D food printing related devices and parts were often sold in the form of designer goods. Being distinct from common kitchen appliances, the prices of 3D food printers were distinct too. With the prices that usually more than a few hundred euros, the users of 3D food printing were inevitably from a narrow niche.

6.3. 3D Food Printing & Health

6.3.1. Making Healthy 3D-Printed Food

Other than the easy operations, convenience, and creative potentials, 3D food printing was often put in light of health too:

> *"Our launch product is a 3D food printer. We call it Foodini. We are using an open capsule model, meaning the consumer prepares and places fresh ingredients in Foodini. Natural Machines is going to make preparing food healthier, easier, and so much fun."*

(The Website of Natural Machines_Q&A)

Designed with open capsules to contain food ingredients for printing, it allowed users to put fresh ingredients before printing. Consequently, 3D food printing was claimed to be make preparing food healthier, because users could printing with fresh food materials. In particular, the developers of 3D food printing targeted at printing food that could replace the pre-packaged foods:

> *"Or take an example of crunchy, savory snacks: chips, breadsticks, crackers, etc. Don't buy pre-package versions that are shelf-stable for years, with preservatives and usually too much salt, etc. With Foodini, you can make your own versions of these convenience foods people have grown accustom to, but creating healthier versions made with fresh ingredients."*

(The Website of Natural Machines_Q&A)

> *"We hope that Foodini will encourage more people to eat healthier, fresher foods... whether it's in their homes or in a restaurant. There are too many processed and "convenience" foods in the market, many with ingredients that are unidentifiable to the common consumer. Foodini can help replicate these convenience foods that people have become accustom to, but making them with fresh ingredients. And taking it a step further, Foodini can help craft/present food into shapes that would be difficult by hand... this makes food fun!*

(The Website of Natural Machines_Q&A)

The pre-packaged foods like snacks that could be purchased on shelves were considered less healthy. 3D food printers were positioned to print the same pre-packaged food, but the printed food would be healthier versions of those convenience foods owing to the fresh ingredients as well as less presence of preservatives and salt. In other words, 3D food printing was targeted to be used to replace the convenience foods in the market in both homes and restaurants. 3D food printers could be used to make the convenience foods with fresher food materials and even in shapes that had been hard to fabricate by hand. The same concept applied to pre-filled food capsules too:

> *"We are also working with food manufacturers to produce pre-filled food capsules, using no or very little natural preservatives."*
>
> *(The Website of Natural Machines_Q&A)*

For those who had no time or will to prepare food ingredients for printing, the developers aimed to provide pre-filled food capsules for them to print food. Furthermore, the product plan for pre-filled food capsules was to use none or very little natural preservative. The naturalness was emphasized again even in pre-packaged capsules.

Overall, the developers of 3D food printing promoted the health benefits by emphasizing on the aspects of fresh and real food ingredients:

> *"The important thing to know with Foodini is that it uses fresh, real food. The user prepares fresh food to go in the capsules to print; it's not processed food. So, it's up to the user how the food will taste: fresh food in, fresh food out."*
>
> *(The Website of Natural Machines_Q&A)*

> *"3D Food Printing is a method of food preparation. Just as any other method commonly used in the kitchen. Simply saying - chicken comes out of the 3D Food Printer if you put chicken-meat in it. The same applies to sweets, vegetables and dairy products, which all are suitable for 3D-printing with byFlow's machine. 3D-printed chocolate is real chocolate and a 3D-printed avocado is a real, fresh and healthy avocado. All the ingredients just need to be properly prepared before printing (for that byFlow provides recipes to their customers) to reach the desirable smoothness and volume. What the machine does, is extruding the food-paste from the cartridge, and while extruding, creating a designed and programmed 3D-shape. Nothing artificial, no magic skills needed."*

(The Website of byFlow)

It was constantly accentuated by the developers of 3D food printing that 3D food printing was fresh real food, unlike processed food. The users were able to prepare the food materials for putting into the capsules for printing. Therefore, when it was the fresh food put into the capsules, what came out of the 3D food printer would still be fresh food. A fresh, real and healthy avocado used for printing, what came out of the 3D food printer would still be the same fresh, real and healthy avocado. The only difference would be the shape, since 3D food printers could print in creative designed shapes. The developers underlined that 3D food printing was not artificial when applying fresh and non-artificial food ingredients for printing.

Other than emphasizing the "freshness" 3D-printed food could be with freshly prepared ingredients, another aspect frequently identified in the research materials relating to health was that 3D-printed foods were often accompanied with natural food ingredients. In figure 39, for example, around the plate of printed spinach quiche in the shape of dinosaurs were accompanied by fresh spinach leaves. Similarly, the starter dish of printed mashed potatoes in the shape of octopus were accompanied by fresh leaves and cooked pike-perch and ratatouille (see figure 40).

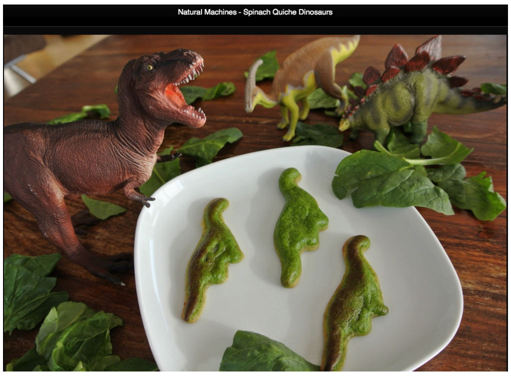


Figure 39.
Spinach quiche dinosaurs
(Natural Machines, n.d.)

Figure 40.
Fancy starter - Mashed-potatoes-octopus on pike-perch fillet and ratatouille
(Procusini, n.d.)

Notably, the developers of 3D food printing scripted the uses design of 3D food printers to make 3D-printed foods more healthy for users to consume. The uses design included having open capsules that allowed users to put fresh ingredients in before printing and pre-packaged food capsules that were produced with very little to no preservatives. The emphasis on the "naturalness" of 3D-printed food could result from consumers' concerns regarding the unnaturalness of 3D food printing. The developers of 3D food printing often accentuated the aspects of “fresh” and “real” food ingredients to “naturalize” 3D food printing and relate it to the healthy benefits. In the study of Lupton & Turner (2018), they discovered that consumers usually preferred natural foods more than printed foods, because 3D-printed food could seem artificial and unnatural to consumers due to the printing process and the sheer fact that the foods were “printed.” In the research materials, it was identified that the developers put emphasis on “fresh food in, fresh food out” to lower users’ concerns and highlight the healthy potential of 3D food printing. The developers situated 3D food printing as any other commonly used method of food preparation in kitchen, normalizing 3D food printers as kitchen appliances that were not alien, artificial or unnatural to use, opening possibilities of more acceptance from users. Furthermore, the developers of 3D food printing often presented 3D-printed foods with fresh food ingredients to make 3D-printed foods to be healthier or at least seemed healthier.

6.3.2. 3D Food Printing & Customization

Apart from printing or combining with “fresh foods” to provide healthier food options, 3D food printing was also presented to offer health benefits by customized and personalized printed food. For people with swallowing problem, for instance, 3D food printing could customize based on their demands:

> *“Can you imagine that there’s people that has swallowing problems, so they cannot even eat food. They always are limited to NutriDrinks or to puree….and all look disgusting. These people don’t have fun anymore with eating. Umm with 3D food printing, we can print that fun back.”*
>
> *(The Website of byFlow)*

Since 3D food printing could make food in creative shapes, it was targeted to be used to print food for people with dysphagia. They had used to eat NutriDrinks or puree which was not appetizing. However, with 3D food printers, foods could be customized with ideal texture and in shapes that were more fun and appetizing for people who had swallowing difficulties.

