PREVENTING DOMESTIC FOOD WASTE THROUGH DIGITAL INTERVENTION:

How to nudge consumers into environmentally friendly behaviour?

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EXECUTIVE SUMMARY

This research focuses on consumers' behaviour as one of the major drivers for domestic food waste in Denmark. Danish households generate roughly 50% of the total amount of food waste nationwide. Although government and civil organisations are targeting the problem, consumers are the ultimate decision-makers. Much of the previous research on the causes of food waste in households involves little discussion of the reasons behind individual behaviour. In spite of the several initiatives on food production and sales, few solutions have targeted food wastage in households. Solutions towards integrated systems that connect retailers with householders while nudging the latter towards responsible consumption do not exist. This study seeks to address this gap through a digital intervention that connects consumers and retailers in a mutually beneficial way while preventing food waste. The empirical research draws on qualitative interviews with consumers' and field experts' insights, based on theory, analysis and strategy.

The consumers' accounts reveal that individuals who purchase their groceries without proper planning tend to waste more food more often. Moreover, storing food without keeping track of products' expiration dates is a fundamental cause for waste. These findings point to the interconnectedness between all the stages of the consumption chain; how one influences the other to create a domino effect. Therefore, the solution considers all the phases of the food supply chain, instead of separate tools with isolated functionalities. The interviews also expose consumers' biases and emotional triggers that can be steered towards making better decisions. Additionally, the analysis highlights the challenges of consumers that lead to waste food. Compared to lack of time, or healthy eating habits, food waste does not figure as a key problem *per se* for participants. This insight forms the baseline for any attempts to address food waste.

The concepts around human behaviour, digital nudging and emotional design, together with the insights from the experts' interviews, *ideate* a human-centred solution drawn on the frame of *Design Thinking*. Upon understanding consumers' needs and *defining* the problem, the solution targets a *desirable*, *usable*, and *convenient* tool that reduces consumers' efforts, while helping them adopt a responsible attitude towards food. This study proposes the inclusion of a 2D barcode scanner, which would expand the supply chain access to consumers, creating a new channel through which producers and retailers can directly communicate with shoppers.

For human-centred research, the design thinking method is an ideal match that provides a structure to understand consumers' context and empathise with their needs, with the goal

of finding common ground to address food waste. By providing the missing connection between the suppliers and consumers, the user-friendly app opens a new communication channel to increase transparency and accuracy throughout the value chain. The expansion of the food supply chain to include the consumption stage can transform the current landscape of the food system, leading to more collaboration and synchronization among all the actors. Food waste is not a regional problem, it is a global problem, it is a human problem and hence applicable to different contexts.

KEYWORDS: human behaviour, consumer behaviour, food waste, GS1 2D barcodes, digital nudging, ICT, design thinking.

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INTRODUCTION

Problem background

Over 1.3 billion tons of food is thrown away each year, with direct economic consequences of $750 billion. This waste is also responsible for approximately 10% of global carbon emissions (World Food Program USA, 2020).

A recent report from Aarhus University stated that the majority of food waste in Denmark comes from retailers and private households, while food waste in primary production and the food industry is minimal (State of Green, 2019). The food waste generated by households contributes to high levels of food waste across the food supply chain in the country. Therefore, this research seeks to gain a better understanding of food consumers' perceptions and behaviours in order to find suitable affordable solutions, by using digital technology.

In economic terms, Danish households' food waste accounts for €2.15 million annually (Sorensen, 2010), from which €390 of edible food is wasted per household every year (Tænk Forbrugerrådet, 2012). Approximately 20 % of the food that Danes buy, ends up in the waste bins. This food would suffice the needs of one million Danes a year.

According to research (Kjær and Werge, 2010), Danish households create roughly 50% of the total amount of food waste in the country. The categories that contribute the most waste are vegetables and salads, fruits, bakery products, beverages, confectionery and desserts (Edjabou et al., 2016). Studies have highlighted that the yearly total amount of avoidable food waste in the Danish households sector equals 260,000 tons (Environmental Protection Agency, 2017), of which 24% represents food that could have been eaten. Previous research also showed that people's food-related practices (meal planning, shopping, storing, cooking and discarding food) at home are some of the main drivers of food waste (Farr-Wharton, Foth, & Choi, 2014; Miljøstyrelsen, 2016; Stancu, Haugaard, & Lähteenmäki, 2016).

Most current efforts by government and civil organisations are targeting consumption behaviours of households. However, consumers make purchasing decisions ultimately determine what they eat or discard (Halloran et al.,2014). In the stores, consumers tend to choose larger food portions. However, it often ends up as food waste at home. Thus, inappropriate packaging size causes food to be thrown away because the total amount cannot be consumed before the product gets spoiled (Halloran et al.,2014). A Swedish

study (Williams, 2011) estimates food loss due to issues with packaging at 20-25% of household food waste.

Additionally, some of the initiatives carried out by retailers to avoid food waste may compel consumers to buy more food that ends up not being consumed at all. For instance, price reduction on food items close to expiration dates may incentivize large purchases of food that will probably not be eaten before they have expired (Kulikovskaja & Ashemann, 2016). This creates an important contradiction since food retailers are the direct link to the consumers and therefore, have a direct effect on consumers' food-related behaviour. Thus, finding a solution that helps reduce food waste at the consumer level without compromising retailers' profitability is challenging.

Furthermore, self-reported food waste at the household level is not a totally reliable source of data, as consumers might be biased towards their own food management and food waste perceptions (Edjabou et al., 2016). Research has shown that efforts to change food-waste-related behaviours in households require a thorough understanding of quantities and composition of discarded food products (Edjabou et al., 2016). The majority of existing studies of Danish households' food waste have provided only estimated data, which leads to inconsistent estimations about food waste generation and targeting solutions to prevent it, as Edjabou et al. (2016) pointed out.

Relevance

To date, few solutions have been proven to prevent food wastage in households. Notwithstanding the initiatives that are currently being implemented at production and retail levels, there is no solution that proposes an integrated system that connects householders with retailers. A bridge to close the gap between the supply and the consumption chains is much needed. This thesis intends to help build this bridge, by laying the foundation - an application through which consumers can interact with retailers' products database. This personalised link also nudges them to prevent food waste in their households.

Accuracy, transparency and traceability are some of the key mechanisms that can alter the course of the food waste landscape towards. Overall, transparency across the food supply chain (FSC) will be enhanced by tracing the food management from farm to the fork. Through accurate monitoring and tracking of the food's journey, new insights on the previous stages of the FSC can be formed. On the other hand, producers and retailers can identify actual consumer needs and expectations in order to find more effective solutions to prevent food wastage.

Expected outcomes

This research seeks to address the existing gap by proposing a digital intervention that connects consumers and retailers in a mutually beneficial way. By doing so, consumers can better monitor and manage their products' shelf-lives at home, while preventing food waste, and retailers can optimise their inventory management and get clearer forecasts. The aim is to lay down the academic groundwork necessary for the solution to become effective, by exploring the current state of affairs and available knowledge, and by collecting empirical data to inform the findings.

To achieve this goal, the investigation will address the following *research questions (RQ)*:

- Main RQ: How can a digital intervention convince householders to prevent food waste while benefiting the food supply chain in Denmark?
- RQ1: How can the design engage consumers to use the technology in a way that influences their behaviours?
- RQ2: What are the challenges and barriers that affect the feasibility of the proposed solution?

Therefore, the *objective* pursued throughout the investigation will seek:

To design a digital tool capable of nudging users to adopt more responsible consumption practices, while benefiting both consumers and retailers.

Scope

The scope of this research lies within the boundaries of the first iteration of the Design Thinking approach (define, empathise, ideate, prototype and test), which is based on the User-Centred Design Methodology.

It is important to note that, although the study explores the digital technologies that can play a role in preventing food waste, the aim is not to dig deep into the technical aspect, but rather to offer a fair understanding of their application. Likewise, no financial or commercial dimension will be studied. In other words, the solution proposed will be presented in terms of a prototype, which will be tested to obtain feedback for further improvements.

Who might be interested in this project

This thesis addresses primarily retail headquarters, producers, manufacturers committed to reducing food waste in the supply chain as well as increasing traceability, transparency and consumer loyalty. Additionally, government institutions like the Ministry of Environment and

Food of Denmark, as well as NGO invested in the fight against food waste such as *Stop Spild af Mad* and *Stop Spild Lokalt.* These Danish organisations can act as strategic forces that collaborate with the further implementation of the solution here proposed.

Due to its design approach, this work could be also relevant to UX (user experience) designers and developers who are eager to create innovative solutions for socially-minded issues. Generally speaking, the target audience for this research includes all researchers and food enthusiasts keen to learn more about how digital technology can help to prevent food waste throughout the food supply chain, with a focus on the consumer level.

"It is disrespectful. Food waste is basically also the lack of respect for our nature, for our society, for the people who produce the food, for the animals, and the lack of respect for your time and your money". - Said Selina Juls (Chairman of the Board and Founder of Stop Wasting Food movement (Stop Spild Af Mad)) in a BBC video about the fight against food waste in Denmark.

This research cares about food, people, and the environment. All the efforts dedicated to finding ways for preventing food waste are driven by the sole purpose of compelling people to make the best decisions in terms of food, for them, and for the Planet.

Chapter I: STATE OF THE ART

This section is intended to provide an overview of the food waste landscape in Denmark's households, as the consumer stage has been found to be the main contributor of food waste in the country. Major triggers and strategies to prevent food waste will be explored as well. In addition, the research will examine digital technologies that have been previously implemented or studied to reduce food waste at the consumers level (see Fig. 1). Special attention will be granted to those able to engage consumers the most.

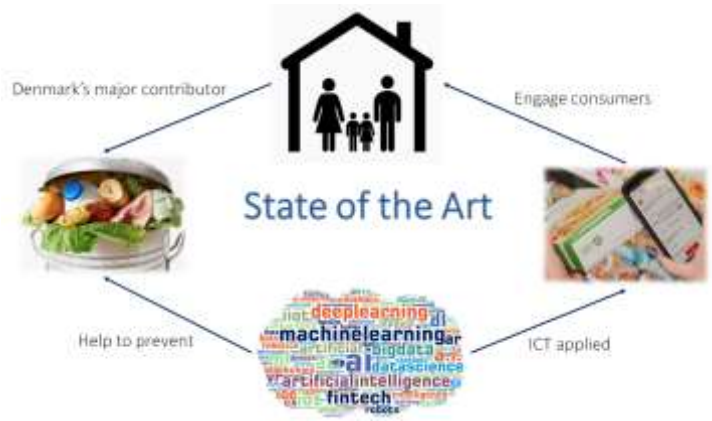


Figure 1. State of the Art elements

1.1 Food and Society, a complex construct.

To understand the role of digital technology in reducing food waste, it is relevant, first, to get a grasp of the social and cultural meanings of food for individuals, in other words, the sociology of food consumption. After all, food is perceived and consumed in thousands of different ways across cultures. Here, the focus is on the social aspect rather than on the individual per se. According to the professor of food sociology in the University of Copenhagen -Lotte Holm (2013), sociological studies of food consumptions cover from culinary trends and eating habits in accordance to demographic and ethnic attributes, to household characteristics and practices. In essence, the sociological framework seeks to explain what influences and what constitutes food consumption, which is understood as a set of practices that individuals perform. The relevant routines that consumers carry out are linked to the acquisition, preparation and eating of food. These, as Holm (2013) stressed, are influenced and differentiated by cultural background, upbringing, interests, values, economic resources and personal skills of individuals.

In his article “Food, self and identity” (1988), the sociologist Claude Fischler discussed the relationship of food to identity formation, whose main principle states that we become what we eat. In other words, by incorporating food, one absorbs all its properties. Thus adopting an identity that reflects the eating habits (i.e. meat-eaters, vegetarians, vegans, etc) also incorporates the eaters in a culinary group whose practices define it. From Fishler’s (1988) point of view, the human relationship to food combines two dimensions: the first one spreading from the nutritional value to the symbolic function, while the second one associates the psychological with the social aspect, understanding practices as behaviours and meanings as wants or beliefs.

The principle of incorporation derives an identity dilemma from the fact that food defines the eater (Fishler, 1988). As such, a vital necessity of identifying and classifying what is eaten arises: *“if we do not know what we eat, how can we know what we are?”* (Fishler, 1988, p. 282). The identification, however, is biased by the cultural background of individuals, as Fishler (1988) suggested. For instance, pork meat does not have the same meaning for a Muslim person as it has for a non-religious regular meat-eater. Social concerns spin around health issues associated with food safety (additives and contamination) and obesity. Additionally, ethical considerations regarding the environmental sustainability of food production, origin and transport are of remarkable interest for consumers (Ward et. al, 2010).

Clearly, food is indeed a complex issue since numerous factors intervene in its relationship with individuals and its meaning in society. However, it is valid to keep an eye on the socio-cultural dimension of food to understand the underlying cause of human behaviour toward its waste.

It is thought-provoking, however, that despite the role of food in society, and even individual self-identity, the problem of food waste has reached such alarming figures worldwide.

1.2 Food waste and its impact

Global organisations diverge when it comes to reaching a common definition of food waste or food loss. Researchers utilize different terms when referring to the various stages of the supply chain. The UN Food and Agriculture Organisation (FAO) defines ‘food loss’ as the unintentional loss of food during harvesting, post-harvest handling, processing and distribution while referring to ‘food waste’ as the food that gets wasted at retail and consumption stages (FAO, 2011). According to the FAO Food initiative, food waste *“is measured only for products that are directed to human consumption, excluding feed and*

parts of products which are not edible" (FAO, 2011). Conversely, the U.S. The Department of Agriculture (USDA) acknowledges 'food waste' as all food lost anywhere across the supply chain including consumers (ReFED, 2016). Garrone et al. (2014) defined 'food waste' as *"the surplus food that is not recovered to feed people, to feed animals, to produce new products, new materials or energy".* This research will adopt Halloran et al. (2014) definition that acknowledges 'food waste' as the food intended for human consumption that ends up being discarded.

Nearly one-third of the globally produced food is wasted, while on the other hand food must be guaranteed for an increasing population of 9 billion people by 2050 (United Nations, 2013, in Göbel et al., 2015). Food loss and waste matters to the environment, the economy and the hunger (Flanagan et. al, 2019). Food Supply Chains (FSC) in Europe are responsible for roughly 17% of direct greenhouse gas emissions and about 28% of the consumption of material resources, according to researchers (Göbel et al., 2015). Meanwhile, the annual market value of food wasted and lost is roughly $940 billion globally (FAO, 2015a). An astonishing 1 billion metric tons of food yearly is thrown out, in a world where one of every 10 people still live on the brink of starvation (FAO et. al, 2018). In high-income countries, food waste hotspots are found mostly in households and restaurants, whereas waste in low-income regions occurs largely when handling and storing foods (FAO, 2011).

The Target 12.3 of the Sustainable Development Goals (SDGs) calls for halving the rate of food loss and waste by 2030 (Flanagan et. al, 2019). The report "Reducing Food Loss and Waste: Setting a Global Action Agenda" instigates all actors in the FSC to:

1. Target-Measure-Act: "What gets measured gets managed". Setting targets to reduce loss and waste, measure to identify hotspots and take action on them.
2. Pursue a short "to-do" list as "no regret" first steps.
3. Collaborate on 10 "scaling interventions" to bolster the implementation of the two previous strategies (Flanagan et. al, 2019).

As stated by ReFED (2016), solutions focused on preventing food waste represent the biggest economic value and environmental welfare. Attempts to prevent food waste involve behaviour change and software (ReFED, 2016). This is the starting point for the present enquiry, which focuses particularly on digital technologies to change the behaviour of consumers.

It is time to rethink the current food sector, to move from a system of purely individualistic values (those of competition, consumerism, individual welfare), to collective values (interdependence, interconnectedness, sharing, caring, stewardship).

1.3 The Food Supply Chain in Denmark

Food waste occurs alongside the whole FSC (Ciaghi & Villafiorita, 2016), in terms of edible crops left in the fields, food lost during transportation, food discarded while packaging or inefficient inventory management (Parfitt et al., 2010). Worldwide, 30% of cereals and fish, 40–50% of root crops, fruits & vegetables, 20% of oilseeds, meat and dairy finish up wasted along with the FSC, according to FAO (2011). Particularly in Denmark, food losses or wastes cause annual financial costs of roughly €1.1 billion from farm to fork (Halloran et al., 2014),

The structure of the Danish FSC as Halloran et al. (2014) described, is composed by primary sector (farmers and horticulture), food processors (slaughterhouses, diaries and manufacturers), retailers (distributors, supermarkets and shops), commercial kitchens (restaurants and institutions' canteens), households (consumers), and food waste handlers.

Halloran et al. (2014) presented alarming statistics regarding food waste in Denmark, where:

- Primary sector: waste roughly 541000 tonnes of potentially eatable food yearly, including dead or discarded animals and lost grain.
- Food processors: annually contribute to an estimated loss of 71,000 tonnes of milk and dairy, as well as 34,000 and 30,000 tonnes of fruit and vegetables respectively (Jensen, 2011, cited in Halloran et al., 2014).
- Retailers: generates around 45,676 tonnes of food waste per year, especially from fruits and vegetables, bread and yoghurt (Nordic Council of Ministers, 2011, cited in Halloran et al., 2014).
- Commercial kitchens: reaches approximately 33,138 tonnes annually (ECONET, 2011, cited in Halloran et al., 2014).
- Households: yearly throw away roughly 237,000 tonnes of food (from which almost half is edible), accounting for 50% of the total food waste generated along with the FSC (Kjær and Werge, 2010, cited in Halloran et al., 2014).