3D food printers could also be utilized in combination with personalized nutrition to provide health benefits. Since users could decide what was being printed with 3D food printers, 3D food printing was often related to the personalized nutrition to provide healthy diets:

*“**Challenge**: Personalizing your diet based on your physiological needs is challenging. The only way to truly personalize your meals and snacks is with a personal nutritionist and chef.”*

*“**Solution**: Our 3D food printer can help you personalize your diet.”*

*“**Benefit**: Stay fit, alert and healthy for optimal performance and longevity”*

(The Website of BeeHex)

3D food printing was positioned as a solution to provide personalized diet for benefits such as staying fit, alert and healthy for the best performance and longevity. The way BeeHex portrayed 3D food printers situated 3D food printing as a personal device that served like a nutritionist and chef at the same time. In figure 41, for instance, BeeHex 3D food printer was targeted at personalizing nutrition based on individual dietary requirements. To visualize personalized nutrition, BeeHex provided an image (see figure 42) to illustrate. The non-verbal elements of the image included a doctor, pills, vegetables and fruits, whereas the verbal elements were energy, diet, health, nutrients, prevention, supplements, balance, wellness, vitamins, fiber and minerals.

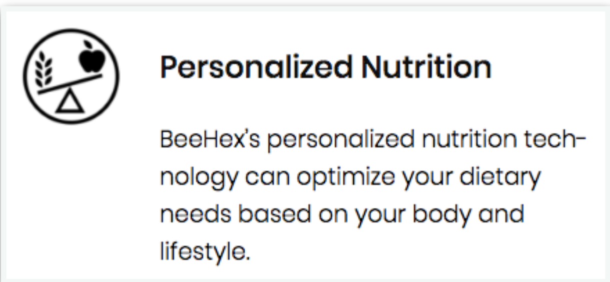


Figure 41.
Personalized nutrition
(BeeHex, n.d.)

Figure 42.
Elements of
personalized nutrition
(BeeHex, n.d.)

Other than relating 3D food printing to fresh and natural food ingredients, the developers also associated 3D food printers with customization and personalization to make the food technology an healthy option. The first application was to customize shapes and textures. For instance, for those who had dysphagia, 3D food printers could reconstruct food in fun customized shapes and dysphagia-friendly textures. People with swallowing problems no longer had to consume only NutriDrinks or unappetizing puree. Providing more appetizing food options for people with dysphagia could prevent them from having malnutrition caused by loss of appetite. The finding about applying 3D food printing for people with swallowing problems resonated with the European Union's vision to transform the meals with the project "PERFORMANCE" that developed 3D food printing to provide people with swallowing problems with safer and more appetizing food options (Pearse, 2014). Notably, the users with swallowing problems were configured by the developers in uses of customizing food shapes and textures for health benefits with 3D food printers.

Apart from customizing shapes and textures, the developers also subscribed the use of 3D food printing with personalized nutrition for health benefits. It was anticipated that 3D food printers could help personalize diets based on individual needs. In the research materials, 3D food printing was seen as a solution to personalize diet with control of intakes such as vegetables, fruits in order to have balanced energy, nutrients, supplements, vitamins, fiber and minerals for health and best performance to live a life of wellness and longevity. The image of doctor and pills in the research materials suggested that 3D food printing for personalized nutrition was seen as prevention of having to visit doctor and take pill when getting sick due to malnutrition. From another perspective, the image also insinuated that 3D food printers, in combination with personalized nutrition, could play the role of doctors and pills to make people stay healthier. The customization stemmed from digitalized information of nutritional values, and digitalized gastronomy provided access to more precise nutritional and textual control for personalized compositions, portions, calories, added nutrients, and so forth (Zoran & Coelho, 2011; Yang et al., 2017). The individuals that sought personalized nutrition were configured as users by the developers in the uses of customizing nutritions in 3D-printing foods.

6.3.3. Configuring Users as the Consumer-Citizen Synthesis

When it came to health, 3D food printers were positioned to provide health benefits with customizations of shapes, textures and nutritions of foods. Moreover, 3D food printing was designed to get people back into kitchens to be more healthy:

> *"From shaping pretzels, to forming gnocchi, to layering ravioli, to forming crackers.... it's designed to help get people back into kitchens, cooking with fresh foods, and*

getting away from buying processed, packaged, pre-made foods. We are not designing a pill-replaces-real-food proposition."

(The Website of Natural Machines_Q&A)

3D food printing was aimed at shaping foods with fresh ingredients to replace processed, packaged and pre-made foods. By taking away the work of forming shapes, 3D food printers were designed to assist users and bring them back to kitchens to make fresher foods. The developers accentuated that 3D-printed foods could be fresher food options rather than replacements of real foods.

Aside from food customizations in shapes, textures and nutritions, the developers of 3D food printing also highlighted the functional feature of 3D food printers to relate it to health. The developers considered that 3D food printers could replicate the repetitive food preparation tasks such as shaping, layering and forming so that people were more willing to get beck into kitchen to make foods with fresh ingredients. In other words, the developers configured the users who looked for convenience but did not want to give in the opportunity of eating healthy in the uses of 3D printing fresh food that did not require users to do repetitive works like forming shapes themselves. The technical designs of 3D food printers to print with fresh food and to take over repetitive tasks scripted the users to get back to kitchens to eat healthier, users could replace processed, packaged and pre-made foods that might contain additives and preservatives with 3D printed fresh foods that were more natural. The designers held themselves responsible for the health of users with the technical applications of 3D food printers. Moreover, the developers emphasized that 3D food printing was not a replacement of real foods, accentuating that it was not like designing a pill replacing a whole meal; rather, 3D food printers made foods that were real, fresh and thus healthy.

The developers put much focus on the health benefits of 3D food printing. Particular, by the convenience of automizing food preparation tasks like shaping, layering and forming, it resulted in less work and more time for users of 3D food printing, encouraging them to get back to kitchen to make fresh foods with 3D food printers. It was depicted that users could gain both convenience and health with 3D food printing. Both the pleasure resulted from convenience and health consciousness were to be satisfied by 3D food printing. In the study of Mol (2009), she discovered that the Dutch public health campaigns related to obesity tended to portray eating healthy food as a devotion towards public health and civic duty as opposed to gain pleasure. Nonetheless, by studying the food packages in the Netherlands, she found that the designers of the food packages constructed the idea in the products that pleasure could actually coexist with devotion to public health. Some food packages suggested consumers could drink or eat with pleasure and simultaneously stay healthy. Mol (2009) thus proposed the concept of a “consumer-citizen” whose pleasure did not collide with practicing good; rather, individual pleasure could integrate with the public good. Similarly, by highlighting 3D-printed meals could be real, fresh and thus healthy food and that 3D food printing could provide convenience, the developers configured users as those who valued not only health but also convenience. In other words, the citizen-consumer synthesis that stayed healthy for public health and sought convenience for individual pleasure were scripted in the technical designs of 3D food printers.