Causes of food waste

FAO (2011) highlighted food waste as a direct cause of insufficient coordination among actors within the food system, as well as cultural, social and economic factors. Research also found that some of the common causes along the FSC are:

- Farms: Insufficient demand for imperfect-looking produce due to strict aesthetic standards, causes a vast unharvested food that is not profitable for farmers to harvest (Halloran et al.,2014; ReFED, 2016).
- Manufacturers: Customer demand for a high variety of products often lead to edible parts being discarded due to repurposing for new end-products (ReFED, 2016).
- Retailers: High food variety, consistency and availability push to the limit stock managers that are triggered to keep the shelves bursting with fresh food products.
- Households: Confusing dates labelling; consumers tend to interpret the ‘‘best before’’ label as ‘‘inedible after, which leads to discarded food in still safe edible conditions (Halloran et al., 2014). Moreover, the demand for variety and abundance without planning cause over-purchasing and consequently food spoilage (ReFED, 2016).

1.3.1 The role of consumers

From all the stages of the FSC, the household is the least regulated despite the alarming figures. In Denmark, food waste is, among other factors, related to consumer behaviour, which often causes largely preventable food thrown away (Halloran et al.,2014).

Consumers are likely wasting far more food than generally believed, according to a study published by Monika van den Bos Verma and colleagues from Wageningen University and Research, The Netherlands (2020). The study shows that people are wasting 527 calories worth of food a day, highlighting consumer affluence as a determinant variable that correlates with the levels of food waste at households (Verma, 2020).

Although efforts from government and civil society organisations target consumption behaviours of households, consumers are entitled to make purchasing decisions and ultimately determine what to eat or discard (Halloran et al.,2014). Thus in order to propose successful attempts to prevent food waste, it is crucial to better understand the perceptions, motivations and barriers faced by consumers when it comes to managing their food provisioning practices.

As the phenomenon of households' food waste escalates (Papetti, 2016), researchers have investigated consumer behaviour in order to understand what drives domestic food waste. Overall, research results have shown that major triggers of food waste at homes are associated with inappropriate purchase planning, cooking abundant portions, and exceeding of products' expirations (Papetti, 2016).

In a research conducted at the University of Illinois, Brenna Ellison, one of the study's authors, noted that *"making sure people know what they are wasting and understanding the consequences of that, is important"* (Ellison et. al, 2018). Therefore, making waste more visible should be a priority to make people understand that their behaviour is problematic.

1.3.1.1 Food waste in Danish homes

The categories that contribute most to food waste in Denmark are vegetables and salads, fruits, bakery products, beverages, confectionery and desserts (Edjabou et al., 2016). Studies have highlighted that the total amount of avoidable food waste in the Danish households sector equals 261,000t yearly (Environmental Protection Agency, 2017), from which 24% represents food that could have been eaten.

Previous research also showed that people's food-related practices at home are some of the main drivers of food waste (Farr-Wharton, Foth, & Choi, 2014; Miljøstyrelsen, 2016; Stancu, Haugaard, & Lähteenmäki, 2016). A study conducted by Stancu and Lahteenmaki (2018) highlighted some behavioural factors:

- Frequency of grocery shopping, usually associated with poor planning.
- Wrong consumers' perceptions of food edibility, associated with misinformation about the edible part of foods.
- Large purchases of food that end up thrown out, due to poor planning and storage practices.
- Often forgotten food on the fridge, freezer or cupboard, due to lack of inventory keeping tools for reminders.
- Impulsive buying tendency is found to be one of the individual traits more challenging, usually encouraged by retail sales promotions.

In sum, according to research (Stancu & Lahteenmaki, 2018; Boks & Hebrok, 2017), the major triggers to food waste in households are:

- Consumer awareness of food waste, and their attitude towards it.
- Households characteristics (size, stability, constellation).

- Perception and assessment of food edibility (lack of information or appropriate reference source)
- Food-related skills and practices (planning, shopping, storage, cooking, eating, disposal).
- Individual characteristics (values, motivation, self-identity, cultural and social norms, lifestyle, age)
- Food purchasing habits (large unneeded amount, non-use of meal plans)
- Barriers to behavioural change against food waste.
- Packaging design, retail waste-avoidance initiatives.

Therefore, researchers suggest that solutions to make these practices easier and fun can support the prevention of food waste in households. For instance, they point out, applications that can turn menus into shopping lists according to estimated meal plans and household sizes could have a significant impact on consumers' behaviour (Stancu and Lahteenmaki, 2018). Moreover, interventions should address consumers' motivations to prevent food waste, of which saving money has been found to be the greatest one (Stancu and Lahteenmaki, 2018). Yet, the study did not identify the amount of money saved that would be considered sufficient as an effective motivation. When it comes to demographic characteristics, the highest proportion of food waste is associated with people aged 18 to 34 having a full-time job, as well as households with three or more members including children (Stancu and Lahteenmaki, 2018).

1.3.2 Reducing domestic food waste

As stated by Papetti (2016), in order to mitigate the environmental, economic and social impact of food waste, differentiated strategies to prevent rather than reducing the waste itself, remain the focus first action aligned with particular consumers' target groups.

The community campaign proposed by U.S. EPA (2016) to reduce food waste in American households - "Food: Too good to waste", identified some strategies supported by digital technologies that can potentially prevent wasted food. The tactics can be grouped into three simple behaviour changes:

1- *Smart shopping:* Create a shopping list before purchasing, based on what there is already in stock and the number of meals intended until the next shopping trip. By doing so, consumers are encouraged to plan their meals and buy accordingly.

2- *Smart storage:* Visual prompt as a reminder for consumers to keep perishable food fresh. Thus, householders are reminded to store, tag and group the food visibly in accordance with the expiration dates and time after being cooked (in the case of leftovers).

3- *Waste measure*: By tracking the food discarded at homes, consumers become conscious of the usually alarming amount of food (and money) they are wasting (U.S. EPA, 2016). According to the EPA's study, waste aversion is a powerful psychological dynamo, therefore, raising consumers' awareness of environmental and economic costs of food waste appears to be a key strategy (Papetti, 2016).

1.3.3 Challenges and barriers to prevent food waste

Studies make a distinction among the different factors that challenge successful implementation and adoption of digital interventions to prevent domestic food waste.

Factor	**Challenges**	**Barriers**
Social	Lack of knowledge of the availability and/or credibility of options (Tetra Pak Index, 2019).	Limited consumers' awareness of food waste costs (environmental, economic and social). (Papetti, 2016)
Economic	- Retailers' sale strategies that encourage consumers to buy large quantities of unnecessary food (Papetti, 2016).	- Higher investments to secure food traceability and expensive smart technologies (Papetti, 2016).

Technological	Consumers' resistance towards using smart technology due to privacy issues or technical skills (Papetti, 2016)	- Existing barcodes used by retailers do not contain essential data such as the batch number, expiration and best before dates. (Papetti, 2016) - Only packaged products can be tracked and monitored. (Papetti, 2016), as fresh loose items do not contain barcodes for data capture.
Regulatory	- Confusing labelling system (best before, use by) for consumers. (Papetti, 2016)	- Lack of rules or mechanisms that encourage traceability systems including consumers (Papetti, 2016). - Lack of rules that force retailers to use dynamic barcode which includes the expiration date (Papetti, 2016).

Table 1. Challenges and barriers to prevent food waste

1.4 ICT **in the fight against food waste**

This section aims to provide an overview of the diverse applications of information communication technologies (ICT) to tackle the problems of the food system. Although different fields of knowledge and sectors adopt a particular definition of ICT, one can claim that the primary definition outlines the acronym as *"the devices and infrastructures that facilitate the transfer of information through digital means"* (Zuppo, 2012). Zapico and

Svenfelt (2016) identified four major areas in which ICTs enable opportunities to improve the food system:

- Efficiency: by monitoring, evaluating and reducing environmental impacts throughout the supply chain.
- Transparency: by increasing traceability across the value chain, which facilitates recalls in the event of outbreaks.
- Connections: Creating networks within the production chain that also include consumers to improve communications in the event of food surplus to avoid food waste.
- Sustainable practices: Changing habits regarding food consumption in households.

Human-Computer Interaction (HCI) scholars emphasise the relevance of social, economic and cultural factors when analysing consumers' behaviour (Brynjarsdottir, 2012; cited in Zapico & Svenfelt, 2016). Furthermore, it is believed that solutions that prevent wasting food in households should not be limited to individuals' conduct but should also be addressed from a holistic view, as many of the consumers' practices are shaped by external socio-economic structures (Ganglbauer et al. 2013).

1.4.1 Artificial Intelligence (AI) to reduce food waste

Among the digital technologies that have been explored to prevent food waste in the supply chain, AI shines a promising light, although few specific studies have been conducted. In the last decades, with the avalanche of Big Data and the necessity to process it at lightning speeds, the terms of "machine learning" (ML), "deep learning" and "neural networks" have become more familiar.

Usually, AI is often interchangeably used with ML to refer to the ability of machines to learn and operate in ways similar to the human brain. The author and technology advisor Bernard Marr makes a distinction between the two terms. In Marr's (2016) words: *"AI is the broader concept of machines being able to carry out tasks in a way we would consider 'smart'"*, concentrated mimicking human decision making processes. Under this umbrella, ML is a subset, a current application of AI-based on the premise that machines can learn by themselves from the data they access. Concretely, instead of programming computers to perform certain tasks, developers train them to 'think' and operate like the human brain does (Marr, 2016).

Neural networks are recognised as the 'brain' of ML. By applying neuroscience, artificial neurons are connected to decode and classify information in human-like ways, speedy and

bias-free (Marr, 2016). This leads to deep learning, which can be understood as a system of many layers of neural networks on top of each other, transmitting information through complex algorithms that simulate human learning (Marr, 2016). Aligned with neural networks, natural language processing (NPL) emerged to facilitate the communication between humans and computers, making both entities speak the same language (Marinacci, 2017). NPL-enabled applications range from voice recognition for processing humans' commands to texts for performing complicated tasks in real time; such as in the cases of Google Home and Amazon Echo.

A vivid example comes from the UK, and Ocado's end-to-end e-commerce, logistic and fulfilment platform, which uses ML-powered systems to understand consumers' habits and thus better forecast demand (Fearn, 2019). Accurate predictions avoid overproduction and overstocking.

Another case worthy of mention is the AI-driven cooking assistant Plant Jammer, a startup based in Copenhagen, Denmark. Plant Jammer combines human intelligence and AI technologies (machine learning and neural networks) to learn to create ingredients-pairings to build vegetarian recipes with ingredients available in stock. This initiative is a creative attempt to prevent domestic food waste and promote more plant-based dishes for a sustainable behaviour change. Householders can find inspiration to pair good-fit combinations of products and ingredients they have at home, reducing their risk of going to the trash bin. Developers train the smart algorithms to find patterns and learn from consumers' behaviour.

Overall, this combination of AI subsets can bring a noticeable change to the consumers' food universe. Nonetheless, the technology does not work automatically, it requires data input to feed the ML algorithms. The next section will explore an effective and efficient way to automatically collect data that could be later analysed by the ML engine.

1.4.2 Barcodes Standards and food waste

Food waste does not only occur in households. As mentioned in previous sections, retailers are the next biggest contributor, and although some are already taking initiatives to reduce food waste, they do not take full benefit of the technology. Instead, they concentrate on solutions like food donation, organic composting and recycling. However, according to Weber et al. (2012), the most obvious approach to preventing food waste is optimising demand forecasts so the gap between predicted and actual sales is reduced and thus avoid overstocks.

On the consumer side, when it comes to responsible consumption, smart fridges, sensors and radio-frequency identification (RFID) technology are usually highlighted in the technology field. However, very little has been explored about the application of barcodes for traceability and monitoring of food at the consumer level.

GS1 is the global standards organisation providing the barcodes that appear in most of the products that consumers purchase in Danish retailers. Although they have been mostly applied in business to business (B2B) contexts, this research points towards a potential application for households. Therefore, understanding how GS1 barcodes work enlarges the spectrum of solutions opportunities.

GS1 standards in action

GS1 standards create a common foundation for companies by uniquely identifying, accurately capturing and automatically sharing vital information about products, locations, availability, assets and more

Identify

GS1 identification (ID) key standards include standards that define unique identification codes that may be used by an information system to refer unambiguously to a real-world entity. ID keys can be encoded in a barcode or EPC (Electronic Product Code)/RFID (radio-frequency identification), which can be scanned to process information regarding products and companies in the supply chain. Some of the standards include the Global Trade Item Numbers (GTIN), which uniquely identifies every individual trade item that includes all products or services that are priced, ordered or invoiced at any point in the supply chain.

Capture

GS1 data capture standards include definitions of barcode and RFID data carriers that allow GS1 Identification Keys and supplementary data to be attached directly to a physical object. Barcodes are symbols that can be scanned electronically using laser or camera-based systems, which are used to encode information to automatically identify and track products as they move through the supply chain. Currently, products found in retailers use linear (1D) barcodes, which is limited in the number of characters it can carry. In contrast, the two-dimensional barcodes are compact, high-capacity 2D symbols suitable for representing all GS1 keys and attributes, therefore can hold a significant amount of information. They include GS1 Data Matrix and GS1 QR Code, and can be applied to hold information such as the product's expiration date, serial number or batch/lot number.

Share

GS1 standards for sharing business-critical information include data standards for master data, business transaction data, and physical event data, as well as communication standards for sharing this data between applications and trading partners. The standards include Electronic Product Code Information System (EPCIS), which enables trading partners to share information about the physical movement and status of products as they travel throughout the whole supply chain including consumers. The ultimate goal of EPCIS is to enable applications to create and share visibility event data.

1.4.2.1 Integration of GS1 standards within the FSC

On their website, GS1 explains how their standards are helping the retail sector integrate store operations, delivery and inventory management to meet the expectations of consumers before, during and after their purchase. Food companies can engage consumers through mobile apps and websites by just scanning a barcode. This might change the relationship between retailers and consumers, paving the way to a more responsible consumption from production to disposal.

The GS1's mechanisms of identification, data capture and information sharing through dynamic barcode technology can open the door into the consumption chain. Sharing accurate information through consumer-facing mobile applications (that integrates barcode scanning) allows householders to track their purchased products and make well-informed decisions based on that. This allows consumers and retailers to also monitor post-purchase 'life' of food products.

Food waste reduction

Importantly, food waste is a problem that cannot be solved at the household level alone; it requires an integrated approach to the whole FSC puzzle. The role of retailers is another crucial component, as they are the direct link to end-consumers. The EU Platform on Food Losses and Food Waste (2019) exhorts retailers to use digital tools that facilitate consumers to report their food waste experience through barcodes and QR codes, which would allow both consumers and retailers to acquire insights into consumptions habits.

Overall, there is little doubt that GS1 barcode standards offer a wide range of applications to tackle the food waste in the food supply chain, and Tetra Pak is a vivid example.

As one of three companies in the Tetra Laval Group – a private enterprise from Sweden, Tetra Pak provides processing, packaging and end-to-end solutions for manufacturers of food and beverages, integrating automation and technical services. From machine sensors sharing big data to QR barcodes on packages, they promise optimized production based on connectivity.

What they call the "Connected Package" platform is a tangible application of the universe of possibilities of barcodes, explained in the previous section. With this solution, Tetra Pak turns packages into full-scale data carriers, increasing traceability and transparency throughout the entire value chain. This unique scannable code facilitates the tracking and tracing of location and history of every product from production to recycling stages. Additionally, besides the message printed onto the item labels, consumers can access authentic information associated with that product by scanning the code with their mobile phones, which allows them to make better-informed decisions. Ultimately, brand owners can directly interact with their target customers by offering tailored promotions and coupons to increase loyalty and boost sales.

1.5 Applications of ICT-based solutions to prevent food waste in households

The majority of the ICT-based tools dedicated to reducing food waste throughout the FSC, primarily focuses on redistribution of surplus food and discount promotion. Despite the domestic food waste alarming figures and acknowledged causes, most of the attempts to mitigate the phenomenon remains focused on the supply chain and waste management systems, while consumers' role has not received the same attention (Papetti, 2016). Nonetheless, various initiatives have been implemented with the ambition of reducing food waste, utilising different mechanisms.

Several mobile applications and websites serve the cause of "food sharing", such as the case of Olio from England, a mobile application that connects neighbours with each other and with local businesses to share surplus edible food instead of throwing it away, as stated in their website. However, the food-sharing mechanism offers a limited solution to the problem (Ciaghi and Villafiorita, 2016), as it focuses on recovering the surplus from food suppliers (retailers, caterings, restaurants) to redistribute it among people that might, later on, waste it anyways.

Contrastingly, Farr-Wharton et al. (2014) observed that providing the consumers with information about their food products (e.g. expiration date) has a bigger impact on reducing domestic food waste. Yet, few researchers have investigated digital interventions that can

prevent food waste in households. That is why this section seeks to provide an overview of some of the more promising solutions, in order to support digital interventions in the future.

QuantoSpreco, from Italy, is an intervention that seeks to optimize food inventory in homes to avoid food waste. According to their website, this application for Android devices provides users with four major facilities:

- Tracking products in the pantry: by manually entering the expiration date and quantity of each item, as well as marking the consumed products, which are automatically added to a shopping list.
- Automatic shopping list: to prevent waste, the app indicates ideal quantities of each product and buying time according to users' eating routines.
- Recipes tips: prioritizing expiring products, the app suggests recipes based on the previously-added items in the pantry.
- Waste records: monitors not only the misused items marked as such by the user but also the wasted money associated with every discarded amount. This mechanism increases the awareness of householders about the food they are wasting and the economic implications.

A second case is Fridgely, an American mobile app that alerts users about products that are close to expiration date. The app is equipped with a barcode scanner that identifies the item and captures its expiration date. Based on this, the app sends reminders and suggestions that help individuals improve decision-making about food-related routines (Link, 2019).

Leftovers also play a role in avoiding food waste, and Love Food Hate Waste app is determined to show how. Besides providing recipes based on leftovers and food already in the kitchen, the app also helps consumers to plan their meals by providing:

- Tips for storage: best storage practices of items alphabetically displayed, as well as tips for cooking or using them efficiently.
- Portion planner: provides the users with guidance on the quantities of food to be cooked/bought according to the category of food, the number of eaters and meals.