6.4. Expectations, the Present & the Future

6.4.1. Expectations & the Present : Avoid Food Waste Now!

As a novel food technology, 3D food printing had been expected to achieve certain purposes. While some expectations were difficult to be achieved and thus located in the future, some expectations were attainable and thus established at the present time. In the research materials, what 3D food printing was expected to accomplish at the present time was to reduce food waste:

> *“3D food printing with Foodini can reduce food waste throughout the food value chain: from the customization of portion sizes allowing people to print what they want to eat and nothing more, to recovering food that is traditionally classified as food waste - such as “ugly” fruits, vegetables, and cuts of meat - and printing these foods making them an attractive and nutritious food source.”*
>
> *(The Website of Natural Machines_Q&A)*

> *“Chocolate, sugar, butter, vegetables, fruit and even meat, with a 3D food printer, startup byFlow can print more than fifty different ingredients. Besides the fact that it’s awesome, it can also help against food waste. With this food, the food that has been thrown away because it has a little spot on there, or because it doesn’t look appealing enough, we can give it a second life with 3D food printing, so we can put it in our 3D food printer and print some beautiful dish for it.”*
>
> *(The Website of byFlow)*

Since 3D food printers could print customized portion of food, it allowed people to print the exact amount of food they felt like to eat without wasting. Moreover, it could also print in customized shapes, so the ugly fruits, vegetables and meat could be reconstructed into food that seemed more attractive and appetizing. Food ingredients that would have been thrown away because of looking imperfect could be used, which helped against food waste as well. 3D food printing was expected to provide a second life for the imperfect produce.

Notably, using 3D food printing to avert food waste was an expectation located at the present time. The expectation was attainable due to the fact that printing with ugly produce in attractive shapes was possible. Unlike traditional subtractive processes of manufacturing that removed materials, additive manufacturing process of 3D food printing could avoid food waste caused by removing materials. Manufacturing food objects in an additive manner, 3D food printing was often deemed as inherently green (Campbell, 2011). In the research data, the developers highlighted the aspect of customizing and printing the exact amount of food that was needed with 3D food printers, which corresponded with the feature of additive manufacture that avoided food waste caused by subtractive way of manufacture. Furthermore, regarding food waste, the developers also emphasized that 3D food printing could give ugly food produce a second life. Since 3D food printers print with food that were pureed, it provided imperfect food produce a chance to be used rather than thrown away. By printing 3D food objects with ugly and unappetizing foods in attractive shapes, the developers configured users who utilized 3D food printing to reconstruct imperfect food ingredients that would have been tossed away and avoided food waste. The findings about applying 3D food printing to provide ugly food produce a second life and avoid food waste were self-evident in the research materials, which echoed with the finding of Lupton & Turner (2016) on the potential of 3D food printing to avoid food wastes by making foods with imperfect food produce.

In the work of Mol (2009), she studied the packages of Fair Trade products, finding that the products successfully and unobtrusively incorporated deliciousness and fairness. She discovered the construction of a consumer-citizen who purchased for sensory pleasure as well as social contribution like societal fairness in the products of Fair Trade. Similarly, on the developers' websites of 3D food printing, it could also be identified in the depictions about utilizing 3D food printers to avoid food wastes that the consumer-citizen was configured. Averting food waste by 3D food printing with imperfect foods that would have been tossed was a contribution towards environmental and societal sustainability. However, contributing to societal goods did not mean having to forsake sensory pleasure; rather, 3D-printed food could still be tasty, aesthetically pleasing and appetizing. The developers of 3D food printing configured users as a consumer-citizen in the uses of 3D printing foods with imperfect produce to provide the foods with a second life.

6.4.2. Become Common Kitchen Appliance & Help the Poor in the Future

While some expectations were set to be actualize-able at the moment, some expectations were set to be carried out in the future:

> *"We believe that in 10 to 15 years, 3D food printers will become a common kitchen appliance in both home and professional kitchens, similar to how an oven or a microwave are common appliances in kitchens today. So, we will target both professional kitchen users and home kitchen users. Currently, we are focused on professional kitchen users."*
>
> *"It's going to keep getting better and better. We envision that 3D printing technology will continually evolve, so we will always be investing in research and development. With food printing, for example, we believe additional textures of food will be suitable for printing, finer-tuned movements to shape food on a plate will be developed, and printing can become faster without losing quality of presentation. Since Foodini is a connected device – meaning it's connected to the Internet – we will provide software updates so our customers have the latest technology on their machines."*
>
> *(The Website of Natural Machines_Q&A)*

It was expected that 3D food printers will become a common kitchen appliance in both home and professional kitchens, just like an oven or a microwave nowadays. Additionally, it was also expected that the food textures would be expanded, the fine-tune movements would be better and that the printing speed will be faster in the future. Due to the connection to the Internet, 3D food printers were able to be updated to be the latest version.

Other than becoming common kitchen appliances, 3D food printers were expected improve lives in areas where people could not afford nutritional food due to economic conditions:

> *"Because users have total control over what is being printed, they can control calorie count, nutritional value, and more. It'll allow people to live healthier lives, but more importantly, it has the potential to help save lives in impoverished areas….People all over the world can't afford basic ingredients. In India, the prices of onions - something small, like onions - are too high for most people to afford, says Anjan*

Contractor, 3D printing expert and founder of BeeHex. Now imagine if food could be printed. You can control nutritional value. You make healthy eating available for everyone. There are people in the world that can't afford food, and 3D printing can change that."

(The website of BeeHex)

It was expected by the 3D food printing developers that being able to control nutritional value in printing made healthy eating more available, especially to people who could not afford food in areas like India. 3D food printing was anticipated to be a solution to save lives and provide healthier eating for people who could not afford food. Since 3D food printing was still pricy and uncommon, the depiction remained an expectation to be actualized in the future.

The developers of 3D food printing expected 3D food printers to be a common kitchen appliance in ten to fifteen years, anticipating 3D food printers to become a kitchen device that would be as common as ovens and microwaves nowadays. The developers configured future users in future uses of 3D food printers as common kitchen appliances. Nonetheless, due to high prices and limited functionality, 3D food printer still remained in the niche market at the moment. By stating the technology to be a common consumer kitchen appliance as the expectation of the technology, the expectation became the representation of the future that guided the present development and embodied the future (Brown & Michael, 2003). In particular, the developers aimed to continually improve the functionality of 3D food printers in developing more food printing textures, finer-tuned movements to form food shapes and faster speed for printing high quality food objects were set as practical expectations to lead 3D food printing to the technology envisioned by the developers. Furthermore, since as digital appliances, 3D food printers were able to control the calorie count and nutritional value of printed food, the developers claimed that it will allow people to live healthier lives, especially in the impoverished regions such as India. The people from poor areas were configured as users who would benefit from the uses of 3D food printing to control nutritional intakes.

Notably, to make 3D food printers become common kitchen appliances like ovens nowadays and to use 3D food printers to help the poor gain affordable and healthier food choices were both high expectations of the novel food technology. Therefore, the expectations were located in the future. Because for 3D food printers to become common kitchen appliances, both users acceptances in functionality, practicality, price and value should all be in place to make 3D food printers prevalent in kitchens. Likewise, to help the people who were in impoverished conditions to eat healthier with 3D food printing, the users acceptances regarding functionality, practicality and affordability should all come in place too. Particularly, in the vision of the developers, they imagined 3D food printers to help the people who could not afford food ingredients like onions to eat healthier with 3D food printing. They expected 3D food printing to help the life of the people who could not afford food, while 3D food printers usually cost several thousands of euros. The expectation to provide affordable and healthy food options with 3D food printing were unattainable at the moment, especially for those who even had trouble buying onions because of the price. The expectations of 3D food printing were not feasible at the moment. There was a huge gap between the expectations and the reality. Normally, in the early stages of technological developments or niche markets, the functionality or capabilities of the technologies tended to fall behind the expectations or promises; in other words, the expectations were both hopeful in demonstrating what they could fulfill and monstrous in the gap between expectations and reality (Geels & Smit, 2000). Understandably, the expectations were set high in the early stages so as to attract interests, bring investments and guide the technological developments (Geels & Smit, 2000).

6.4.3. A Gap Between the Present and the Future

Some expectations could be actualized in the current time, and some expectations were to be realized in the future. However, some expectations blurred the line between the present and the future:

> *"3D Food Printing isn't anymore a technology of the future – it's a revolution happening on our plates right NOW! Participants of Horecava 2018, the biggest Food Industry event in The Netherlands taking place in Amsterdam on the 8th till the 11th of January, will have a chance to try 3D Food Printing on their own and see how it will change the way they prepare food on a daily basis. This 3D Food Printing experience will be organized by byFlow, a Dutch company selling and producing 3D food printers. The first 3D Food Printer, named the Focus, is on the market since the end of 2016 and already this year byFlow was celebrating its 100th sale."*
>
> *(The Website of byFlow)*

3D food printing was depicted to be a technological revolution that was happening on the plate at the moment. 3D food printers were no longer technology of the future. However, the revolutionary effects of 3D food printing on how the changes it would bring to the way people prepare food daily were not yet actualized and remained in the future. Noticeably, the line between the present and the future was obscured.

3D food printing developers had the tendency to juxtapose the present and the future in order to blur the gap between the two. Particularly, the gap between the present and the future was abridged by executing the future expectations. In the video of Food Ink, for instance, at the beginning of the video of fine dining with 3D printed food, the title announced that the best way to predict the future was to invent it (see figure 43). The idea was further elaborated on the online website of Food Ink. As shown in figure 44, Food Ink brought together architects, artists, chefs, designers, engineers, futurists, industrials, inventors and technologists to turn their revolutionary visions a present experience. To them, future were worth pursuing; therefore, they were working on emerging technologies such as 3D food printing so as to bring their visions about the future to the present time.

Figure 43. To predict the future is to invent it (Food Ink, n.d.)

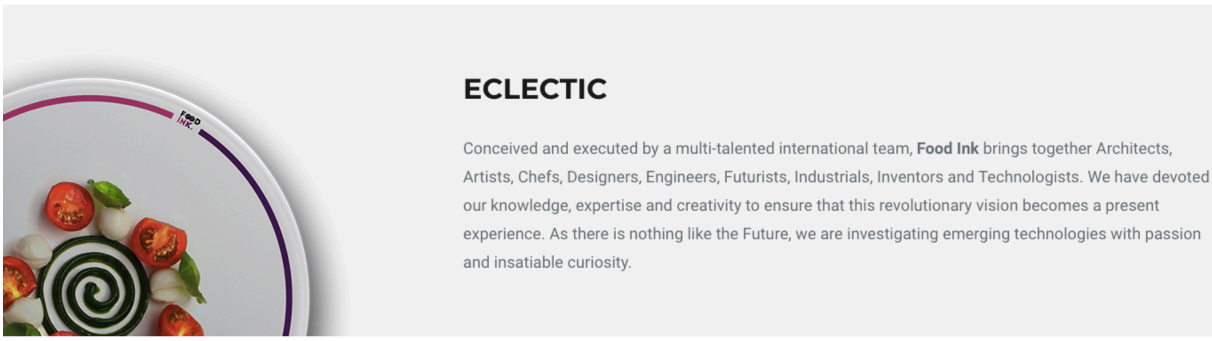


Figure 44. Revolutionary vision becoming a present experience (Food Ink, n.d.)

Apart from blurring the line between the present and the future or juxtaposing the present and the future, the developers of 3D food printing sometimes would equate the future as the present. At the InnovationaLAB Horeca 2018, for example, byFlow indicated that the future was here by introducing 3D food printing (see figure 45). 3D food printing was regarded a futuristic way to make food, and it was brought to the present. Similarly, the developers of Food Ink highlighted the dining experience with 3D food printing provided by Food Ink was the most futuristic gourmet experience in the known universe which allowed people to taste the future today, as shown in figure 46 and figure 47. 3D food printers printing were presented at the background of highlighting futuristic gourmet experience and tasting tomorrow today, showing that the futuristic devices were already available at the present.

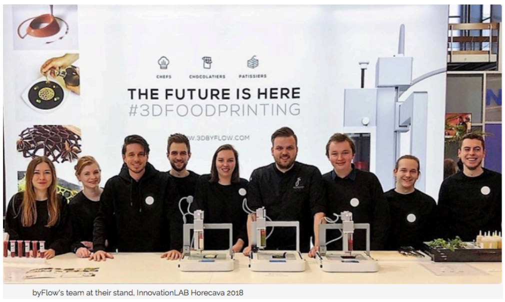


Figure 45.
Future is here
(byFlow, n.d.)

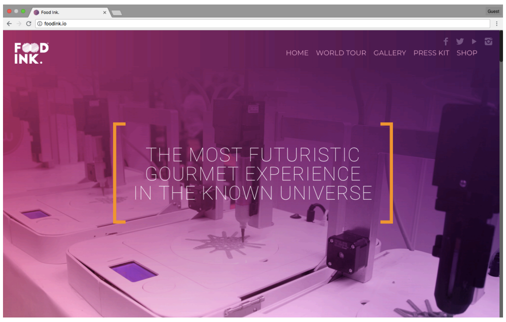


Figure 46.
Futuristic gourmet experience
(Food Ink, n.d.)

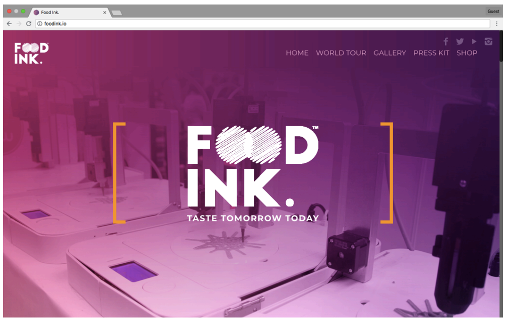


Figure 47.
Taste tomorrow today
(Food Ink, n.d.)

Nonetheless, by blurring the line between the present and the future, juxtaposing the two or even equating the two, the gap between the expectation and reality could sometimes surface. For example, while 3D food printing was developed to help astronauts in deep space missions, the gap between the expectation and the reality was visible (see figure 48). Although it was anticipated to work in deep space missions, the image of a preliminary 3D food printer printing pizza appeared as a contrast and gap between the anticipated goal. Likewise, in the video of byFlow, it mentioned 3D food printing was the future; however, what was showcasing in the video image was a 3D food printer printing chocolate, as shown in figure 49. While it was emphasized that 3D food printing was the future of food manufacture, it formed a contrast when it was printing chocolate only rather than a sophisticated dish.

Figure 48.
Gap between reality and expectation
(BeeHex, n.d.)