In spite of these existing solutions, there is not one that proposes an *integrated system* which besides helping householders improve their food management, also connects them

with the supermarkets' systems. Moreover, mechanisms dedicated to persuading consumers to adopt a more conscious and caring attitude are scarce, as suggested by Papetti (2016). In order to achieve this, it is imperative to understand consumers' needs, food-related behaviours and motivations, while in parallel raising their awareness of their role in food waste.

Chapter II: CONCEPTUAL FRAMEWORK

As highlighted by previous sections, food waste is largely a behavioural problem. Thus, interventions should focus on triggering behavioural change, rather than just raising awareness and educating citizens, as stated by the Europe Platform on Food Losses and Food Waste (2019). Yet, how to change people's behaviours remains a difficult issue among researchers. In order to find a digital solution that can nudge consumers to change their behaviour, it is crucial to understand the pillars of persuasive design. This chapter mobilizes concepts derived from behavioural economics, psychology, neuroscience and design, to create a foundation for the empirical work and analysis of the findings. Because this is a design research with particular focus on persuasive technology, I will pay particular attention to digital nudging and emotional design.

2.1 Human behaviour

Any attempt to promote behaviour change falls short if it does not rely on an understanding of why people behave as they do. Psychologist Gregg Henriques, author of "A New Unified Theory of Psychology", explains human behaviour in a frame of three processes: investments, social influence and justification (Henriques, 2019). He notes that individuals do what they do as a means of investing in certain actions whose cost-benefit analysis are justified by their beliefs. Those investments can be either shaped by other social factors or influence other individuals' investments (Henriques, 2019). Henriques' standpoint suggests a useful approach to further understand how to change people's behaviour. By knowing what set of beliefs shapes their 'doing' (investment), we can envision what might be valuable to individuals to the extent of influencing their behaviour.

In support of Henriques' standpoint, Holzwarth (2019) proposes two primary driving forces of human behaviour. One represents the *obstacle* of performing a certain behaviour - called 'friction', and the other symbolizes the 'fuel', being a given factor that makes a behaviour more appealing. In short, friction pulls backwards and fuel pushes forward. Therefore, Holzwarth (2019) argues that *"changes in behaviour can occur through changes in fuel and friction".* By the same principle, the neuromarketing expert Roger Dooley, in his last book "Friction: The untapped force that can be your most powerful advantage", sheds light on what is probably the most undermined trigger of human behaviour. According to him, eliminating or reducing 'friction' can be a secure way to ease the accomplishment of the customer's goal, and thus increase their level of satisfaction.

In his book “Changeology: How to enable groups, communities and societies to do things they’ve never done before”, Les Robinson (2012) suggests setting the foundations for a change by asking the target audience about its concerns instead of selling them the passion for the desired change. With a design thinking, change-makers are encouraged to get immersed in people's lives to understand their visceral needs, hopes and frustrations (Robinson, 2012). There is no behaviour change possible without advantage for the adopter -he stated, stressing that threat-based appeals often lead to resistance. Thus, knowing the audience’s motivations can mitigate waves of rejections.

Provided that users’ drivers and needs have been identified, a question arises as to How might we use technology to reduce friction and fuel people’s responsible consumption towards preventing food waste?

2.1.1 Digital Nudging

“By knowing how people think, we can make it easier for them to choose what is best for them, their families and society,” wrote Richard Thaler and Cass Sunstein in their book ”Nudge”. Nudge is the term the authors coined and described as *“[...] any aspect of the choice architecture that alters people’s behaviour in a predictable way without forbidding any options or significantly changing their economic incentives”* (Thaler and Sunstein, 2009, p5). Here the authors introduced the term ‘choice architecture’ to describe the various manners in which choices can be displayed to influence people’s decisions. *“To count as a mere nudge, the intervention must be easy and cheap to avoid”* (Thaler and Sunstein, 2009, p5). In the context of this inquiry, an example of nudge could be a push notification that reminds the consumer about an expiring food product that she should use before it gets spoiled, suggesting appealing recipes accordingly and highlighting the amount of money that will be saved as a result.

The nature of digital environments these days, with the excess of information and abundance of options, hamper users to make the right decisions. *Digital nudging* addresses this problem, based on insights from behavioural economics. The paradigm, originally introduced by Thaler and Sustain (2009) and extended to the digital environment by Weinmann et al. (2015), uses design elements -*nudges,* to affect individuals’ decision-making (Mirsch et al., 2017) without restricting their freedom of choice (Meske & Potthoff, 2017). That liberty-preserving approach, used to influence people's behaviour to make better choices towards a longer, healthier, and better life, is what Thaler and Sunstein (2009) called ‘libertarian paternalism’. In other words, nudges appropriate psychological

insights to lead individuals towards better choices, in an attempt to predictably alter their behaviour without forbidding any alternative (Thaler & Sunstein, 2009).

The research that underpins Thaler and Sunstein's book (Tversky & Kahneman, 1974), identified a number of psychological effects or biases. Table 2 lists a selection of them in accordance with the focus of my research:

Psychological effect	**Explanation**	**Nudge application**
Social norms	Described as rules and standards that guide social behaviour without laws' mediation (Cialdini & Trost, 1998). Individuals tend to seek validation from others in the social system when failing to assess their own behaviour.	Testimonials from other consumers using the product/service, or well-known companies collaborating, set the ground for social proof that the evaluating user might adopt as a standard.
Status Quo Bias	Assumes that people tend to stick to their status quo since the drawbacks of leaving the current state outweigh the advantages of the change (Kahneman et al., 1991).	The majority of websites set default cookies that collect users' data for a better-customized service. Customers who do not agree, need to deactivate these options manually, to which most of the times they give up due to time constraints.
Loss aversion	The hindrance of giving up an object is greater than the benefit associated with acquiring it (Tversky and Kahneman, 1974). Therefore, losses have a stronger impact on preferences than gains do (Kahneman et al., 1991).	Users that do not want to miss out an offer or a popular option, are triggered by messages like "There is only one left", "12 people are looking at this right now" or "This offer expires in 5 minutes", which usually leads them to hasten to act.

Belonging and community bias	Humans need to feel they are part of a group. The lack of belonging may trigger customers to take action to fulfil that need. Being surrounded by people who share their same goals and sentiments, brings confidence about their decisions (Wolf, n.d).	The proliferation of Facebook groups are an example of how people gather to express their opinions and get inspired by others'. There is nearly a community for every possible topic with which people identify themselves by common goals, interests or motivations. Building a community around a movement would likely call more people to join that movement.
Social comparison bias	People tend to compare themselves with others. By seeing how others who are alike yourself are doing, we feel prompted to adopt the same approach, or aim otherwise (Kay, 2019).	For instance, fitness and wellness campaigns usually show "beach body" people exercising, in order to show the audience that it could also have such a look, by taking action and working out.
Optimism/ overconfidence	Individuals have a tendency to underestimate costs or consequences, while overrating benefits and the simplicity of unknown tasks/processes. This usually steers to wastage, delays, procrastination, and frustrations (Thaler and Sunstein, 2009).	When people shop overly abundant amounts of food, they fail to rightly estimate the number of meals they can cook, the expiration dates and the combination of the ingredients. This mismatch when assessing the risk of food spoilage could be avoided by nudging consumers to plan better their meals and do their purchases accordingly.

Self-control	Generally, as people become aware of their weaknesses, they develop strategies to protect themselves. However, those mechanisms usually become new heuristics that make them vulnerable to nudging.	For instance, during epidemics, people will tend to hoard unneeded quantities of food and other products. The fear of running out of food makes them fail to evaluate amounts properly, which also represents a waste of money and does not fulfil the initial goal, which was having enough food. Nudging consumers to control their tendencies/weaknesses may help address this problem.

Table 2. Psychological effects.

Any attempt to change consumers' behaviour should involve an engaged use with the technology. Then the right design of nudges can help to achieve the overall goal -the prevention of food waste. When designing effective nudges, special attention has to be paid to the incentives and make them outstanding (Thaler and Sunstein, 2009).

2.1.2 Emotions and design

Emotions fuel decisions. According to the neuroscientist Antonio Damasio in his book "Descartes' Error" (1994), people without emotions fail to make any decisions, as drastic as it sounds. For Damasio, emotions act as a biological bridge between the subcortical layers and the higher-level of complex cognitive functions like analysis and critical thinking. In short, people *"make emotional decisions first and rationalize them later"* (Morin and Renvoise, 2018, pp. 97). But, what *kind* of emotions influence our choices, and how might we spark them?

In his wheel of emotions, the prominent psychologist Robert Plutchik (1980) illustrates that there exist eight primal negative and positive emotional states from which all the emotions derive. On the negative side: Fear, Sadness, Disgust, and Anger. On the positive side: Anticipation, Joy, Trust and Surprise. Supporting this arguably old yet prevailing model, Morin and Renvoise (2018) contend that the most effective approach to influence choices is to create a cocktail of pleasant and repulsive emotions. Study shows that the primal brain,

which is the receptor of external emotional stimulus, reacts quicker to negative events. Therefore, messages that spark negative emotions like fear of regret (Morin and Renvoise, 2018) are proven to be excellent attention grabbers. On the other hand, provoking delightful emotions like joy and trust, by presenting people with a vision they can relate to, makes the perfect blend for predictable choices.

Users who enjoy interacting with an object are more likely to engage in using it for a longer period of time, therefore turning that behaviour into a habit (Clear, 2018). In support of previously mentioned constructs, James Clear (2018) in his book “Atomic habits” pointed out that people need a trigger to act. Thus creating a positive and memorable user experience (UX) by evoking desirable emotions like pleasure, trust, control, peace of mind, can be a good starting point for people in order to start using the technology. Building upon the Plutchik’s wheel of emotions, the ultimate goal of an emotional design is to reinforce the power of anticipation (Morin and Renvoise, 2018). As such, designers should reflect on the emotional connections of the users with the objects they interact with, to ensure engagement and consequent behaviour change. As Baker (2019) highlights. *“Before people can love an experience, they must desire that experience, [...] derive some expected value, [...] begin to trust the product and feel compelled to use it.”*

2.1.2.1 Norman’s three levels of Emotional Design

In his book Emotional Design: Why We Love (Or Hate) Everyday Things, Donald A. Norman (2004) proposed a three-level model of emotional design: visceral, behavioural, and reflective, which emphasizes the importance of emotions to the user experience (UX) (Komninos, 2020). In other words, how humans emotionally connect to objects transcend the mere usability considerations (Baker, 2019):

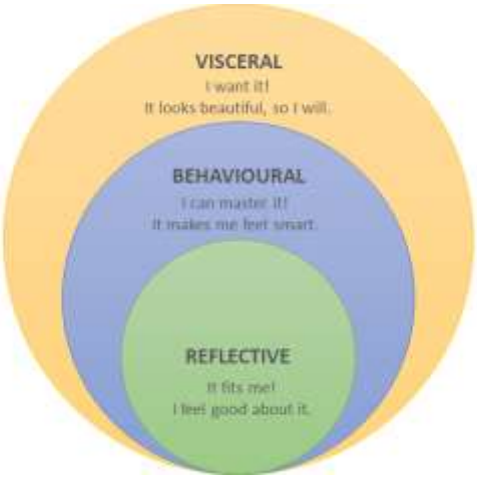


Figure 2 Three Levels of Design Appeal

1. *Visceral Design:* This is the level most concerned with appearances. Refers to the perceptible qualities of the object and how they make the user/observer feel (Komninos, 2020). A visceral reaction is then triggered by an initial sensory experience, in other words, it is that first impression that sets the mood and initial framing for which the user will explore everything else. (Baker, 2019). It is at this level where designers have to appeal to the primal brain by sparking desirable emotions that will lead to action.

2. *Behavioural Design:* Refers to the perceived pleasure and effectiveness of use, to the practical and functional aspects of a product, more often referred to as usability (Komninos, 2020). According to Baker (2019) in a review of the Normans' book, a behavioural reaction is how the user feels as she is immersed in the product experience, the reaction to the product interactions and the value derived from the product's usability. In short, one thing is to grab the attention by triggering positive emotions, and another thing is to retain that attention.

3. *Reflective Design* – This is the highest and most intricate level of emotional design, the most judgemental and at the same time meaningful to users. It considers the rationalization and intellectualization of a product (Komninos, 2020), capturing its meaning, the potential to be shared, and the cultural impact (Baker, 2019). It is at this level where users wonder how the product fits in their self-identity. Thus a reflective reaction talks about how the user will feel after having been immersed in

the experience (Baker, 2019), the “And so what” of the result. This can involve reflecting on past (similar) experiences, and how the object adds to the personal development to enhance their lives (Komninos, 2020).

These three elements interweave to create a delightful, engaging user experience, that sticks to people’s minds (see Fig. 3). According to Baker (2019), people only love a product when it is desirable, usable and compelling:

Figure 3 Facets of emotional design.

In the illustration above:

- Desirable: Individuals might remember objects in accordance with the emotions they spark, this goes beyond any practical functionality (Baker, 2019). As Maya Angelou (1928-2014) would say: *“People will forget what you did, people will forget what you say, but people will never forget how you made them feel”.* That initial attraction counts.

- Usable: Usability has been and it still is, the cornerstone of Human-Computer Interaction (Carroll, 2004). It is believed it can increase the user’s willingness to adopt the product (Baker, 2019), as it encompasses qualities like aesthetic, entertaining, efficiency, collective welfare, improved creativity, and viscerally speaking - “easy to learn, easy to use” (Carroll, 2004).

- Compelling: As discussed in session 2.1.1, the decision-making process is mediated by a number of psychological effects and emotions. Thus a persuasive design that breeds trust, will enable positive decisions (Baker, 2019).

- Emotional: Users value experiences they can relate with, feel and own (Baker, 2019). So providing mechanisms where they feel attracted to and can personalize according to their needs and sensations, cultivates their love for the product (Baker, 2019).

The insights from digital nudging and emotional design concepts can be used as a guide to design a digital intervention that engages consumers to use it. As it becomes embedded in their daily life, their food consumption and purchasing habits will likely change. As a result of that behaviour shift, domestic food waste rates could drop significantly.

Chapter III: METHODOLOGY

This inquiry followed a *qualitative approach* by using *semi-structured interviews* to collect empirical data while drawing on *grounded theory* and thematic analysis based on *inductive* reasoning. This methodological framework challenges the researcher's assumptions and explores the empirical data without a predefined hypothesis.

Beyond *understanding* the problem at hand, my research also focuses on consumers and how to *solve* their problems in relation to food waste. I draw on a human-centred design approach, particularly *Design Thinking* while employing *Personas* and techniques of *Empathy Mapping* to synthesise the insights of users.

Further sections will explain at length my methodological choices.

3.1 Qualitative approach

Mohajan (2018, cited in Creswell, 2009, & Punch, 2013) describes qualitative research as a multimethod model that occurs in a natural setting and collects non-numerical data with the aim to interpret meanings that help researchers to understand social life, perceptions, and experiences through the study of targeted populations or places. Qualitative research involves an interpretative, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them (Denzin & Lincoln, 2011). As the purpose of this inquiry revolves around understanding people's behaviours, a qualitative approach provides the necessary fundamentals for reasoning, collecting data and analysing it.

Inductive reasoning

My research is largely *inductive*, which according to Reichertz (2004) is a form of scholarly reasoning that seeks to generalize traits of a small selection of elements of a particular group to represent the characteristics of all elements of that group. In other words, qualitative induction complements the observed features of a sample with others not perceived, meaning that there is a high level of inference. Because this way of thinking leaves room to explore the data without preconceived ideas, it is a suitable approach to analyse the world of consumers as they perceive it.

The inductive journey of my study began with a rough research question based on an existing problem, followed by the collection of empirical data. Once a substantial amount of

testimony was gathered, I started the search for patterns and connections, aiming at developing new insights that could explain those patterns. The result is, then, a probable form of inference derived from the interpretation and analysis of the data. While open-ended and inductive in this manner, the study is nonetheless directed at a clearly defined topic, guided by established questions, concepts and theoretical insights.

Grounded theory

Inferences based on inductive reasoning facilitate the emergence of new theories from the data. The theory is "grounded" in actual data, which means the analysis and development of theories happen after data has been collected (Eckman, 2016). Willig (2013) explains that grounded theorists attempt to refrain from theory-driven interpretations of the data. Instead, they prefer to take as evidence participants' accounts. In other words, *"researchers concentrate on what people do and the meanings they make of their actions and on the situations in which they are involved"* (Thornberg and Charmaz 2013, p. 154).

This study draws on grounded theory as the most appropriate strategy to analyse the data; meaning that it is committed to discovering new patterns and insights, rather than testing existing theories or pre-established assumptions. In operational terms, this involves collecting data from partially structured interviews, followed by a thematic analysis in the search of emerging patterns that expand the previous knowledge.

3.1.1 Procedure for data collection

Sampling strategy

In qualitative research, sampling decisions are made with a focus on a specific set of the population with a particular 'biased' or 'information-rich' – perspective (Patton, 2002). Hence, the interview sample has distinct characteristics which are significant to the scope of the research questions and offer guidelines as to what groups of people, depending on the unit of analysis, need to be sampled (Patton, 2001). Researchers have drawn upon different sampling strategies: Gobo (2004) refers to purposive, snowball, quota, emblematic, while Patton (2002) adds 16 new types including critical case, stratified, purposeful and convenient. These classifications suggest that there should be a reason that justifies the sampling strategy because any choice will have an impact on the data analysis and therefore also on the findings. Below, I explain the reasoning followed by this study.

Recruitment plan for consumers

The venue intended to recruit study participants was Rema1000, due to the retail reputation of being the pioneer retail chain against food waste in Denmark. Rema1000 is also acknowledged to be the first Danish retail in collaborating with the *Stop Wasting Food* movement. In a Corporate Social Responsibility Report, the CEO of Rema1000 claimed: *"Our vision is to run a business where our customers can buy healthy and affordable products of high quality, which are produced with consideration for the environment, people, and animals".* One could then argue that people who choose Rema1000 might be more tuned into the problem of food waste.