Figure 49.
Printing chocolate while mentioning 3D food printing=future
(byFlow, n.d.)

In the research materials, it was noticed that the developers tended to mingle the present time with the future in three ways. The first way was the blur the line between the present and the future. For instance, the developers depicted 3D food printing as a technological revolution that was going on for the dining experiences, stating that 3D food printers were no longer the technology of the future. Nonetheless, the revolutionary effects of 3D food printing that was promised to change the way people prepared food daily was not yet attainable. Even though 3D food printers were not future technology, the revolutionary effect that was anticipated remained in the future. In other words, the expectation of 3D food printing changing the way people prepare food on a daily basis was caught between the present and the future. The second way was to juxtapose the future with the present in order to blur the gap between the two. For example, it was suggested by the developers that to predict the future was to invent it. The developers brought the revolutionary and futuristic visions to become present time experience. The future was worshiped by the developers and embodied with emerging technologies. The third way of bringing the future together with the present was to equate the future as the present. With catch-phrases such as “future is here,” “the most futuristic gourmet experience in the known universe” and “Taste tomorrow today,” it was suggested that 3D food printing was a technology of the future, and that future technology was already available at the present time.

Scientific and technological developments had become more future-oriented and regarded the future as a better version of the present; therefore, scientific and technological developments were filled with expectations and visions in order to attract investments for developments, so the expectations of novel technology tended to exist before the technology, making expectations wishful enactments of a desired future (Borup et al., 2006). Expectations had the power to enroll actors in the developments of science and technology, guiding and shaping the developments of their own desired outcome (Pollock & Williams, 2010). Understandably, the developers blurred, juxtaposed and equated the future and the present in order to mobilize resources that could fund the developments of 3D food printers to go further. By stating that 3D food printing was a revolutionary technology at the present but locating the expectational effects of the technology in the future, the developers made their expectations guide the developments towards the future by gaining recognition and funding for the further developments at the present. Similarly, by bringing futuristic and revolutionary visions as a present experience with emerging technologies, the developers utilized the expectational visions to shape the current experiences with 3D food printing. Last but not least, by equating the future with the present, expectations were substantialized. The expectations served as the constitutive forces that made the desired future happen.

Nonetheless, expectations were usually set high to mobilize resources and gain momentum for technological and scientific developments, so the actual functionalities and capabilities of the technologies or scientific breakthroughs tended to have a gap between expectations or promises (Geels & Smit, 2000). The gap between the actual functionalities and the expectations could be identified in the research materials. For example, while it was mentioned that 3D food printers were designed for deep space missions, the image of a prototype-like and unimpressive 3D food printer next to the description formed a drastic contrast. Similarly, while the developers mentioned 3D food printing equalled the future in a video, what the video image showed was only printing chocolate in shapes rather than printing a complicated dish. The inconsistency between expectations of 3D food printing and their actual performance could be identified. Despite the inconsistency between expectations and reality, expectations were imperative and led the present promises to be held accountable for the expected future (Borup et al.,2006). It should be noted that the gap and inconsistency existed because expectations were expanded at the first place due to the reason that they were performative.

7. Conclusion

To conclude this study, this chapter will summarize the key research findings that are relevant to the research aim and questions. Moreover, reflections on the contributions as well as the limitations of this study will be included so as to propose opportunities for future researches. To begin with, in the social studies of the reviewed literature on 3D food printing, the researches have worked on the sociotechnical imaginaries in the online news media (Lupton, 2017) and on consumer reactions (Lupton & Turner, 2016) as well as consumer attitudes (Lupton & Turner, 2018; Brunner et al., 2018) so far. The perspectives from the developers of 3D food printing could provide another take on the developments of the novel food technology. As a consequence, this research aimed to investigate how the developers of 3D food printing scripted and configured the uses and the users in order to make sense of the novel food technology. Based on a qualitative content analysis in combination with a multimodal critical discourse analysis of the official websites and the videos created by the 3D food printing developers, the study results were summarized as below:

7.1. The Utilitarian, Creative and Healthful Uses of 3D Food Printing

Utilitarian Uses of 3D Food Printing

In the studied websites and videos created by the developers of 3D food printers, the developers presented the uses 3D food printing in three major approaches. The three major approaches were "the utilitarian purposes," "the creative purposes" and "the healthful purposes" of using 3D food printers. First and foremost, the developers put much emphasis on the utilitarian purposes of 3D food printing. To bring out the utilitarian purposes of using 3D food printers, the digitalized food-making process tended to surface to the forefront. The digital features, devices and operations were often accentuated to highlight the easiness of making food with 3D food printers; for instance, the process of 3D food printing was condensed into actions of selecting 3D template online with a screen to print with 3D food printers. 3D food printing was characterized as easy, simple, convenient and time-saving. Due to digital operation, the automating aspect of 3D food printers were also emphasized to highlight the efficient production with the technological devices. The tireless hands of 3D food printers were scripted by the developers as replications of human skills and the evolution of hand-crafting. In addition, because 3D food printers manufactured in an additive manner, plus updatability of 3D food printers and 3D object designs, it was mentioned that 3D food printing could not only save time but also cost, for the traditional customized molds for making food objects were no longer needed. Furthermore, the design of 3D food printer parts, such as cartridges, stainless steel mashers and stainless steel tips were designed to be dish-washer friendly, saving users from having to wash the parts by hand. The convenient use of 3D food printing was inscribed in the designs of 3D food printer parts. Overall, the utilitarian purposes were manifested in easy, convenient, time-saving and cost-saving uses of 3D food printers.

In relation to the utilitarian purposes of 3D food printing, it was discovered that the developers of 3D food printing situated 3D food printers as kitchen appliances. The developers assimilated 3D food printers like the other consumer electronic devices in the kitchens, e.g. ovens, microwaves and dishwashers. 3D food printers were regarded as the reduced version of manufacturing facility that could be placed in kitchens as a stylish kitchen appliance. As kitchen devices, the abilities of 3D food printers to form shapes and conduct repetitive food assembly tasks were scripted by the developers to help users replace pre-packaged foods with 3D-printed foods so as to eat fresher foods at home. The developers situated 3D food printers as kitchen devices in order to normalize the novel food technology as a part of kitchens. Nonetheless, despite being depicted as easy and convenient in use, it was visible in the research materials that 3D food printers were not scripted as all-in-one devices. 3D food printers were regarded as kitchen devices used to form shapes and automating repetitive tasks. Despite the limited functions at the moment, in order to accentuate the “utilitarian purposes” of 3D food printing, the developers tended to present the process of 3D food printing as an easy and convenient one. To make the process of making food with 3D food printers seem easy and convenient, they were prone to oversimplify the process of 3D food printing by underlining only the digital process and overlooking the requirements for manual preparation or other kitchen devices such as food processors, ovens or stoves. Notably, 3D food printers served as augmented kitchen devices rather than all-in-one stops to manufacture foods at the moment, although the developers created ambiguity between being an augmentation and all-competence by oversimplifying the process of 3D food printing.