Once in the store, the first step would have been to observe the shoppers' behaviour, from which I could have drawn some purchasing patterns. Next, I would have approached those people who tended to buy more perishable products, as an indication of potential food waste. The third step would have been to ensure that participants met two main criteria: 1) that they were young householders (decision-makers as it relates to food at home), and 2) that they lived with a family of three or more members. As informed by the previous research (see section 1.3.1.1), food waste in Danish households is most associated with young full-time job families with children, which would have been a purposeful sample to collect rich empirical data from.

However, the COVID19 pandemic changed the course of my research and disrupted my recruitment strategy. Quickly, I had to switch to an online approach. My sampling strategy changed as well. Instead of purposely recruiting a particular type of participant at the supermarket, I then needed to reach people out through social media, especially Facebook groups. I spread a post that encouraged readers to collaborate with my thesis project, concerning *"[...] how digital technology can support families, especially those with children, in managing the food at homes to prevent food waste".* This post attracted 12 participants willing to talk about their *"[...] needs, food-related routines, expectations and motivations to safe food".* The wording was intentionally used to attract family members interested in 1) better managing their food provisions, 2) avoiding food waste by using digital technology.

One can then argue that those Facebook-users who took the step forward, are people who meet at least some of those criteria, which would provide a sampling with a particularly useful perspective. Additional *eight* participants were recruited via friends' connections. Once the 20 participants confirmed their disposition for the interviews, they were sent two documents: 1) *Participant Information Sheet* to inform them about the nature of the project and expected questionnaire (see Appendix 1) and 2) *Consent form* to disclose the

implications of participating in this study (see Appendix 2). After they signed the consent form, the interviews were carried out on the date and time agreed with participants.

Recruitment plan for experts

The recruitment process for experts was to some extent similar, although not necessarily disturbed by COVID19. The participants were purposefully selected on the basis of a professional experience that could support the conceptual framework across five areas of knowledge: 1) The food system, 2) interaction/UX design, 3) GS1 barcode standards application, 4) communication strategy and 5) human behaviour. All experts were contacted via LinkedIn through a connection request, following the same procedure than consumers upon confirming their participation.

Overall, the recruitment and data collection process lasted roughly three weeks between the months of March and April. Once date and time were fixed, interviews were conducted via ZOOM, Skype, Facebook Messenger and phone calls.

3.1.2 Data collection method. Semi-structured interviews

"How you collect data affect which phenomena you will see, how, where, and when you will view them, and what sense you will make of them" (Charmaz, 2006, p. 15)

According to Kvale (1996, p. 174), an interview is *"a conversation, whose purpose is to gather descriptions of the life-world of the interviewee"* with respect to interpretation of the meanings of the 'described phenomena'. The semi-structured interview is a qualitative data collection method in which the researcher asks informants a series of predetermined but open-ended questions, yet with more control over the conversation than in unstructured interviews (Given, 2008).

This method is best used when there is little opportunity to interview the informant more than once (Cohen & Crabtree, 2006), and when the intention is to give the participants the chance to speak their minds openly yet within the topics of the researcher's interest.

Consumers interviews

Interviews sought to explore consumers' social context and inner world in relation to food and waste. The questions surveyed the consumption chain (planning, purchasing, storing, cooking and discarding), as well as individual characteristics (food waste awareness, motivations, attitude, lifestyle) and willingness to use digital technology to combat food waste. Consumers were also invited to reflect on the ethical concerns of a digital

intervention, from a privacy perspective: What might people consider intrusive when it comes to monitoring their food consumption and waste through digital tools? Finally, the interviews aimed to collect inputs about the challenges and barriers that consumers perceived in order to combat domestic food waste. The transcripts of all the consumers' interviews can be found in Appendix 3.

From the total of 20 consumers' interviews, 12 fell in the category of 'singles', five were 'family' members and four were living with their 'couples'. From them, 12 were women and 8 were men, in a range of age from 23 to 40 years old. Although nationalities varied, all of them were residing in Copenhagen, Denmark.

Expert interviews

The interviews with experts contributed with rich information from the academic and the industrial world, which helped to answer the research question while providing a better understanding of the solution from their expertise perspective. Moreover, experts' opinions about the potential outcome contributed to validating the idea itself. In Table 3 below it can be found a breakdown of the participants' names and titles for those who agreed on their names being revealed. One of the experts, however, requested to remain anonymous. In the analysis below, quotations and opinions all specialists are referred to with an ID instead of their actual names.

ID	Name	Title / Expertise
E1	Mukti Ram Chapagain	Food Sustainability. Concept Design for Culinary experience
E2	Thor Ravnsfjall	Marketing Psychology and High-Value Sales
E3	Peter Bock	Country manager in a sales and marketing bureau.
E4	Antonio Casals	Professor. Science Director Neuromarketing and NeuroStrategy in HMS-ISG-EEN
E5	Martin Fenge	Chief Producer Officer (16 years of Design experience)
E6	Jannick Kirk Sørensen	PhD, Associate professor in Digital Media and Interaction Design (17 years experience)
E7	Mads Kibsgaard	Standard & Relations Manager at GS1 Denmark

E8	Saimonas Skurichinas	Chairman FoodSharing Copenhagen
E9	Jura... Brázdil	CTO and Data Scientist at Plant Jammer
E10	Anonymous	IT consultant in Salling Group

Table 3. Experts' information

E1's inputs about food sociology were the first ideas that helped to shape the direction of this research, as the interview was conducted in a very early stage when very little was defined. As such, E1 was asked for his idea of a feasible digital intervention to change consumers' behaviour to prevent food waste at homes. Similarly, from his experience dealing with food waste through Foodsharing Copenhagen for more than three years, E8 suggested focusing on the household sector since no much initiatives had been seen in that regard in Denmark.

Since this research focuses a great deal on human behaviour, experts in the field of communication, marketing and sales have accumulated sufficient experience that can enrich the empirical work by confirming the theories or adding new insights. While E2 and E3 brought their viewpoints from marketing and sales, E4 contributed with an interesting new perspective from neuroscience, which enriched the persuasive strategy of communication. The interviews were oriented to explore *how can the use of digital technology trigger behaviour change.*

In the landscape of interaction and user experience (UX) design, E5 and E6 provided insights from the industry and academic perspective, very useful when ideating the solution.

Exploring the second part of the main research question (benefiting the FSC), the collaboration with E7 was crucial to understanding how GS1 standards work as to consider them part of the solution. E7 also provided insights about retailers' operations in relation to the use of barcodes and inventory management to reduce food waste. In consonance with E7, E10 brought some inputs from his perspective as a consultant in Salling Group.

Lastly, the interview with E9 aimed to better understand the possibilities and practicalities of the machine learning algorithms to learn people's behaviours in order to influence a change.

Bellow, there is a sample of the questions asked on the experts' interviews, nonetheless, the entire questionnaires for experts can be found in Appendix 6, and the interviews in Appendix 4:

- How do you persuade consumers to engage in an activity that might be tedious for them and that they have never done before?
- To what extent the design of digital technology can influence behaviour change? Why, how?
- When designing nudges, how do you find out users' mindset to understand what might influence their choices?
- Do you collect consumers' eating habits to improve demand forecasts and prevent food waste?
- How do you envision the use of GS1 Barcodes to prevent food waste at homes?
- To what extent ML algorithms can learn consumers' food-related routines to influence their decision-making to save food in their households?

3.1.3 Qualitative thematic analysis and coding

Thematic analysis is related to the process of determining themes in the data which capture meaning that is important to the research questions, as well as making connections between such themes (Willig, 2013). Like coding, it demands reflection on participant meanings and outcomes, including research questions, conceptual framework and literature (Saldaña, 2012).

Coding entails reviewing transcripts and/or field notes and creating labels to specific contents that own potential theoretical significance and/or looks relevant within the social context under study (Bryman 2016). *"Once an initial coding has been completed, revision of the codes is necessary"* (Nadin and Cassel 2004, p. 273). For instance, there may be needed to merge some codes with related topics or break down one that is too big, or even eliminate some categories that are redundant or not relevant.

This study used a combination of both thematic analysis and coding; meaning that the data were categorized in accordance with themes that were somehow connected. Informed by the State of the Art and the theories, it was possible to create codes that reflected participants' meanings and insights. The coding process sought to find connections among consumers' behaviour, food waste and the potential of technology to prevent it.

Conducting 20 interviews of roughly one hour each generated a massive amount of data that needed to be reduced and organized. A necessary first step was to transcribe all the

interviews, followed by coding through the program NVivo Pro 12. I conducted a thematic analysis, by linking conceptual labels with sections of the transcript that could be associated with the labelled topic (Flick,2013). As such, the literature related to food waste and consumer behavioural triggers, as well as technology perceptions, helped to create and structure the nodes (digital containers of coding, representing the themes). The nodes cover all the main topics embedded in the questions discussed during the interviews.

After having all the nodes coded as a result of the NVivo search queries, it was needed to revise and clean up repeated codes. Therefore, I conducted two more iterations of coding. In the first iteration, I carefully revised and uncoded all the quotes that were not relevant. In the second iteration, I revised every interview file to make sure that no significant information was left behind. Once the third iteration of coding was completed, I structured and organized the raw data, preparing it for interpretation and analysis, after roughly four weeks of transcriptions, thematic analysis and coding.

3.2 Design Thinking, a human-centred design approach.

A human-centred approach implies a commitment to putting the users' needs as a central point of the design process (Marti & Bannon, 2009). This philosophy considers users as sources of innovative insights as they are asked or observed to draw conclusions about their needs (Dell'Era & Landoni, 2016). Of particular importance here is the classification of those needs, since users will likely engage more with those products that satisfy their most visceral needs - their pains, rather than wants or likes. Secondly, the identification of needs becomes challenging as it relies on their explicit acknowledgement by the users or the inference of the researcher about what was not said.

The pioneer of Design Thinking approach Tim Brown stated in a Ted Talk in 2009 that Design Thinking means balancing desirability, technical feasibility and economic viability. It starts by focusing on people's needs. What makes their lives easier, more enjoyable, what makes technology more useful and usable? Before any attempt to fulfil those needs, it's vital to understand the culture and context that might shape aspirations and motivations. Simply said, design thinking is a problem-solving approach based on holistic empathy for the user (IDF, 2020).

The Hasso Plattner Institute of Design defines Design Thinking as a five-phase iterative process that seeks to understand humans, challenge assumptions and redefine problems in order to find alternative solutions to what initially might have been presumed (see Fig. 4).

The process can vary depending on the business case, but my research will adopt the model as explained in the sections below:

Phase 1 - Empathise: Research users' needs

Empathy is the foundation of understanding humans behaviour and feelings. In order to grasp consumers' needs, motivations and problems, conducting empathic user research can gather valuable insights to fuel the design thinking process. *"If you want to build a product that's relevant to people, you need to put yourself in their shoes",* said Jack Dorsey, the co-founder of Twitter. In other words, this stage calls for leaving our assumptions aside and avoiding preconceived ideas. Instead, the focus is on users' accounts objectively (IDF, 2020). Qualitative interviews serve this aim well, by directly asking people for their insights about a given research topic. By using Empathy Maps and Personas methods the interviews provide a comprehensive view of who the user is, by establishing connections and patterns.

Phase 2 - Define: Present the needs and problems of users

Having clustered people's perceptions, it is time to break them down and synthesise them to define the core problems to solve. Also called 'point of view' (POVs), the problem statements are descriptions of current design challenges. A useful tool for an actionable problem statement definition is the POV Madlib framework, which presents the user in a descriptive way, her needs as an action verb and the insight as the meaningful reason underlying those needs. Friis and Yu (2020) highlight four main attributes for a good problem statement as follow:

1) Human-centered: The problem should be outlined in terms of users needs and insights gathered on the Empathise stage.

2) Broad enough: There has to be room for creative freedom, thus it should not focus on a particular method, requirement, or technology.

3) Narrow enough: Although it might seem contradictory, the problem should be manageable, thus making it too broad may lead to nowhere.

4) Actionable: For a goal-oriented ideation, the problem has to integrate the users needs and insights extracted from the analysis, using this formula: [User . . . (descriptive)] needs [need . . . (verb)] because [insight. . . (compelling)]

To open up to the ideation phase, the ”How Might We” (HMW) questions allows us to explore a variety of possibilities.

Phase 3 - Ideate: Divergent thinking and ideas generation

With the problem stated, the room for creativity opens to generate ideas and identify suitable solutions. Brainstorming is considered a particular technique in this stage because it allows us to explore multiple ways of solving a problem. It is in this stage where the design team comes together to pitch their thoughts in a non-judgemental environment. All ideas are welcomed, no matter how unconventional they may look at first sight. As the process is iterative, all possibilities collected will most likely be refined later. In short, the ideation phase provides the material and fuel for creating the prototype.

Phase 4 - Prototype: Start to create solutions

This is the stage where ideas come to life. After an explorative brainstorming session and redefining the potential solutions, the aim is now to unify all the pieces of the puzzle to create the best possible solution to the problems encountered. Besides offering a more tangible, yet not finished version of the solution, prototyping facilitates testing the feasibility of the idea with users, as well as finding out how they feel about the product. Prototyping methods are essentially classified as low and high fidelity prototyping. Low fidelity implies using basic models that might not be entirely illustrative of the final solution yet complete enough to convey the main features of the value proposition. It might include visualizations like storyboarding and sketching. They are cheap to produce and time-efficient, which facilitates changes for new iterations. High fidelity prototypes, however, operate close to what it would be the final version of the product, so users can interact directly and actively with the prototype. This variant tends to provide more accurate feedback for designers to come up with a finished product.

Phase 5 - Test: Validate the solution

This phase seeks to test the prototype with the user in mind, against their expected behaviours and needs. The aim is to improve further versions, and identify gaps between expectations and practised reality. Testing the prototype often involves observing the representative users as they interact with the interfaces. Generally, the goal of an evaluation is to find out how to make a given design easier to use. Additionally, evaluators may test the effectiveness and efficiency of the technology, and the satisfaction of the user. The overarching idea is to identify the weaknesses and strengths of the prototype, as well as troublesome points and preferable features.

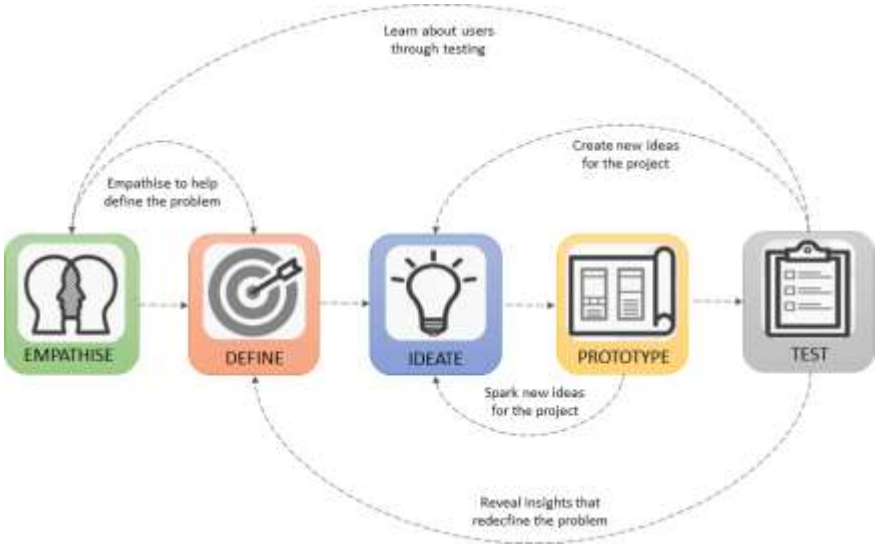


Figure 4. Design Thinking Approach.

As can be seen in the figure, the Design Thinking Approach is iterative and not necessarily sequential (IDF, 2020). Instead of following a fixed sequence of steps, the approach seeks to understand a problem by providing insights *from the users*, and conceiving new alternative solutions in each iteration. The approach provides researchers with an adaptable framework.

3.2.1 Empathy Map

The underlying concern in my methodological approach is inductive, in the sense that I stay focused on people's actual needs, to try to find the best way to understand people's state of mind, while silencing my own preconceptions.

To achieve this, the Empathy Map is a helpful tool. It is a simple, easy-to-relate visual that captures a person's behaviour, attitude, goals, and needs (Leigh, 2018). Particularly useful at the beginning of the design thinking process, the Empathy Map helps to build the Persona after user research. The map can be updated throughout the process as new data is collected. It is worth noting that Empathy Map is not a replacement for the User Journey Map, which provides a wider view of the entire user experience as she interacts with the product or organisation. However, the former offers a simpler and faster visualization of the target audience's feelings and thoughts (Leigh, 2018).

Empathy Maps vary in formats but essentially display common elements. The simplest version contains four quadrants referring to what users said, did, thought and felt. A more advanced variant (aka the Canvas Empathy Mapping) created by the founder of Xplaner, distinguishes between the observable phenomena and the inferred mindset of a person, expanding her universe to incorporate goals, pains and gains (Gray, 2017).

Since the ultimate goal of this tool is empathising with people's needs, Abraham Maslow's Hierarchy of Needs can help to identify the underlying needs of consumers, especially in the cases in which they are not explicitly acknowledged. Maslow's standpoint suggests that human needs can be classified in five major levels, which visualized in a pyramid, situates the most fundamental physiological needs at the bottom, and the need for self-actualization at the top. The most basic level of needs must be satisfied before the person is able to focus on the upper levels. This journey of empathy-building will help to get closer to the consumers, by developing a Persona that represents the target audience.

3.2.2 Personas

Personas are "fictitious, specific concrete representations" of common behavioural traits of the target audience (Pruitt & Adlin, 2006, p 11). The method is often used in the Define stage as a representation of the users' world after empathising with their needs. The use of Personas in the design process facilitates a better understanding and depiction of the users' needs after the stage of user research during the Empathise phase of the Design Thinking process. Research has found five major benefits of this technique (Miaskiewicz, 2011), with the first-place winner being the ability to focus on the actual goals of the target customers. Who is going to use the product, for what purpose and who is not?, are questions that a Persona can help to answer.

Prevention of self-referential design and challenge to assumptions (Miaskiewicz, 2011) are also regarded as a significant output of using Personas, as designers' pre-established beliefs fall beneath users' voice. Equally important, beyond having a strong customer focus, Personas help to narrow down the target audience by prioritizing the segment that is most likely to be satisfied with a specific (vital) set of features. As Miaskiewicz (2011, p. 11) pointed: *"Products that satisfy 100% of the needs of a few personas will have a greater chance of success than products that serve 10% of the needs of the all-encompassing 'everyone'"*.

Chapter IV: EMPATHISE. Researching the users' needs

4.1 User research: Empathise with the audience.

Understanding the needs, goals and motivations of a group of users requires hands-on research. As highlighted in the theoretical framework, behavioural change requires researchers to familiarize with the concerns and needs of the target audience (Robinson, 2012). This stage was supported by the semi-structured interviews, which allowed to collect consumers' insights about their challenges, their level of awareness of solutions to their problems, their feelings, their goals, their frustrations.*"The first step is to ask the right questions"*, said Tim Brown in 2009, when the concept of Design Thinking was emerging.

Broadly speaking, the process of analysing interview data covers three main phases: 1) data reduction, 2) data reorganisation and 3) data representation (Flick, 2013). I covered the first two stages through the coding process of the thematic analysis. The third one took place once I categorized the data in different themes. To grasp the meaning of what participants said, I have sought to represent the findings in a concise and synthesized way. Essentially, the aim of this section is to generate a better understanding of what the interviewees responded, considering their biases and context.

To interpret people's meanings means acknowledging the fact that individuals behave according to the meaning they attribute to their acts and reality (Bryman, 2012). I carried out multiple layers of interpretation: the understanding of the person's behaviour from her own perceptions, the comprehension of the hidden or unclear meaning beneath the statements, and the further interpretation from the standpoint of concepts, theories and literature. Valid to note though, that no interpretation below should be taken as the definitive or all-encompassing revelation of the phenomena studied, but rather a partial representation of the data set according to a specific perspective (Roulston, 2011). Note that during the process of interpreting, the researcher's own expertise and bias will serve as lenses through which the meanings will be eventually interpreted.

4.1.1. Household scenario

As a result of the thematic analysis and the coding process, four major themes emerged (see Fig. 5):

1) Consumption chain: Refers to food-related practices or behavioural factors that may cause food waste.

2) Personality traits: Reflects individuals' characteristics that may influence their behaviour.

3) Food waste: Includes how people consider the problem of food waste, the factors that trigger householders to waste food, and the challenges or barriers they face to avoid wasting food that could have been eaten.

4) Technology: This topic includes discussions related to consumers' perceptions of mobile applications and previous experiences that may shape their willingness to use technology in their daily lives. This category also covers participants' desires for an ideal tool, as well as the privacy concerns and barriers that would hinder its adoption.

As suggested by previous research, the triggers for domestic food waste rest primarily on behavioural factors and individual traits. Based on the sociologist perspective of the human relationship to food (Fishler, 1988), this section seeks to understand consumers' behaviours through their food-related practices and their meanings through their wants and beliefs. Additionally, since this research focuses on how to persuade individuals to change their behaviour through technology, I also examine consumers' perceptions and use of technology.

Loyal to the human-centred approach understanding the context of use aims to identify consumer pains (including needs, wishes and motivations) associated with food wastage, as well as challenges that householders face to prevent it. Mapping the household scenario puts the consumer into perspective. Understanding the context in which consumers operate, facilitates empathising with their feelings and behaviours - the ultimate goal of the Empathise phase. Furthermore, the study sought to understand what participants felt about using a digital assistant to support their food routines. Would consumers at all be willing to adopt a potential digital solution?

It is necessary to distinguish between the types of households when interpreting the data, because behavioural triggers and challenges, as well as food-related practices, vary depending on the household size and composition.

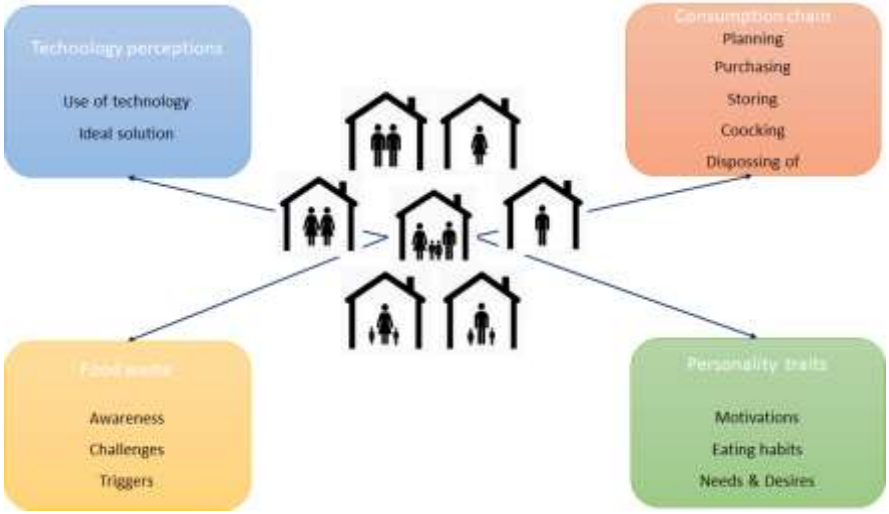


Figure 5. Food waste - The household scenario

4.1.1.1 Consumption chain

The consumption chain is the sequential steps that householders undertake in order to eventually consume the food. The attitude assumed in the different stages can greatly impact the outcome of the subsequent phase. For instance, consumers who are not used to planning their meals and purchases tend to shop by impulse, triggered by their tastes or cravings. Oftentimes, that food ends up in the trash bin. Three of the four families interviewed stated that they do not plan their meals nor their purchases, generally due to lack of time or habit.

When asked whether they plan their purchases beforehand, one of the participants with two-kids expressed with hesitation:

> *"[...] Yes. Yeah. Plan in the sense that we usually make a list of what we need and then I buy it. Um... but oftentimes regarding, mostly regarding the food for dinner, I, um... I just find out whatever. When I'm in the store, I find out what I want to make, and maybe sometimes I buy four several days. Sometimes I buy only for that day I'm there."*

Similarly, a single mother stated with a clear resolution that planning is not, at all, part of her food-related routines: *"[...] Normally, when I'm going out to shop, I do not make a list. I just know that I have to make dinner, you know, and then I go and, you know, just shop."*

Those who purchase their groceries without proper planning tend to waste more food more often, regardless of the shopping frequency, as they are susceptible to self-control bias. The following account reflects this:

> *"[...] If I get up and I think, you know what, I'm not really sure what I'm going to have today, so I would just go to the supermarket. I look around, I see what, what, you know what I can get […] and then I buy too much, I come home, I prepare it, and then you know what? Then the next day, I don't feel like I need that anymore"*

Individuals living alone, like families, tend to be spontaneous and carefree when it comes to a disciplined meal and shopping planning. Some are driven by discounts or appealing looks, and others keep in mind track of what is needed or liked. These individuals are emotionally triggered to underestimate the consequences and overrate the benefits of their decisions. Those who are more aware of the food waste problem buy products with the shortest shelf life, and although the frequency varies among singles, those who buy only what they need every day, tend to waste less.

A single young woman, who took pride in her mastering the art of cooking for one person, said: *"[...] So basically I try to purchase groceries as often as I need instead of in one go, because I feel that if I divide my purchases across the week based on what I feel I'll be cooking, or I think I'll be cooking, then I could in that, in that space, eliminate waste".*

Conversely, a young man expressed with a hint of shame: *"[...] I go for milk and then I end up buying a lot of stuff. Yeah. One thing, I like to eat my food, I don't like to waste."* This excerpt illustrates how consumers think and feel in a certain way, but incur in behaviours that counter their own values.

The conversations with the members of couples revealed a different dynamic. The couples had a clear goal of what they want to cook on a two or three days basis, and said they use shopping lists that they stick to. Contrary to their past single life, when the amount of food waste was massive as there was no planning or consistency in eating habits, purchasing and cooking, couples seem to be more responsible and conscious of their behaviour. One half of a couple explained that:

> *"[...] We go grocery shopping depending on what we're going to make, so then we make sure we're not overbuying things. We try to really just buy what we're going to use in the day, which is annoying because you have to go to the grocery store a lot, but it also saves us a lot of money cause we've just bought you what we need."*

The extract suggests that saving money can be a good incentive to foster more conscious consumer behaviour, even though financial rewards are seen only in the longer term.

According to my interviewees, the way people store food influences how they cook and purchase it. Those participants who place their food in their pantries or fridges, without caring much for the expiration or purchase dates, tend to forget what there is in stock. As such, they are more likely to buy products they already have, causing the oldest purchase to go to waste. Most interviewees did not have a clear understanding of how best store their food products to extend their shelf life.

Participants emphasized that cooking was often spontaneous, and unplanned: *"I just look at what we got in the fridge and cook something from what we have. So... it's often a spontaneous thing"*, said a woman in a four-member household. Families with children adjust the meals to children's tastes, which also leads to buying more food that will most likely be neglected. When asked about how they handle the leftovers, a father of two infants responded:

> *"[...] When we got children, you know, before it was very much easier because then we could just eat. We had the other day, but now, you know, we have more leftovers because children, sometimes they don't like it".*

Couples, however, appear to have more structure in their cooking routines, as they are used to cook every day and in the event of leftovers, these are either eaten next days or frozen. One of them expressed:

> *"[...] Usually we cook for the day, but like every once in a while we will cook something that is like a big portion that we will eat some other day, and we'll freeze it like in small bags for like in individual portions and then when we don't have time to cook. We'll just take it out of the freezer, warm it up, eat that, and we´re good to go".*

Cooking routines for singles vary. There is no clear pattern in terms of frequency, amount of food and use of recipes. However, one thing remains common for all: The desire for tasty, healthy and different food on a daily basis.

> *"[...] I don't want to eat this again every day, if I feel it's going to be super delicious, I'll make it for two days and then I can handle it. But I think it's just really boring to eat the same thing every day because I don't want to waste anything".*

Singles with a busy schedule have a different approach: *"[...] I usually cook for a few days, especially when I'm busy".* Those individuals tend to make less use of recipes, as they prefer to improvise usually something quick that they can eat over the next few days. However, when they feel they lack creativity, they rely on recipes, especially to cook vegetarian dishes: *"[...] For me the recipes would be nice cause I'm not creative at all with cooking. I need to have like you need to do a, B, C, and D. I think for me the key is like it needs to be something that I can cook quickly because I hate spending three hours cooking"*

Generally, the food that people dispose of is leftovers and over-purchased groceries. The majority of families, couples and singles stated that they throw out mostly leftover salads and rice, as well as extra-bought food. They highlighted the lack of planning and self-control when buying groceries, as well as the unintended extra cooked meals, as direct triggers to wasting food. When participants were asked whether they were aware of the amount of food they waste, they struggled to come up with an amount, which could suggest that they pay the matter little direct attention.

4.1.1.2 Personality traits

As suggested by behavioural scientists and psychologists, a person's behaviour relies a great deal on her personal meaning and understanding of the world. Her motivations and frustrations derive from that meaning, masterfully explained by Viktor E. Frankl in his book "Man's search for meaning". On the other side of the equation, a little change in a behaviour turned into a habit can lead to big changes, as pointed out by James Clear in his book "Atomic Habits". Thus, when aiming to change people's behaviour, we need to understand why they behave as they do, what lays behind their habits, and what motivates them to engage with them. That is the reason why the interviews attempted to gather participants' eating habits, their motivations to store food, as well as their frustrations and desires in relation to food consumption.

All participants expressed their habit of eating lots of vegetables and fruits, many of them having preferences for organic products. This suggests that consumers attribute importance to health and (in some cases) sustainable consumption. Pro-environmental decision-making seems to be no longer a minority trait, but rather a well-adopted mindset among consumers of different backgrounds and demographics. Across all categories, consumers indicated that they were interested in knowing about the nutritional values and the sustainability behind the production such as animal welfare and fair trading, Nonetheless, when asked why they would choose ecological products, they would massively agree on

the goal of eating healthier and with better taste, seemingly with little care for the ethical implications.

Based on the interviews, one could argue that consumers' eating habits are shaped by their motivations of having healthy nutrition and pleasant food experience. However, the question remains: what would motivate them to consciously avoid wasting food? The answers collected from families, couples and singles, boil down to two common incentives:

1) Compassion for those people who cannot afford food in poor regions, including some minorities in Denmark.

> *"[...] I should not waste food because I have seen hunger and how homeless people suffer. So I should respect my food. I mean, I should. I should be grateful for what I should not waste. It's a blessing "*, one participant said.

2) Values of upbringing based on the respect for food, for money, and for the hard work that goes into bringing food to the table -- from farm to fork.

> *"[...] I've always been taught by my grandparents and from my parents that you don't waste food. That back to the point that when the bread goes stale, before you throw it out, you gotta give it a kiss "*.

Without necessarily being aware of what psychologists call social comparison bias, householders tended to compare how others were doing in regard to food waste at a macro or micro levels. How do friends manage their food practices? How is Denmark handling food waste, compared with other European countries? - and so on so forth. As long as they assess their own behaviour as good enough compared with others who are doing worse, they consider themselves free of sin. In other words, they seek validation from the surroundings to set the standards guiding their behaviours.

On a smaller scale, it appears that saving money is a significant motivation for some. *"[...] It's a waste of money if you, you know, spend money on the food and then you just throw it out, then it doesn't make sense".* Nonetheless, not everybody would agree with that remark. People have different opinions, expressing the low power of money to truly motivate people to commit in the long run. *"[...] When you say to people that if you stop smoking, you'll save 10,000 a year, it doesn't change people, it's not motivating enough"*. In the same vein a participant added:

> *"[...] I think beyond the capital, there are more important issues at hand. I mean, if we focus on it from the aspect of money, some people will say, well, I have a lot of*

money. I don't care. You know? And that's why, if we go for it from more heart-related reasons, then we can get more people to connect and be mindful about taking an action together so that the change can actually happen."

Ultimately, the core motivation to prevent food wastage seems to be the need to feel good about their core values, their perception of what it is socially acceptable, and their own identity (what will others think about them, or how will others see them?). Regardless of their level of awareness about the consequences of food waste, it all cuts down to how they feel about the matter. Thus, another question arises: What could provide a direct link to their emotions, which make them feel that goodness they long for?

When participants were asked about their struggles with food and the potential ways to solve them, they provided reasons associated with daily routines, seeking to make their lives easier. The common problems among families and singles were 1) the lack of time for planning purchasing and for cooking all produces before the expiration date: *"[...] the feeling of being in a hurry all the time; if I had more time would be better at planning"*, and 2) Bad nutrition due to harmful additives: *"[...] When I think about food, what concerns me right away is not food waste, the biggest, all my first concern is always, uh, that so unhealthy and processed food is being promoted and it should be illegal".* Couples appeared more concerned about their financial situation, whereas some singles also suffer from lack of creativity and budget concerns: *"[...] I would like to plan the dinners according to what it is at a discount in the supermarkets, it will be cost-effective for me".*

To solve their frustrations, participants' prevalent needs point towards three areas of possible assistance: meal planning, recipe suggestions and track of products in stock. Additionally, couples wish they had a way to prevent them from unintended over-expenditure, while singles would like to keep track of their money spent or wasted in food as well as monitoring the expiring products. Based on these answers, one can argue that there is little to be done since there already exist solutions to those problems, as demonstrated in previous chapters. Consumers from different types of households mentioned that they had already been using some mobile apps to fulfil some of their needs. However, domestic food waste still accounts for 50% of the total in Denmark, and there is no common consensus about what the real need is. It is not sufficient to know that it is a behavioural problem. We need to go beyond that knowledge and arrive at the bottom line, what is the underlying, unconscious pain that can inspire action?

Across categories of people and households, people do not consider preventing food waste *per se* as a need, or a pain. Some do not even consider it a problem with serious

consequences for the environment, the economy and society. Since in Denmark the food is guaranteed, there is not pain directly associated with wasting it. If this is the case, the question then becomes, what could really motivate them to take action? One can think of Maslow's Pyramid (1943) of human needs, to find that food as a physiological need is well fulfilled. However, when stepping up Maslow's hierarchy, the upper layers encompass safety, love/belonging, and esteem needs happen to make sense of consumers' conscious/unconscious motivations and behavioural patterns. Here it is one illustrative opinion, by a single person:

> *"[...] When I think about food, what concerns me right away it's not food waste, the biggest, all my first concern, it's always, uh, that so unhealthy and processed food is being promoted and it should be illegal."*

Simply put, consumers want to feel that they are eating as healthy as possible; they care about their economy, about the opinions of others; and they want to feel good about themselves.

4.1.1.3 Food waste

Understanding the actual problems that consumers face is the first step towards designing a digital intervention to prevent food waste.

Across the three categories of households, single individuals showed more concern and consciousness about the problem of food waste and its consequences for the environment, the economy and the society. *"[...] What really drives me crazy is knowing that there is or should be enough food for everyone, but it just gets thrown away. So this is a waste of resources. It has a large impact on the environment"*, one participant said. Another informant agreed that:

> *"[...] it's not good for your own personal economics because you're wasting money; but I would probably lean more towards environmental and social. We already are having global restrictions on the amount of food that we have. We already have so many different areas where people are really hungry or they just don't have the access"*.

In support of the previous account, another interviewee added: *"[...] I can't change the world, but I can start with myself"*. This level of self-awareness can serve as a good basis for people to change their behaviour.

Although not at the same level of singles, the majority of couples also expressed their overall awareness of the problem of food waste.

The family members I interviewed appear less disturbed by and appreciative of the issue:

> *"[...] I have never really read about it (food waste) other than, you know, sometimes you get a kind of an article somewhere, which says, well, the Danes throw so much out every year or something. But I really, I don't know how big the problem it is in the big picture in our country versus other countries. And compared to, for example, environmental problems, I have really not that much of a clue"*

The quote comes from a well-educated participant who believes that *"[...] there are other things we could do to make the world a better place; like don´t take airplanes"* for instance. *"[...] If you told me that food waste is the number one environmental problem in the world right now and that we in Denmark are leading the charge in a bad way, then maybe I would, yeah, be more, you know, conscious about it"* - he concluded. Such statements can indicate that the public debate about food waste in Denmark has gone astray. It does not seem that campaigns to lessen food waste are connecting with people's emotions. Why should they stop wasting food, and what would be the best way to raise awareness?