Creative Uses of 3D Food Printing

The second approach that the developers presented 3D food printing was in the uses of 3D food printers for creative purposes. 3D food printers followed digital instructions from computers; therefore, as long as the consistencies of food materials and computer designs were printable, the design shapes for printing were incalculable. The uses of 3D food printing thus were approached in utilizing the technology for the creative purposes. 3D food food printing was viewed as way to innovate food products and create artistic showpieces, offering a way to transform creative ideas into real food creations. Notably, with 3D food printers, the focus on food manufacturing shifted to thinking, designing, creating and experimenting with new shapes and ingredients. 3D food printing brought food-making to the level of design and creativity. The study results regarding the creative purposes of using 3D food printers resonated with what was mentioned in Zoran & Coelho (2011) that digital gastronomy offered a new space for food fabrication and experiments on food designs. Moreover, due to the creative potentials, 3D food printing was often labelled as a technology of "innovation," "novelty" and "revolution" in the online news reports on 3D food printers (Lupton, 2017). In relation to the ability to innovate and create food objects in intricate shapes that were difficult or even impossible to make by hand or with molds, the creative uses of 3D food printers were also scripted by the developers to attract and provide fun experiences in commercial settings. The creative uses of 3D food printing were intended to attract publicity, fascinate customers, raise attention and stand out from competition for businesses.

Healthful Uses of 3D Food Printing

Aside from the utilitarian purposes and creative purposes, the third approach to the uses of 3D food printing was for the healthful purposes. The developers scripted the uses of 3D food printers to make 3D-printed foods more healthy for users to consume. For instance, the uses design of 3D food printers' printing capsules were created to be open capsules, so that the users could put fresh ingredients in before printing. Additionally, for those who did not felt like to prepare fresh ingredients to put in capsules, the available pre-packaged capsules were made with very little to no preservatives. It was discovered in the study of Lupton and Turner (2018) that consumers usually preferred natural foods and deemed 3D-printed foods as artificial and unnatural to consume due to the printing process the foods went through as well as the sheer fact that the foods were "printed." Printing was often associated with marking on surfaces with ink or manufacturing plastic toys, and both seemed artificial and unnatural to eat; therefore, the idea of 3D printing food to eat was simply eerie to some people (Lupton & Turner, 2016). Noticeably in the research materials, the developers put much focus on the "fresh," "real" and "naturalness" of food printing ingredients in order to naturalize 3D food printing and highlight the healthful benefits of the technological devices. Moreover, the developers also presented 3D-printed foods with fresh food ingredients; for example, fresh spinach leaves were accompanied in the presentation of 3D-printed spinach quiche in the shape of dinosaur. Understandably, the developers did so reinforce the natural aspect and to avoid the linkage between 3D food printing and unnaturalness that kept people from accepting the novel food technology.

Other than applying and associating 3D food printing with fresh food ingredients to create healthful purposes of using 3D food printers, the novel food technology was also related to customization and personalization to make 3D food printing an healthy option. There were two main applications of customization for health. The first application was to customize shapes and textures. It was aimed to help people with dysphagia be healthier and avoid malnutrition caused by the lack of appetite. The second application was to customize and print food based on the requirements of individual needs for nutritions. 3D food printing was seen as a solution to personalize diet. Controlled digitally, 3D food printing was expected to customize, control and 3D-print foods based on the digital information regarding personal requirements of nutritional values such as calories, nutrients, and so forth (Zoran & Coelho, 2011; Yang et al., 2017). With digital control of personalized requirements of nutritional intakes, customizing food with 3D food printing was seen as a way to make people become healthier. The developers even insinuated the healthful purposes of 3D food printing to prevent people from having to visit doctors and to take pills.

7.2. The Configured Users of 3D Food Printing and the Implications

Users Who Sought Convenience

For utilitarian purposes of using 3D food printers, users who were looking for convenience were configured by the developers. Particularly, when accentuating the the digital features and the other digital devices required for 3D food printing, rendering food-making process as simple as instructing digital devices, 3D food printers appealed to those who had little time and looked for a convenient way to make foods. Additionally, with online databases and connectivity, 3D food printing allowed users to print food in intricate shapes and stay up to date with the latest design of 3D object templates. The updatability of 3D food printing was catered for the users who looked for a convenient way to make foods in unique shapes, which was especially useful for business owners to keep coming up with new food creations with 3D food printing without having to customize molds or make laboriously by hand. Overall, the users who did not have time to make foods or who were not good at making food were configured as the users of 3D food printers. 3D food printing for the users who sought convenience could be discovered in the research materials.

Users Who Sought Creativity and Novelty

For the creative purposes of utilizing 3D food printers, users were configured by the developers as those who utilized 3D food printing to experiment, design, create and innovate. Users who sought creativity and novelty were configured. Notably, the ability to design and innovate also implied the potential to attract and provide users with fun experiences, making 3D food printing ideal for commercial applications. In the research materials, the developers were pronounced with the uses of 3D food printers in professional kitchens. In other words, professionals from professional kitchens, catering businesses, bakeries and confectionery shops were configured as the users that could benefit from the creative potentials of 3D food printing. It was emphasized by the developers that 3D food printers would not hinder the creativity of their professional roles or even replace their specialty. Instead, 3D food printing offered a creative space for the professionals to experiment and innovate. In the research materials, other than professionals of food industries, universities were also listed as users of 3D food printers by the developers. The universities played the role of being researchers that explored the potentials of 3D food printing for the food industries. 3D food printers were expected to liberate users from traditional ways of manufacturing food (Campbell et al., 2011). At the moment, 3D food printing was intended to revolutionize food businesses with its creative potentials.

Other than professional users from food industries and universities as users, 3D food printing was catered for people who were looking for something special in general. While 3D food printers were related to winning awards of technology and innovation, positioning 3D food printing as a positive technology and innovation, it appealed to users who were intrigued by novel technology and innovations. Similarly, by introducing 3D food printers in occasions like hospitality trade fairs or design events as a InnovationaLAB with the concept "the future has arrived," the users who looked for novelty and something special were targeted. Moreover, often associated with fine-dining experiences such as molecular cuisine, high-tech ambience of dining environments, the users such as demanding foodies who looked for the extraordinary in foods were configured by the developers of 3D food printing. Relating to the fine-dining experiences and users who looked for something special in general, 3D food printers and the accessories were often sold in the format of designer goods. Moreover, the prices of 3D food printers usually cost a few hundred euros, which was much more than the average prices of common kitchen appliances. Therefore, the users who looked for special things and valued the creative potential of 3D food printing were inevitably from a narrow niche that could afford to pay for the novel food technology.

Users Who Valued Health & Users as the Consumer-Citizen Synthesis

The healthful uses of 3D food printing were intended in two ways: the functional uses and the customized uses. Since 3D food printers could automate and replicate repetitive food preparations tasks, it was anticipated that 3D food printing would get people back into kitchens to make foods with fresh ingredients without additives and preservatives. The developers configured the users as those who wanted to eat healthier with a convenient way making food. In the depiction of developers, processed, packaged and pre-made foods that might contain additives and preservatives were replaced by 3D-printed fresh foods for users to eat healthier. The health benefits of 3D food printing often derived from the application of fresh food ingredients. The users who valued health by eating fresh food without additives and preservatives were configured by the developers.

Other than staying healthy with 3D-printed fresh and real foods, the uses of customizing food for health was often related to 3D food printers as well. For instance, dysphagia patients who had problem with swallowing were considered to be users that could gain health benefits from 3D food printers and customization of food shapes and textures. 3D food printing was scripted to prevent dysphagia patients from malnutrition caused by loss of appetite due to unappetizing puree or the option to drink nutritional drinks only. Reconstructed food made by 3D food printing were intended to provide healthful benefits to people with swallowing problems. Likewise, customized 3D printed meals based on personal demands on nutritions also aimed to provide health benefits to users in general. The individuals who searched for personalized nutrition for healthful purposes were configured as users of 3 food printing by the developers.