Provided there is indeed plenty of information out there, one could question what it takes for consumers to take responsibility for the issue, and change their habits. When asked whether she would like to know more about food waste problems through an educative tool, one family member said:

> *"[...] Yeah. Maybe if it's in a question point, maybe a game. So it's not like my face directly. Instead of, uh, you know, telling me: Hey, this is not good or this is just how much food has been wasted, you know, like trying to change my actions instead of giving me information".*

In general, a paradoxical gap seems to exist between, on the one hand, people's awareness of the food waste problem, and on the other, their lacking care to actually change one's behaviour to prevent it. Although this does not concern all participants, especially not to singles, it does apply to some respondents, who claim to be greatly concerned about the issue while at the same adopting a wasteful attitude:

> *"[...] Oh my God, I think it's a very, very huge problem. To me, it's actually a social problem, so people who do not have their three meals, or maybe they can just manage one meal a day and some actually don't have anything to eat [...] the thing with me is that I throw it away because I don't know what to do with it."*

Consumers also spoke about the challenges or barriers they face when trying to avoid wasting food in their homes. Some of those obstacles overlap with the triggers of wasting food as well as the problems participants acknowledged in previous sections.

Lack of time is one such factor. Both family members and single individuals agreed that the lack of time to cook what was intended to eat leads them eventually to not cook at all. Therefore, food often gets spoiled. Scarce time, together with big size packages in the supermarket and irregular cooking routines, hinder responsible consumption. One individual complained that: *"[...] In most of the cases, they [the supermarkets] don't have single-person portions, so you end up wasting a lot of food".* Lack of creativity about how to combine especially fresh products seems to be a common challenge for both singles and couples. For the latter, the attitude of people surrounding them seems to also influence. In that regard she added:

> *"[...] Sometimes people find it funny to do it [save food] or they don't really care. So that sometimes forces you to just go with it and don't really care about the situation"*

One can argue that people's behaviour is affected by others, sometimes regardless of their own values. They do what they see because they want to feel accepted. They are subject to what psychologists call community bias, which can be understood as their attempt to satisfy the need for belonging, as described in Maslow's hierarchy (1943).

Besides limited time, lack of planning also appears among the factors that trigger families to waste food. Planning involves purchasing and cooking phases, which is why the impact can be quite big if one is not mindful about the food that is bought and cooked. A family member highlighted the problem in this way:

> *"[...] The issue with me is that I don't know how to measure and then how much, you know, how much I should prepare for me and my son, the portions. If I had a plan, a weekly plan that I can stick to "* The same problem with cooking the right portions also bothers couples.

Big size packages in supermarkets and the lack of creativity for cooking were also identified as triggers to waste more food. Yet, overarching these concerns, eating healthy appears to be the strongest motive in people's food consumption, far more important than the concern for food waste.

4.1.1.4 Use of technology

The driving motivation of my research is to find out how to nudge consumers to actually change their behaviour through digital technology. Hence, it is imperative to understand people's perceptions and preconceptions, as well as their habits of digital tools, if a digital intervention is going to be of any impact.

As explained in the interview guide, I inquired about whether consumers were already familiar with mobile applications, similar to the ones mentioned in the State of the Art (above). This sought to provide an overview of their level of awareness when it comes to solutions for their needs. The extent to which a person is already using a given digital technology speaks to their openness to use such tools. By inquiring about people's past experiences from different apps, I sought to capture what they like or dislike in such interventions. I was particularly interested in discovering the friction that made their user experience unpleasant, which led them to stop using the technology.

In relation to technology use, consumers were asked three types of questions: 1) open questions about how they thought a possible mobile app could make their lives easier, 2) direct questions about their willingness to try specific functionalities, and 3) privacy-related questions.

It turned out that the majority of participants, especially single individuals, either had used or were currently using different digital services to satisfy their needs. This indicates their positive perception of technology in their lives. One family member spoke of how content she was from using the Coop App:

> *"I usually just enter, I would scan all the products that I need and then pay through my phone so I don't have to, you know, wait in line or anything. It's super quick and it also gives me a receipt at the end of it, to see what I've bought."*

Some people mentioned using Plant Jammer to generate recipes and as a source of inspiration to combine ingredients in stock. One participant mentioned Grim, a Danish company that delivers fresh and organic products from farms directly to consumers. Another highlighted the use of Bring, a mobile app that creates shopping lists from recipe suggestions. Others acknowledged the existence and sometimes use of apps like TooGoodToGo and Olio, mentioned in precedent chapters.

Considering the whole range of benefits that barcodes bring to consumers and retailers, participants were specifically requested their opinion about the use of a barcode scanning

for food waste monitoring. They were presented with and asked about their perceptions of two scenarios:

1) Once in the supermarket, they would scan the barcode on the products' packages with their phones, pay through the same mobile app and go home;

2) After purchasing the groceries as they normally do, once at home, they would scan the barcode of all the products before storing them.

I then highlighted the benefits that this small change of scanning barcodes would bring, especially the efficiency and thus time-saving, together with the elimination of the tedious task of inputting data. All participants agreed on the same idea: If the app was synchronized with retailers' apps and offered enough benefits that made their lives easier, they would be willing to try it: *"[...] If this app could sync with the Coop app, it would help me also keep a track of what I have bought and exactly when"*, remarked a family member that already uses Coop app.

"[...]I think it all comes with a balance of costs and benefits", a participant said, alleging he would prefer scanning in the store. This variant was the most popular overall among participants, as many pointed out that doing it when at home might run the risk of procrastinating it: *"I think the problem is really if you have to scan it later, you get more lazy"*, said a single householder. Thus scanning in the supermarket sounded more attractive to them due to the possibility to skip the counter by just paying through the app and leave: *"[...] I would use it if I can skip the lines"*, said a couple's half. In addition, single participants also found close to their heart that the app offered value to the common good.

Since people tend to be benefit-oriented, the way to get them to adopt a new habit seems to be as straightforward as framing the positive benefits to their personal values, what matters for them. Knowing that individuals tend to overrate the benefits, a well-presented frame of gains that connect with their emotions suggests a promising outcome. It is valid to mention, nonetheless, that some participants found that the process of scanning could be tedious, which could make them eventually get bored of using the app. Others, however, showed great excitement with that new possibility, and others seemed sceptical since they did not have any previous similar experience.

Benefits come to be the carrot to the donkey, also for privacy concerns. Overall, consumers seem flexible enough to exchange their data for the sake of the gains they might get out of that. Their major concerns are: giving up their personal information such as bank accounts, data being sold to third parties and used for big marketing purposes. Regarding this, a family

member stated: *"[...] I don't want big corporations and the shareholders to make a lot of profit on me. Because I give them my data."*

The most common barrier to adopting such an app is the fact that consumers do not perceive it as a need, but rather as a "nice-to-have". A couple's half affirmed as such: *"[...] Well, I don't really need it, but it would be nice".* Therefore, nudging them to acknowledge their pains and showing them the gains, is crucial to get them to desire to start using the app. Among the potential barriers that could lead to a discontinuity of use, participants find it annoying to receive too many push notifications. Having so many apps in their phones, with each one requiring action from their users, makes their life not much easier, but rather overwhelming.

Complexity is a threat to usability, and too many options to choose from is something that consumers seem not to welcome. This is what behavioural marketers call "choice overload", which leads to decision paralysis. Studies have shown that people make better decisions when they are presented with fewer options, which makes the decision-making process (Ariely, 2008): *"[...] If I feel that just using this app is gonna be complicated, then I may not want to even try it in the first place. Why should I stress my life?"* Another single householder expressed from his own experience as a chef: *"[...] This is already a subject that people don't care about. So it has to be something easy, fast, effective, and straight to the point".*

4.1.1.5 Ideal solution

"What we expect influences our behaviour", says Morin and Renvoise (pp. 54, 2008) in their book "The Persuasion Code". Here the authors suggest that humans' desires shape their expectations, while the latter tend to override our rationally explicit needs. Therefore, I considered it relevant to dig into what consumers want and expect from a solution to their problems. When householders were asked what they would need or like to solve their frustrations, they answered with a number of features they would like or find useful (for full accounts of all the features, see Appendix 3). Some of the ideas overlap among participants, thus a summary of the most relevant are presented in the table below, and used in further sections to derive the functional requirements and design the prototype.

Type of household	**Desired features**
Families	-Personalized suggestions: Quiz with about 10 questions to gather users' preferences (diet, nutritional goals, restrictions, taste, etc) so that the suggestions for shopping and recipes are personalized.

Comentado [1]: Quote some of the participants' account expressing this wishes.

	-Customizable recipes: Inbuilt guidance step by step for the recipe preparation. Possibility to customize to adjust the number of eaters, exchange ingredients, kitchen appliances. - Online shopping: Possibility to shop online linked to retailers' app and have the order delivered to the doorstep. - Filters: Possibility to filter the recipes according to kitchen appliances required, type of diet, nationality, ingredients. - Monetary value: Match the food wasted or close to expire with its monetary value and the benefit to save money -"you will save this much if you don't let this go to waste and then you will be able to buy this". - Inspiration: Morning suggestions of recipes based on pre-set preferences and ingredients in stock. Also, suggest basic, must-have ingredients for different sauces or topping, to maximize the actual consumption of leftovers. - Main desirable attributes: Time, food and money saver. Super simple. Easy-to-use. - Gamification: Give points or rewards for every food saved.
Couples	- Menu suggestion: Not only one recipe but other dishes' recipes that combine well (appetizer, main course, dessert, drinks) - Google Home: If the app were connected to Google home to access all its features through. - Monetary value: Match the food wasted or close to expire with its monetary value and the benefit to save money -"you will save this much if you don't let this go to waste and then you will be able to buy this". -Stock Overview: Have an easy overview of products in stock that allows you to track them and suggest shopping lists accordingly. - Customizable notifications: Possibility to choose when, and how frequently to receive notifications.
Singles	- Inspiration: Morning suggestions of recipes based on pre-set preferences and ingredients in stock. Also, suggest basic, must-have ingredients for different sauces or topping, to maximize the actual consumption of leftovers.

	- Sharing recipes and shopping lists: Possibility to share the recipes and shopping lists users cook with social media and within the app. - Gamification elements. Comparison or competition with other users in terms of food wasted (%) and the equivalence to GHG emissions. - Community: Build a community around the app for people to interact somehow. Link podcasts as an education tool about cooking, food waste, nutrition, wellness, health and fitness, etc. - Storage advise. Give advice about where and how best to store products to extend their shelf life. - Stock Overview: Have an easy overview of products in stock that allows to track them and suggest shopping lists accordingly. - Smart anti-waste shopping list: Suggest shopping lists according to the products in stock, # of eaters (for portions), number of meals intended and meal plan. - Reminders: Send reminders about expiration dates of products in stock and suggest recipes accordingly. - Meal plan: Possibility to plan the meals over a period and suggest recipes and shopping lists for it. - Real-time shopping suggestions: Possibility to search for a product and see what other products can be combined with it to create specific recipes, suggesting the correspondent purchase. - Producers information: Possibility to check manufacturers, producers or brand owners' information for every product suggested and in stock. - Customizable notifications: Possibility to choose when, and how frequently to receive notifications, and what about. - Monetary, environmental and social value: Match the food wasted or about to be, with its monetary value, as well as the contribution to the social good. -"you will save this much if you don't let this go to waste and you will save this amount of CO2" - Main desired attributes: Convenient, so the app does not require entering any information. Easy to use. User-friendly and Intuitive.

Table 4. Desired features.

4.1.2 Summary of the analysis

After a walk through the map of the household scenario, the main takeaways can be summarized as follow:

Consumption chain

- In a nutshell, the consumption chain involves the consumers' journey towards feeding the household members. Starting from planning their meals and purchases, followed by purchasing their groceries, storing them, cooking them, and discarding them.
- As all the stages are linked to each other, one's outcome considerably affects the next and precedent ones. Therefore, the solution to domestic food waste should be thought of as one that can cause a positive ripple effect.
- Across the different stages, the behavioural practices vary among families, couples and single individuals. Couples tend to be more organized and therefore waste less, whereas families and singles appear to have more unstable and busy lifestyles, which lead them to waste more food.
- Overall, the lack of planning, the irrational purchasing and the disproportioned cooking trigger food waste in all the cases.

Individual traits

- Human behaviour comes along with one's individual characteristics, and both are shaped by the way they make sense of reality. In an attempt to understand why people behave as they do, it is relevant to understand their wants, motivations and frustrations as it relates to food and eating habits.

- The majority of interviewees coincide with the concern of eating healthy by incorporating more fruits and vegetables to their diet, organic and sustainable when possible. In short, consumers' eating habits are formed by their incentives to having good health and desirable food experience.
- When it comes to motivations for actively avoiding food waste, two main emotional factors are common denominators: 1) the upbringing values and 2) the empathy for the minority suffering from food insecurity. Other motivations account for: money-saving, social comparison and, ultimately, self-esteem.
- Consumers associate their frustrations mostly to the lack of time and the poor nutritional value of many food products. On a smaller scale, the lack of creativity and financial tightness also represents a problem. What is obvious is that wasting food per se does not represent a pain, nor a need and in some cases not even a problem.

- All needs boil down to feel safe by eating healthy, care about their financial condition, feel accepted by social norms, and feel good about themselves.
- To solve their defeats, householders showed to be aware of what could help, that being: meal planning, recipe suggestions and track of home inventory of food. In addition, some participants wished they could have some tool that prevents them from overbuying, while others want to keep track of their money and food waste.

Food waste

- When thinking about designing a digital tool to prevent domestic food waste, it is crucial to understand consumers' level of awareness of their own pains and the food waste issue. Since the latter does not figure as a problem for them, the goal here is to find a correlation between their needs and food waste, so the solution can be targeted directly to their pains, and indirectly to prevent food waste.
- Single householders appear to be more conscious and concerned about the consequences of food waste for the environment, the economy and the society. Families however, showed lower awareness about the issue, alleging more concern about food safety for their children, and food insecurity for less privileged individuals. These findings suggest a potential market segment of early adopters of the solution.
- The lack of time is a factor that was acknowledged by consumers as a challenge to avoid wasting food as well as a trigger for wasteful behaviours. The time issue arouses the lack of planning, which in turn affects the purchasing and cooking phases and thus generates more food waste. Besides those two, the size of packages and the lack of creativity for cooking were identified as common triggers too.

Use of technology

- The majority of participants revealed having had some sort of experience with digital services for different purposes, which speaks to their potential willingness to adopt the proposed solution. Some of the previous or current uses related to food include the self-scanning Coop app, Plant Jammer, Grim, Olio and TooGoodToGo.

- All participants coincided in their willingness to scan their food products and use the consumer app if this was synchronized with the retailers' app. This pattern suggests that the final solution could consider integrating retailers' systems with the app here proposed, to increase the rate of a successful outcome.

- The perceived benefits may be a good incentive for consumers to engage with the app, as well as to give up their data to retailers. Hence, they appear to be flexible to negotiate the privacy terms as long as the gains outweigh the costs.

- The major barrier for the eventual adoption of this solution is the perception of the app as ideal, but not required. This stands in alignment with the fact that they are not fully aware of their own visceral needs. Other obstacles that could lead them to stop using the app, include receiving too many unwanted notifications, having too many options and finding it too complex.

The ideal solution

- Although not necessarily requirements, participants were given the chance to envision what they consider an ideal solution to their acknowledged problems. They spoke about every possible variant that they could think of and came up with some interesting suggestions.
- The majority of interviewees of the three household categories expressed that they would want a financial value, meaning that they could monitor their food waste *associated with money waste*. This reaffirms that saving money could be an important motivation to engage with the app.
- Families and singles share the same desire of being inspired by receiving recipes that use the products in stock.

- All participants expect a customizable solution in which they can filter recipes, products, and determine what type of notifications they want to receive.

- Overall, single householders expressed more enthusiasm when providing possible features, and suggested creative ways of solving their frustrations.

Chapter V: DEFINE. Present users' needs and problems

Once consumers' interviews have been analysed, the insights can be synthesised to define the target user and the design problem.

5.1 Defining target segment

Experts provided insights as to how to define the target audience whose needs constitute the problem to solve. They pointed out that:

- People's problems and motivations related to food vary depending on the individuals' characteristics such as family size, lifestyle or parental status. Likewise, the reasons for wasting food diverge among the different types of consumers (E1). Therefore, there might not be a single solution but rather various ones, which lead to the need for rather focusing on one target group (E1).
- A good strategy to segment the audience is to research the pain throughout a varied sample, so we can spot the pain of every sector. *"[...] Wherever recurring or common pain applies, it would be the market segment"* (E4).
- A movement of people who already care about food waste and the environment suggests a target audience that would embrace the solution. These people are to be grown enough, aspiring to build a better world for their future generations. Thus couples or families with children might be a potential target audience, essentially those who share a common goal of caring about the environment and want to make a difference (E3).

From the three categories of consumers, the previous analysis suggests two groups whose situations, attitudes and motivations point towards a potential target audience. Families and singles displayed more willingness to try out a digital technology that can inspire them to have better nutrition, and support them to avoid food waste by better managing their products in stock. The majority of singles showed a higher level of consciousness in regard to the environmental, economic and social consequences of food waste. Moreover, most of them tended to have health goals. They would appreciate a tool that could support their health targets and eases their lives.

Family members, on the other hand, showed more interest in food safety, which makes sense, given that they are concerned about the health of their children and relatives. Although not very concerned about food waste, and often sceptical about the use of technology, they would appreciate a digital tool that could help them to become more

organized in the food management, and optimise their scarce time. As pointed in previous sections, time is considered a precious resource for both individuals and families.

Members of couples, however, showed a different dynamic. They tend to be more organized, more conscious about how they manage their food, their finances and less reliant on technology. Couples seem to operate more as a team, finding the motivation to collaborate with each other and accomplish household tasks together. These particular settings leave small room for motivation to use a digital tool that might not make such an impact in their lives, as they currently succeed with their companionship.

With that said, the interview data points more towards singles as potential first adopters of the solution, while families could follow once there is a movement created, a community with enough social standing. When testimonials start showing that the app supports them to achieve their goals while helping them to avoid waste of food and money, they will find proof of the gains they need to take action. Hence, for the first iteration of the design thinking process, the Single category will be chosen as the subject of the Empathy Map and the Persona definition.

Defining the pain

Identifying consumers' needs was not an easy task. Oftentimes they would not state it clearly, so it was necessary to read between the lines. However, neuromarketing expert's insights about finding the pain when conducting user research helped to navigate through the challenge.

- According to E4, there is a difference between need and pain. If we compare the level of awareness with an iceberg, above the sea level (the conscious mind) we find what people think they like and want, whereas below the sea level (the subconscious) there is the biggest part of the iceberg (90-05%) -the needs, pains and fears (Morin and Renvoise, 2018). Although needs can be a good incentive in some cases, pains are what authentically motivates people to take action (E4). That's why diagnosing the pain becomes so crucial.

- *"[...] Scarcity of food is a pain, food waste is not"*, said E4. Therefore, the dilemma here is to find a pain that can be associated with food waste as a consequence. *"[...] Then you have to revive that pain so that people remember that they have it so that it hurts, and the healing can be appreciated".*

- When searching for the pain, it is advisable reading between lines of participants' accounts. We seek what distresses or motivates people the most (70%) throughout

the sample. *"[...] If any of the pain that comes out of that study can be related to the problem of food waste, then you already have it"* (E4).

5.2 Empathy Map and Persona

There are multiple techniques that can be used to synthesise the findings from the analysis and define the design problem as well as the target users. However, as mentioned in the methodology chapter, this project will make use of the Empathy Map (see Fig. 6) and Personas (see Fig. 7) to condensate consumers' needs in a visual, easy-to-digest representation. This will support the definition of the design problem that will guide the ideation stage.

The Empathy Map below illustrates both the observable and inferred mindset of the Single-subject, which will then be depicted in the Single Persona.

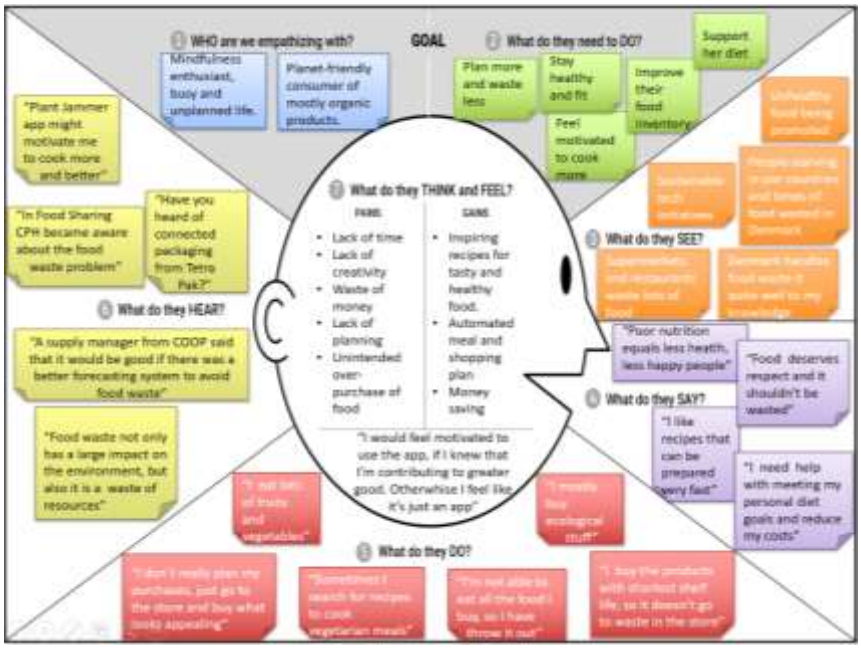


Figure 6. Empathy Map

The creation of the map helped to build empathy toward consumers and consequently create a Persona that represents a condensed version of the target segment of consumers. The image below shows the 'Single' Persona, the ideal consumer that will most likely welcome the solution the most. *"[...] Every time we speak, we speak to one person, for an*

audience of one, or an audience of 1000", says the famous transformational coach Lisa Nicholson. In this case, as individuals showed more enthusiasm and commitment with a greater cause, they might influence their friends, families and social networks, creating a ripple effect and serving as inspiration for others to join, to form a community.

That being said, the ideal consumer is also a busy person who lives alone, and is concerned mostly about her health and state of mind, *as well as* about the environment and social wellness. This ideal person is active in social media therefore will be a great channel of distribution. Fueled by her story, motivated to make a difference in the world, she will drag people into a movement of health, wellness and less waste.

Figure 7. Single Persona

5.3 The problem statement

Once we have empathised with consumer needs, wants and frustrations, it is then time to define an actionable problem statement whose solution will be depicted in the design (Friis and Yu, 2020). This stage is the prelude that kicks off the Ideation stage after all the

observations from the consumers' interviews are analysed. It is here where the analysis is synthesized to define what the actual problem is.

Building on that foundation and following the POV approach, an actionable problem statement can be described as such (see Table 4):

User	Needs	Insights
A busy, single professional - Lene, with a mindful attitude towards food consumption and the environment.	Eat healthy to feel safe and good with herself.	Lene is committed to eating healthy and sticks to her mostly plant-based diet, thus tends to overbuy fruits and vegetables intending to eat them all. However, due to her busy and unplanned lifestyle, lack of time and creativity to cook, she frequently fails to consume all the purchased products. That makes her feel bad, as she knows it is a waste of money and brings negative consequences to the environment. She has been trying different solutions but it is overwhelming to have in the phone so many apps, for different purposes that are not integrated.

Table 5 POV for Problem statement

Simply put in one actionable statement, the design problem can be defined as:

Busy working professionals need an easy, time-efficient and convenient way to eat healthily because they often lack time for planning how to shop and cook tasty plant-based meals.

Now that the target audience is identified and the design challenge is defined, it is time to ideate potential solutions. Before exploring the possibilities, the "How Might We" (HMW) questions can help to fuel the ideation sessions by shedding light on the possible directions in which the solution can go (Friis and Yu, 2018). Thus, breaking down the problem, the foundational HMW question may be outlined as such:

How might we design an easy and convenient tool that helps consumers to eat healthily and avoid waste?

Other sub-questions may be narrower and suggest different nuances to expand the spectrum of possibilities that are in line with the objective of this research. For instance:

- How might we design a digital tool that integrates different solutions for a responsible consumption to avoid food waste?
- How might we design a digital tool that supports consumers with their goals of eating healthy, enjoying their meals, while saving time and money?
- How might we design an engaging digital tool that supports the greatest cause of preventing food waste, while solving consumers' problems and also impacting the food supply chain?
- How might we design a digital tool capable of engaging consumers to use it consistently and, as a consequence, change their behaviour towards a more responsible consumption?
- How might we design an engaging digital tool that motivates consumers to stop wasting food?

Having these questions put into perspective the ideation sessions, which will aim at answering them from different angles and fields of knowledge.

Chapter VI: IDEATE. Divergent thinking and ideas generation

The most popular technique for ideation is the brainstorming sessions, where a team of researchers, designers and stakeholders gather together to pitch possible solutions to the design problem. However, this enquiry utilised experts' insights to generate new ideas that may respond to the HMW questions. Ultimately, the goal is to provide a solution that consumers will want to use and stick to because it inspires them and helps them to meet their goals. As suggested by Robinson (2012), there is no behaviour change possible without an acknowledged benefit for the user.

6.1 Ideation

After sorting and categorizing the data from the experts´ interviews, four major themes were distinguished in line with the area of expertise of the participants and the presumed theoretical constructs:

1) Behaviour change: Encompasses experts' opinion about behaviour change and target segments.

2) Marketing and communication: Envelops emerging topics that, although not preconceived from the literature or the theoretical framework, resulted to be relevant to be analysed. This category also touches upon the significance of the persuasion techniques when communicating the message that addresses consumers' pains.

3) UX design and technology: Includes the do's and don'ts for an effective digital intervention to communicate the value that engages consumers, from a UX design perspective.

4) GS1 barcodes: Contains reflections about the potential benefits of the use of barcode standards as part of the two-fold solution to prevent food waste. Furthermore, identifies the challenges and requirements to be considered for further implementation.

Behaviour change

When experts were asked about the potential of a mobile app to influence consumers' behaviour, their viewpoints spun around the importance of creating value by targeting individuals' visceral motivations and needs. In that line they pointed out that:

- Any likelihood of influence on consumers' behaviour generally implies that the tool turns people's job/lives easier (E1, E3) and more efficient (E5), so they might find it

convenient and thus will probably start using it. "[...] As soon as it becomes a habit" (E3), it will most likely prompt users to action.

- Targeting major incentives and motivations of consumers is key to attract their attention in the first place (E8). Thus appealing to personal goals is a wiser approach than targeting directly the fight against food waste, as it has become a buzzy term that does not necessarily resonate with people´s concerns.

- What motivates people to change behaviour is to cure a pain they might be suffering. Thus finding the hidden or resentful emotion and targeting it with a proper message, will make people begin to use the tool, which is supposed to cure their pain.

- Creating a community sense will add great value to any digital intervention (E2) as it will drive consumers' community bias. Human beings are social by nature, and the way the world is going will bring more loss of community to society, more and more isolation. Hence, the community will soon be in scarcity, and that is what people are going to miss and suffer from (E2).

- When E6 was asked about how we can create an engaging user experience so consumers start using the solution, he answered with no hesitation: *"[...] That this a very classical marketing problem or a communication problem".*

Communicating the message

Delivering the right message in the proper way is a precondition to any behavioural change. In agreement with Morin and Renvoise (2018), the first step to influence an overall engagement is to grab the attention, followed by triggering the emotions and ensuring retention. *" [...] A great attention grabber is showing people how my product is going to cure their pain"* (E4). Under this paradigm, experts agree on that:

- The message has to claim the cure of pain in a credible, strong and memorable way, and demonstrate the gain (value minus cost), a tangible benefit to users (E4). In other words, the messages should communicate clearly the problem that is being solved (biggest pains revealed in the interviews) while the gain is nothing less than the proof of the high-value proposition. Customer testimonials are proven to be the stronger proof of value (E4).

- When communicating the value, you can reward or scare people (E6), but the best approach has been proven to be the reward. This could be a personal benefit or could be social, in which the consumer feels good because is contributing to a

common good. It is important that the person can easily relate, identify herself with the content of the message. It is not the content itself, but how it is presented to attract attention.

- Clarity is key. *"[...] I think that the successful communicators today are extremely clear in what they stand for and what they offer"* (E6).
- The biggest problem is creating the narrative around the messages (E6). Who is speaking? Is it someone I can relate or identify with? The voice, the tone and the conversation style should not be overlooked.

Persuasion techniques

From the E4's viewpoint, once the pain is found, the next step is to claim the cure to persuade people to take action, that is to say, to change behaviour. In this regard, experts point out that:

- *"[...] you have to put thoughts in people's head, you have to tease them with the positive feeling that they could get from doing something, you have to kind of put a picture in people's head".* This was the response of E3 to the question: Once the attention is grasped, how do we trigger the emotions? In consonance with the E4 standpoint, that means that the art of persuasion is mastered by creating a vision, an image of the desired status that people could aspire for, in order to heal the pain.
- People tend to behave like the social norm states since what the majority does is perceived as normally accepted. *"[...] Nobody wants to be left out, they need to feel they belong to"*, said E3, referring to the belonging bias. Therefore, when provoking individuals' emotions, it is key to make them feel that they will be part of something, like everyone else.
- The persuasion strategy can be validated and tested through a focus group, in which participants are presented with the whole idea (pain-claim-gain) to examine their reactions. The audience's feedback is then collected and its perceptions will speak about the effectiveness of the persuasion strategy.

Effective intervention

From the UX design perspective, experts brainstormed their insights about what core characteristics that a digital tool (to prevent food waste) could aim for in order to stick in people's minds and meet its purpose.

- There are still some people who do not know how to properly store food products to extend their shelf life (E1). Therefore, an educational tool could be appreciated since consumers can learn and incorporate good practices to prevent food wastage.

- When it comes to behaviour change, feedback is welcome. People need to see how well or bad they are doing and the app should be able to showcase that (E8). For instance, having a monthly report about the impact of their behaviour swift that compares previous spending with current ones could become an incentive. Also, a financial and environmental overview that provides a comparison of the average consumption with other users in the community will probably trigger consumers' social comparison bias.

- Building a community around is a wise strategy since *"[...] people tend to behave according to what is nicely acceptable in their community"* (E1). In other words, individuals certainly care about what others do and think about them. So, if the community around is taking actions against wasting food, E3 pointed out, they will most likely want to integrate instead of positioning themselves in the dark side of the spotlight.

- Contrary to what other experts expressed, E4 believes that less is more, stressing his disconformity with the idea of building a community around the app -*"[..] it should be tremendously simple"* (E4).

- Simplicity, according to E5, is by far the most crucial attribute when it comes to UX design and communication; both E5 and E3 coincide in that having around three or four vital functions that can make the biggest difference in prospects' lives, will be a sufficiently good starting point. *"[...] Start with an MVP [Minimal Viable Product] that is simple, useful and memorable, otherwise the idea will die before it kicks off"*, E5 said. If tabulated with E4's input, those three features should target the strongest pains that were identified during the user research through the interviews.

- Other major attributes that experts agree upon to be present are: user-friendly, easy-to-use (E3), convenient and fun (E1). Nowadays, with the excessive abundance of information and even less time, people want to avoid thinking too much to accomplish daily tasks. They want what they need easily available at the right moment (E1).

- According to E5, it is a terrible mistake that many start-ups make, to load their products with a wide range of features, which end up killing a brilliant idea before it

can be appreciated by its target customers. The mission, vision and values are not easily visible right away, and as a result, the project fails.

- E8 advises avoiding so many notifications and reminders that the users did not ask for or are not interested in. Being pushy does not help and rather discourages users from following the instructions or suggestions. That would lead to the opposite effect of persuasion, which is resistance.

- E6 raised a thought-provoking reflection to bear on the mind -*"Either you sit on the audience, or the audience will sit on you"*. With this metaphor, E6 was referring to the importance of not to aim at pleasing every single desire or requirement expressed by consumers for the sake of personalization. Said in other terms, he suggested to stand up with authority.

Digital Nudging

Overall, experts agree on the fact that visuals communicate more effectively than written words. Nonetheless, the use of reminders might need some persuasive texts that icons or images can´t clearly express.

- E6 recommends the use of icons wherever possible, as they are meant to communicate quicker and in smaller spaces. Used properly, icons may suggest intended actions that guide users to a predictable outcome.

- The most important features, or perhaps the least appealing, should be the most easily accessible to users (E6).

- When claiming the gains, visual effects are powerful as they speak directly to the primal brain (E4), so the prospect can capture the message faster.

GS1 Barcodes as a vital part of the solution

As discussed in section 1.4.3, having a barcode-scanning feature on the app can bring multiple benefits both for retailers and consumers in different dimensions, and most importantly help to prevent food waste. E7, as an expert in the application of GS1 barcode standards, provided highly valuable insights about how 2D barcodes can add efficiency to a potential solution to reduce food waste.

2D barcode advantages over 1D barcodes

- The problem of food safety is often underestimated when it comes to its impact on food wastage. Retailers are missing out the opportunity of saving tones of good food

from being recalled since 1D barcodes can´t differentiate the items that are contaminated from those that are not.

- While 1D barcodes only contain the GTIN, the 2D barcode can embed the batch and the serial numbers, production or packaging dates among many other types of information, which facilitates to identify and separate the implicated items. In other words, the simple swift to 2D barcodes can prevent a great deal of food waste.
- In connection with the previous issue, consumers can be also affected, as 1D barcodes do not prevent them from taking home products that have already expired or those whose batch is problematic.
- When weighing the differences between the QR barcode and Data Matrix, E7 remained neutral about the use of one or the other. On the one hand, the GS1 QR barcode does not require any specialized scanning application to be read, but only the users´ regular smartphones. On the other hand, Data Matrix has been more tested by different partners and thus has proven positive results. Therefore, the solution proposed will not make a distinction in terms of which 2D should be adopted but rather leave it open to the manufacturers' decision.

Challenges and barriers to 2D barcode adoption

1) According to E7, the challenges of adopting a solution that implies 2D barcodes is to a great extent a national issue. In other words, the fact that in Denmark a small number of very powerful retail chains dictate the rules of the game means that such change in the system will require that one of them demand for that, using their purchasing power (E8). However, the reality is that the current status quo is profitable and comfortable enough to jump into such disruptive change, regardless of the benefits it entails (E7). Aside from this fact, realistically speaking E7 identifies four major barriers:

    a) At the manufacturers level, the inclusion of 2D barcodes will affect their production speed. As the data encoded will be dynamic, every batch will have different data according to production, expiration, best before dates. That implies they will need to print the barcodes on-demand within the production, instead of pre-printing as many as an entire year's worth of boxes, which they can do now with the 1D barcode that contains the same GTIN for all the items. Hence, the challenge relies on to demonstrate the

advantages that the 2D barcode will have for manufacturers if they were to organically make the decision.

b) Retail stores lack the required equipment to scan the 2D barcodes as most of them still use old barcode readers on their point of sales, good enough for what they currently do. Although pricey, it can be argued that they could upgrade the machinery and acquire modern scan equipment; but the question is: -what stops them from doing it? This barrier, nonetheless, could be conquered if retailers implemented the self-check-out mechanism, through which consumers scan and pay for their purchases with their mobile phones.

c) Some companies that count on the necessary scan equipment may lack the updated version of the software, so having to upgrade their SW every time might become a pain point for some retailers and see it as a barrier.

d) Provided that all the previous obstacles are overcome, an obvious challenge remains to be to get consumers to scan the new 2D barcodes on the products in the stores.