Noticeably, the abilities to automate food preparation tasks and to digitally customize food shapes and nutritions were deemed to provide convenience to users. The convenience then in turn encouraged the users to get back into kitchens to eat healthier rather than rely on packaged and pre-made foods with additives and preservatives. The depictions in the research materials showed that users could gain both convenience and health benefits from 3D food printing. In the study of Mol (2009), she discovered that eating healthy was often related to the devotion towards public health and civic duty in the national health campaigns about obesity. By studying the packages of food products, she proposed the idea of a "consumer-citizen" whose pleasure were not in conflict with doing things for the public good; instead, a consumer-citizen embodied individual pleasure that integrated with the public good (Mol, 2009). In the study materials, the developers configured users as those who valued not only health but also convenience. Both the pleasure coming from convenience and the health consciousness could be obtained with 3D food printing. The citizen-consumer synthesis that stayed healthy for the public health without forsaking pleasure attained by convenience was configured as a category of 3D food printing users.

7.3. The Performative Force: Interweaving the Present & the Future

As novel food technology, 3D food printing were endowed with expectations, especially the expectations that could bring contributions to the society. Some expectations located at the present, some expectations were positioned in the future, and other expectations were caught between the present and the future. In the research materials, one particular expectation of contributing to the society at the present time was utilizing 3D food printing to avoid food waste. 3D food printers could be used to reconstruct imperfect food produce into attractive shapes to make them look more appetizing. Since 3D food printers could utilize ugly food produce that could have been thrown away to print food, 3D food printing was regarded to be helpful in fighting against food waste. The finding about applying 3D food printers to avoid food wastes echoed with the finding of Lupton & Turner (2016) on the potential of 3D for printing to avoid food wastes by printing with imperfect food produce. Notably, the developers emphasized 3D food printing contributed to environmental as well as societal sustainability by reducing food wastes, and they also underlined the aesthetically pleasing and appetizing foods 3D food printers could create. That meant contributing to societal goods did not entail having to give up pleasure. In the study of Mol (2009), by studying the food packages of Fair Trade, she discovered that consumer-citizen who purchased for both sensory pleasure and social contribution like social fairness were constructed as consumers of the food packages. Similarly, in my study, it was found that the developers of 3D food printing configured users as consumer-citizen synthesis who enjoyed the tastiness of food but at the same time avoided food waste for the societal good.

Certain expectations of 3D food printing were achievable at the present time; nevertheless, some expectations were located in the future. Expectations like 3D food printers as common kitchen appliances and to help the poor were the expectations that positioned in the future. Notably, both expectations could be actualized only when user acceptances in functionality, practicality and affordability all came into place. The expectations of making 3D food printers prevalent in kitchens and using 3D food printing to help the poor were simply not feasible at the moment. Understandably, the gap between expectations and the reality existed because expectations were usually set high from the start in order to attract attentions and bring investments to guide the technological developments (Geels & Smit, 2000). The high expectations of making 3D food printers common kitchen appliances and helping the poor with 3D food printing served the purpose of attracting more attention and investments to fund and direct the development of the technology moving towards the goals, although it would not necessarily end up as expected.

It was identified in the research materials that the developers interweaved the present time with the future in three ways. The first way was to blur the line between the present and the future. Second, the developers juxtapose the future with the present. Lastly, the present was equated as the future. All three ways served the same main goal: to enact the future. Particularly, by equating the future with the present, expectations of the future were substantialized, serving as performative and constitutive driving forces towards the desired future. Understandably, at the early stage of technological developments, high expectations were constitutive forces that mobilize resources and applied to gain momentum for further developments; therefore, the actual functionalities and abilities of technologies tended to fall behind the expectations (Geels & Smit, 2000). Nonetheless, despite the inconsistencies between expectations and reality, expectations were significant and made the present promises to be held accountable for the expected future (Borup et al., 2006). It should be noted that the gap and inconsistency of the expectations towards 3D food printing existed performatively in order to guide and shape the developments of the novel food technology.

7.4. Reflections on the Research

As my research aimed to examine how the developers of 3D food printing scripted and configured the uses and users in order to make sense of the novel food technology, the research findings on “the utilitarian, creative and healthful uses,” provided an outlook of the purposes that the developers intended 3D food printers to provide. Moreover, regarding the uses of 3D food printers, even though the developers put much emphasis on the easiness of operation and the convenience 3D food printing could provide, the developers actually did not script 3D food printers as an all-in-one device; rather, 3D food printers were scripted to be an augmented kitchen device for doing repetitive food assembly tasks like shaping. 3D food printing might require human involvements in preparing food ingredients for printing as well as other devices for processing or cooking. In short, it was discovered in the study that the food-making process of 3D food printing were often oversimplified. The finding about 3D food printers as augmented kitchen devices for doing specific repetitive tasks formed a contrast to the portrait of 3D food printers in online news media as a resemblance of the Star Trek Replicator that could synthesize meals magically (Lupton, 2017). Understandably, expectations might vary due to the different closeness to the actual technological development site (Borup et al., 2006). Locating at the actual development site, the developers of 3D food printing were more prudent and realistic about expectations of 3D food printers, whereas in news reports, the reporters might elevate expectations to attract more attention since they were not as accountable as the developers regarding the enactments of expectations.

Even though the developers of 3D food printing emphasized much on the utilitarian purposes and the functionality of 3D food printers, in this study, it was found that the other aspects such as creativity and love were accentuated as well, unlike the presentations of most common kitchen appliances. It was enunciated by the developers that 3D food printing did not undermine the love that went to the food. With the enunciation, it made 3D food printers become more approachable and avoid the association between high-tech and coldness. Similarly, by accentuating the creative potentials, it made 3D food printers stand out from the rest kitchen appliances. Even though being positioned as a consumer kitchen appliance, 3D food printers were different because they sparked creativity, making it an unique novel food technology. The finding about creative potentials presented by the developers resonated the idea proposed by Campbell et al. (2011) about how 3D food printing could liberate users from conventional ways of making food. Nonetheless, it should be noted that the creative potentials like making food in creative shapes might not necessarily be valued as much by the intended users. In the works of Lupton & Turner (2016 & 2018), they found that intricate shapes brought unsettling feelings to consumers and that some consumers regarded printing food intrinsically unnatural and hard to accept. Notably, whether the creative potentials of 3D food printing appealed to consumers might not align with the configured users and creative uses that the developers anticipated.

Notably from the research findings about the uses of 3D food printing, the meaning and the role of 3D food printers played was not stable but fluid. As for the findings about "users who sought convenience, creativity, novelty, health and the consumer-citizen synthesis" helped to grasp who were the configured users. Applying the analytical concept about user configuration proposed by Woolgar (1990), it could be noted that the composition of users configured by the developers of 3D food printing was more inclined to the "users multiple" than "users' singular," so more users could be included at the early stages of the food technology. However, since 3D food printing was still being developed, it could be anticipated that the technological process and applications of 3D food printers would keep changing so as to meet the users' requirements (Sun et al., 2015). Even though in the research findings of this study showed that it was currently situated as an augmented kitchen appliance that conducted repetitive food assembly tasks, it might keep evolving to offer more and play different roles in the lives of future users. In relation to future users, the findings about "the prefermative forces of interweaving the present and the future" helped to recognize how the developers utilize expectations in order to attract attentions and make sense of the novel food technology. Expectations worked as representations of the future and guided the present development (Brown & Michael, 2003), which resulted in the gap between the actual functionalities of technologies and the expectations (Geels & Smit, 2000). The gap between expectations and reality of 3D food printing could often be identified in the research materials. Not only did the online news reports form a sociotechnical imaginaries about 3D food printing (Lupton, 2017), the developers of 3D food printers also constructed promissory expectations in the presentations of the 3D food printing uses and users.

In the literature review, Zoran & Coelho (2011) discussed about the potential the potential of 3D food printers to experiment not only new shapes but also new flavors, textures and scents. Nonetheless, in this study, the aspects of coming up with new flavors and scents of food with 3D food printing were missing. Understandably, the aspects were not visible due to the limited functionality at the moment. Other than the invisibility of experimenting with flavors and scents, the uses of insects in 3D food printing were not identified in the websites and videos made by the developers of 3D food printing. The reason why 3D food printing with insects was missing might be related to the findings of Lupton & Turner (2016 & 2018) about consumers' disgust with the idea of eating insects despite they found it natural. Although 3D food printing was recognized in its potential to contribute to food sustainability and solve food shortage by using alternative food sources like insects and algae (Khot et al., 2017), as a novel technology, the developers might have to attract rather than deter users from accepting 3D food printing, so not mentioning about 3D food printing with ground insects might be a strategic decision.

Despite the intriguing findings about 3D food printing from the perspective of developers, in this qualitative study, the research findings might not be generalizable due to sampling size. Taking feasibility and limited time span into consideration, this study was based on the websites of five 3D food printing developers including BeeHex, Procusini, byFlow, Food Ink and Natural Machines and two videos respectively made by byFlow and Food Ink. The insufficient sample size might result in non-holistic results. Moreover, the chosen developers of 3D food printing ranged from the US (BeeHex), Germany (Procusini), the Netherlands (byFlow), the UK (Food Ink) and Spain (Natural Machines). Notably, they were all countries of the Western world. The research findings might differ when the developers from other regions of the world were included. Aside from the sampling limitations and bias, the methodology design might affect the study results too. Since there were many research materials that were in the format of images and video contents, the multimodal critical discourse analysis was applied as an auxiliary way to analyze research data. The major approach was qualitative content analysis. The research findings might differ too when multimodal critical discourse analysis was adopted as the only approach. Furthermore, to investigate how the developers script and configure the uses and users of 3D food printers, instead of studying the websites and videos created by the developers, the research data could also draw from interviews with the developers. The results might vary from the findings derived from the websites and videos made by developers. Building on the research findings of this study on the current configuration of users and uses, future studies could focus on how the meanings and roles of 3D food printing might have changed and played different roles in users' lives. Also future researches could focus on whether the configured users differ from the configured users found in this study. With the same take on the perspectives of the developers on 3D food printing, further researches could also be conducted with interview data. There might be differences and inconsistencies in comparison to the research results stemmed from websites and videos. Future studies could also include research data coming from more regions around the world to generate more all-inclusive research findings.

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9. Tables & Figures

Tables

Figures

10. Abstract (English)

Situated in the field of social studies on science and technology, this study investigated how the developers of 3D food printing scripted and configured the uses and users. The objective of the research was to identify how the uses, the users and the promises of societal contributions were presented by the developers of 3D food printing in order to make sense of the novel food technology. The official websites and videos of five developers were chosen to study how they made sense of 3D food printing technology. To study the official websites and the videos created by the five companies that developed 3D food printing, qualitative content analysis was applied as the major approach, and a multimodal critical discourse analysis was adopted as the auxiliary approach. There were three major findings in the study results. First, regarding the uses of 3D food printing, the developers had the tendency to focus on the utilitarian, creative and healthful uses of 3D food printing. Second, about the findings on users, they were configured by the developers of 3D food printing as users who sought convenience, creativity, novelty and health. Moreover, users sometimes were configured as a consumer-citizen synthesis who enjoyed the tastiness of food but avoided food waste for the societal good at the same time. Lastly, it was discovered in the study that 3D food printing technology was endowed with expectations, especially the ones that could bring contributions to the society. The expectations served as a performative force that interweaved the present and the future. From the research results, it could be concluded that in order to make sense of 3D food printing and sell the products, the developers of the novel food technology scripted and configured the uses and the users in pragmatic as well as expectative light.

Keywords: **3D food printing, users, uses, sociology of expectation, consumer-citizen**

11. Abstract (German)

In dieser Studie, die im Bereich der Sozialstudien zu Wissenschaft und Technologie angesiedelt ist, wurde untersucht, wie die Entwickler des 3D-Lebensmitteldrucks die Verwendungszwecke und Nutzer skripteten und konfigurierten. Ziel der Untersuchung war es, herauszufinden, wie die Entwickler des 3D-Lebensmitteldrucks die Verwendungszwecke, die Nutzer und die versprochenen gesellschaftlichen Beiträge darstellen, um der neuartigen Lebensmitteltechnologie einen Sinn zu geben. Die offiziellen Websites und Videos von fünf Entwicklern wurden ausgewählt, um zu untersuchen, wie sie die 3D-Lebensmitteldrucktechnologie darstellen. Zur Untersuchung der offiziellen Websites und der Videos von fünf Unternehmen, die den 3D-Lebensmitteldruck entwickelt haben, wurde eine qualitative Inhaltsanalyse als Hauptansatz und eine multimodale kritische Diskursanalyse als Hilfsansatz angewandt. Die Ergebnisse der Studie enthielten drei wichtige Erkenntnisse. Erstens konzentrierten sich die Entwickler in Bezug auf die Verwendungszwecke des 3D-Lebensmitteldrucks tendenziell auf die utilitaristischen, kreativen und gesundheitlichen Verwendungszwecke des 3D-Lebensmitteldrucks. Zweitens wurden die Nutzer von den Entwicklern des 3D-Lebensmitteldrucks als Nutzer konfiguriert, die Bequemlichkeit, Kreativität, Neuartigkeit und Gesundheit suchen. Darüber hinaus wurden die Nutzer manchmal als eine Synthese aus Verbraucher und Bürger konfiguriert, die den Geschmack von Lebensmitteln genießen und gleichzeitig Lebensmittelverschwendung zum Wohle der Gesellschaft vermeiden. Schließlich wurde in der Studie festgestellt, dass an die 3D-Lebensmitteldrucktechnologie Erwartungen geknüpft werden, insbesondere solche, die einen Beitrag zur Gesellschaft leisten können. Die Erwartungen dienten als performative Kraft, die die Gegenwart und die Zukunft miteinander verflochten. Aus den Forschungsergebnissen lässt sich schließen, dass die Entwickler der neuartigen Lebensmitteltechnologie, die Verwendungszwecke und die Nutzer, sowohl in pragmatischer, als auch in erwartungsvoller Hinsicht beschrieben und konfiguriert haben, um dem 3D-Lebensmitteldruck einen Sinn zu geben und die Produkte zu verkaufen.

Schlagwörter: **3D-Lebensmitteldruck, Nutzer, Verwendung, Erwartungssoziologie, Verbraucher-Bürger**