After having empathised with the consumers, defined the design problem, and gathered experts' insights for the ideation sessions, there is sufficient material to propose a feasible solution.

6.2 The solution

The solution here proposed aims to respond to the HMW questions outlined in the Define stage, having the main research question as a guiding light for a holistic picture of the problem:

How can a digital intervention nudge householders to prevent food waste while benefiting the food supply chain?

Nudging consumers while upwardly favouring the food supply chain, requires a twofold solution -a digital intervention that: 1) is targeted to influence consumers' behaviour towards more responsible consumption and 2) provides retailers with data points that help them prevent food waste while optimising the FSC. As such, the proposed solution presents an opportunity to connect retailers and consumers' goals of reducing their food waste through a mobile application equipped with a 2D barcode scanner. The presence of this feature creates a communication bridge between the supply and the consumption chains, through

which data flows upstream to improve inventory management, demand forecast and food-waste-mitigation strategies.

The 2D barcode is to carry relevant data which both retailers and consumers can make better-informed decisions with, to prevent food waste sustainably.

In short, the twofold impact of the mobile application here suggested, is meant to trigger consumers to take action and overtime change their behaviour, while having a ripple effect that benefits retailers and producers/manufacturers.

6.2.1 Impact on consumers' behaviour

Behaviour change will be a consequence of a new set of habits in consumers' daily lives. But before this occurs, there must be a reason for them to start using the solution in the first place. It is here where the stages 1 and 2 of the design thinking process converge to provide the why. Why should consumers start using a new app whose benefits are yet to be proven? -Because the design of this app is thought to attract and retain their attention while satisfying their most essential needs.

From the theoretical concepts and the data analysis, an effective nudging formula might be thought as followed:

1) Identify the level of awareness (of problems, possible solutions)
2) Spot consumers' motivations, aspirations, frustrations, needs.
3) Define the design problem, derived from challenges that consumers face.
4) Design a digital intervention that eliminates friction to make their lives easier, satisfy their needs and connect with their emotions.
5) Communicate the value of the solution: the emotional outcome to the consumer that will fulfil her ultimate goal.

Steps 1, 2 and 3 are thoroughly explained in the previous sections: Empathise and Define, while step 4 will be disclosed in the next chapter: Prototype. The fifth step is the glue of the solution on the consumer side, as there is no behaviour change possible without emotions being involved. And the persuasion strategy explains how to nudge householders towards the desired outcome, which is the ultimate answer for the second research question. How can UX design engage consumers to use the technology in a way that influences their behaviours?

Communicate the value of the solution. The persuasion strategy

Communicating the value of the solution should have a strong persuasive nuance. Since the problem of food waste is not precisely acknowledged as such by consumers, a change in their behaviour should be nudged using persuasion techniques. Also pointed out by E6, it is a communication problem to grasp consumers' attention. Besides the elements of digital nudging and emotional design discussed in the conceptual framework, the way we communicate the value of the intervention is crucial to persuade users to engage with it.

The persuasive message must engage the primal brain, which rules decisions and influences the rational brain to take conscious actions. As coined in the Neuromap model (Morin & Renvoise, 2017) previously recommended by E4, the primal brain acts as a filter between the message and the decision to take action. We can think of it as an irrational doorman who reacts to emotional, visual and tangible stimuli before any critical thinking takes place. That is the reason why it is so important to find the right message that, teaming up with the design, triggers consumers' emotions that will lead them to engage with experiencing the app.

Applying E4's insights, which encourage taking as a foundation the Neuromap approach (Morin & Renvoise, 2017), the persuasive message that communicates the value of the solution should involve the following stimuli:

1) *Visual*: The visual sense is the most dominant. Therefore, images are powerful since they are processed faster than text is. Visuals should be bold and salient. To exploit this catalyst, the app will have images that illustrate a vision, a desirable state of mind and goodness that consumers aspire to have.

2) *Personal*: The primal brain empathizes and prioritizes events that imply its well-being. Hence, threats to that state if goodness is more potent and faster attention grabbers. The app will combine both images, icons and texts messages to convey the benefits, which are linked to consumers' goals and rationalized needs.

3) *Memorable*: The primal brain has low memory capacity, therefore, the message should be simple and powerful at the beginning and the end. It should revive the pain first and thus provoke primal emotions like fear of regret. To fulfil this stimulus, the app will open with a text that presents the pain (gathered from the interviews), claims the solution and conveys the gains for the consumers. This will be supported by a background image that appears, at first sight, showing both the negative emotions aroused from the problem and the pleasure triggered by the solution.

4) *Tangible*: The primal brain seeks minimal cognitive effort. Hence, the message should be simple, concrete and relatable. Most importantly, it should present credible evidence of the claim, which is, as mentioned earlier, no more than the proof of the gain.

5) *Contrastable*: Noticeable contrasts like before & after that make the best choice obvious, appeal to primal brain driving quick decisions. To avoid delayed and confusing decisions, the message should highlight the unique benefits that make the app stand out from the crowd of options. To support the contrastable effect of the pain and the gain, the background, in the beginning, will be a combination of two images showing how the pain and the solution can feel like.

6) *Emotional*: As the primal brain is irrational and sensitive to emotional triggers, the message should activate first risk-avoidance emotions like fear of regret, and positive ones like the pleasure of anticipation, that ignites the desire of the solution claimed. Only when emotions are involved can persuasion happen, because, without emotions, there are not retention, nor decisions possible. That is why the message will start with a frustration revival, followed by the claim of the solution the app is bringing, and closing with the proof of the gain.

The integration of these six stimuli, encoded in the Neuromap framework of Pain-Claim-Gain has proven to be an effective persuasive strategy. Additionally, it is aligned with the principles of digital nudging and emotional design. Therefore, the design will aim at nudging consumers to engage them with experiencing the app, and as a result of a behaviour change in their consumption routines, prevent food waste.

Consumer's benefits

The following benefits will be also included when communicating the gains in every interface of the app:

- Consumers will be able to have an overview of what products they have in stock and what their expiration dates are, without the need to input data. This will enable consumers to better manage their foodstuff more efficiently and effectively.

- At the point of sale, buyers may benefit from discounts as their chosen products are close to expiring, which may inspire them to buy more expiry food and consequently liberate the retailers from wasting those products.

- If retailers implemented this kind of solution in which consumers could scan the products before paying and get all the information encoded (i.e. expiration date, best before), they would be able to make well-informed decisions.
- For consumers, knowing what is behind the production of the food, creates transparency and a close relationship with the brands and favourites products. This mere fact inspires trust and, therefore, a more pleasant nutrition experience overall.

6.2.2 Impact for retailers

As mentioned in earlier chapters (see State of the Art), The food waste phenomena is not only a consumer problem, or a retail problem, or a producer problem, it is a whole system problem. While there is not a single solution, any attempt to prevent or reduce food waste should be designed in a way that can impact as many stages of the FSC as possible.

Even though this research focuses on the consumer stage, the role of retailers is fundamental since not only are they the direct link to end consumers, but also have a strong bargain power in the whole supply chain. The use of 2D barcodes can open new communication channels between the consumption and supply chains, allowing access to insights that can be used by retailers and producers to optimise their operations.

Retailers' benefits

- Optimised inventory management: With the facility of encoding more data (i.e. expiration and best before dates) into the 2D barcodes, retailers can improve their inventory management -*" which a lot of them need"* (E7). They will be able to better track every single item from the warehouse to the shelves to the points of sales, which would offer a much more transparent overview of their in-store stocks.
- Supply chain feedback: An improved inventory management would have a *"[...] ripple effect back to the chain"* (E7). As retailers grant the sales data to manufacturers and producers, these will be capable of better predicting their supply quantities, which can reduce the unnecessary overproduction. Producing what is needed and demanding what is actually being sold, can prevent tones of wasted food.
- Sales growth: Based on other countries' experience using the 2D barcodes, not only sales are expected to rise but also consumers' satisfaction rates, affirmed E7. Once buyers start to understand all the benefits associated with scanning the 2D barcodes in terms of food safety and financial profits, their level of loyalty will most likely

increase too (E7). Furthermore, closing the gap between predicted and actual sales can avoid overproduction, overstocks and as a result prevent wasting food.

- Accurate recall: The issue of recalls are usually undervalued because they are most of the times handled before reaching consumers - as long as there is not an outbreak (E7). But the reality is that under the current 1D barcode system, recalls results to be painfully expensive to both retailers and manufacturers. Every time there is a recall, supermarkets must discard all the products received from that specific manufacturer within a particular period, as the items are not individually identified with the corresponding batch number. So, considering an ideal but perfectly achievable scenario, in the event of a recall, retailers would be able to only remove those products belonging to the affected batch, while the non-implicated items would be saved from being unnecessarily wasted.

Overall, the use of 2D barcodes is undoubtedly a financially and environmentally sustainable solution for retailers, producers and manufacturers, which would benefit the whole supply chain from farm to fork, business and consumer-satisfaction wise.

Integrating GS1 Barcodes

As previously mentioned, optimising demand forecast and inventory management is the most obvious, efficient approach to preventing food waste in a sustainable long run. Likewise Tetra Pak (see State of the Art), manufacturers could turn packages into full-scale data carriers through the 2D barcodes, increasing traceability and transparency alongside the whole value chain. Additionally, besides the message printed onto the packages, consumers can access authentic information associated with a specific product by scanning the 2d barcode with their mobile phones, which allows them to make better-informed decisions. Ultimately, brand owners and retailers can directly interact with their target customers by offering tailored promotions and coupons to increase loyalty and boost sales.

The 2D barcodes will carry the data that manufacturers decide upon, depending on the purpose for which that data will be used and their interests. Nonetheless, to have a standardised solution that can be relevant for all the actors in the supply chain including consumers, the minimum input required should include the following GS1 Application Identifiers (GS1 AISBL, 2020):

- GTIN: Currently used in the 1d barcodes, will also be required in the 2D barcodes to uniquely identify every individual trade item at any point in the supply chain.

- Batch number: Associates a product with the information that the manufacturer considers relevant for traceability purposes. The brand owner and the manufacturer are responsible for ensuring the non-duplication of batch number, in cases where the same item is manufactured in different locations,

- Best before date: Indicates the end of the period under which the product is considered to comply with specific quality attributes. That does not mean that the product should not be eaten, but that quality will probably decline. This information may be interpreted by the retailers as the date to sell by, which will allow them to strategically mitigate the risk of wasting those products in an early stage.

- Expiration date: States the limit of consumption of a food product. Therefore, it indicates the likelihood of a health risk as a consequence of using the product after this date.

- Extended packaging URL: Contains the identification of a brand owner authorised URL to be used with the GTIN associated with that product.

With the 2D barcode as a backbone, three scenarios of the solution can be outlined as follow:

1) *Scan at home:* Consumers purchase their groceries in the supermarket through regular points of sales and scan the products when they arrive at their homes: This variant might not be sustainable on time since consumers will likely drop interest in scanning the products consistently. Unless the perceived benefit is remarkably bigger than the cost, there is a big chance that they will not commit in a long run. This reasoning is also supported by E7.

2) *Scan at the stores:* Where the self-scanning approach is already in place, consumers may scan the products at the store through a loyalty program that is integrated to the point of sales of the shop, such as the case of Salling Group with the Netto's Scan&Go app. The point of sale would then feed the consumer app with the purchase data and generate a digital receipt, which consumers can access later through their phone. In a second interview with E7, he pointed out his concern about this scenario landing in the limit of trust, whether the retailer will agree or not to share their sales data with a third party organisation that manages the consumer app. Because there is a load of market value that can be derived from the point of sales, which can be subject to security issues as it relates to competitors' access to that data. A solution to this could be creating a sort of encrypted system whereby every

retail can access exclusively their own data. In other words, all retailers can access to the consumers' app through a common API, which is connected to the retailers-owned app.

3) Self-scanning and pay: For those retailers that still remain with the old-fashion payment method, the app here suggested could be taken as a framework for them to adopt a self-scanning system that already has the consumers' side prototyped. Then, they could mould it by adding new features and customize the interface to their brand. Essentially, this scenario can be thought of as a two-module system: one for retailers' use and another for consumers, whereby the 2D barcodes will be the bridge that connects both schemes. By offering a self-scanning online feature for consumers' mobile phones, retailers can leverage their cross-selling promotions by sending discount offers and tailor-made suggestions based on past purchases. As consumers would use their own mobile phone to scan, it would free retailers of having to change their barcode-reader equipment for modern image-based scanners. As a matter of fact, not having to queue at the counter, will also represent an incentive for consumers to engage with the scanning and thus with the app itself, instead of counting on their motivation voluntary commitment. It is a win-win solution for retailers, consumers, and the environment. Agreeing with E7 in the second interview, this could be a great outcome.

In sum, this retailer integrated solution requires retailers to have a system that can be connected to the consumers' app, so the communication channel can be created. between both chains (supply and consumption). Shoppers are not meant to be a member of supermarkets' loyalty programs, but rather have access to every grocery store and decide which one they want to become loyal to. That decision will likely be made on the judgement of the customer experience that retailers offer through their products, their customized promotions, and their ethics. Put it simply, all supermarkets will be required to have their own app connected to the consumers' app here suggested through a common API. It can be argued that these new flows of communication from consumers to retailers will implicate a competitive advantage for those who adopt this solution. This, in turn, might encourage both retailers and manufacturers/brand owners to change the current trading strategies that are triggering food waste.

6.2.3 The use of ML algorithms

Together with the barcode scanner, ML is to play an important role in this solution as the algorithms eliminate the human biases in decision-making while always finding the best

possible option. The same way the British retailer Ocado uses ML to understand consumers' shopping habits and thus better forecast demand, retailers in Denmark can take the lead on this promising technology. To optimise the FSC, they will be able to accurately forecast to avoid overproduction and overstock. What is more, it will be possible to guarantee that the right products are sold at the right time to prevent food waste.

On the consumers' side, the ML algorithms will find patterns and learn about food-related habits of the households, creating more tailored suggestions of recipes and products to buy, helping them at the same time to make better decisions. Likewise Plant-Jammer's users (see State of the Art) householders can be more inspired by the using tasty-match combinations of products and ingredients they have in stock, thus mitigating the risk to get them spoiled.

An app with similar characteristics of Plant-Jammer can integrate a conversational AI with voice recognition. This would create more interaction with users in a simple and engaging manner. The AI-powered engine would learn from consumers' behaviours, their emotions, and improve over time their suggestions and predictions that can be used by retailers and manufacturers to optimize their food management. Users, in turn, would find a new assistant that knowing them so accurately, is capable to help them to prevent food waste and have a more pleasant nutrition experience.

In the interview with the data scientist of Plant Jammer (E9), he talked about what type of data can be collected from consumers to be used by retailers and producers to better forecast demand and optimise inventory management. E9 claimed that some of the useful data points include: dishes and ingredients consumers tend to eat; dietary settings and their changes through time, shopping lists and frequent purchases. What is more, there is a possibility that the ML algorithms can learn people's cooking habits and tastes, "[...] so we can better suggest what to cook next, preferably from sources that are cheap and more sustainable" (E9) Being this possible, when consumers start following the suggestions and see positive changes in their lives, they will most likely also change their shopping habits, which will need to be revised by retailers and brand owners in order to adopt more sustainable practices.

6.3 Functional requirements

From the analysis of consumers' interviews, especially the explicit wants and needs, seven main functional categories were identified. Despite the fact that no participant is required to

monitor her food waste, this feature will be added and a nudging element for consumers to be aware of their wasteful behaviour both in terms of money and food.

1 Customization

The app should provide the possibility for the users to enjoy a customized experience.

RF1: Personalize user profile by choosing:

- nutritional goals (organic, gluten-free, vegetarian, vegan, sugar-free, etc) and restrictions; favourite products.
- Number of a family member
- Budget limit per shopping to prevent impulsive purchase on real-time.
- Customize notification settings by choosing what kind of reminders the user wants to receive,

2 Recipes

The app should suggest recipes tailored to the user favourite food, health goals and diet restrictions, as well as create recipes with the products available at home

RF2: Suggest recipes for inspiration with products in stock, prioritizing ingredients close to expiration and considering user's profile specifications.

RF3: Create new recipes by searching for the ingredients in stock.

RF3.1: Save to favourites, share them with social media and personal contacts.
RF3.2: Adjust recipe according to # of eaters. automated resize of portions.
RF3.3: Filter recipes by preferred cuisine, type of diet, appliances.

3 Purchasing

The app should be able to create smart shopping lists automatically and manually.

RF4 Create an automatic shopping list: Keeping track of the inventory, favourites and regularly purchased products are automatically included, having into consideration the portions according to consumption patterns.

RF4.1 Turn recipes and meal plans into shopping lists.

RF5: Create new lists manually and turn recipes and meal plans into shopping lists, with needed portions and supermarkets where to find the products.

4 Barcode scanning

This feature is meant to facilitate the interaction with the app since consumers will not need to add the products manually. Additionally, it creates a pathway to connect consumers and retailers and improve customer experience.

RF6: Scan products' barcodes and collect all the information encoded:

- GTIN
- Batch number:
- Expiration date
- Best before date
- Manufacturer URL

RF7: Send alert push notification real-time during purchasing, when consumers are reaching/ crossing their budget limits as they scan the products and add to the shopping list.

RF8: Show products' information related to nutritional values, storage tips, expiration date and sustainability parameters including manufacturers reference.

5 Inventory

The app should provide an easy-to-digest overview of the products in stock, allowing the user to track their availability and suggest shopping lists accordingly.

RF9: Update the availability of products in different storage locations.

RF10: Send reminders when products are about to expire.

RF11: Monitor the left quantity and the expiration of products in order to suggest the repurchase if required.

RF11.1: Check out products consumed or wasted.

6 Meal Planning

The app should give the user the possibility to plan the meals over a period.

RF12: Create a meal plan on the chosen days, by allocating recipes already saved or after creating a new one for each type of meal (i.e breakfast, lunch, dinner)

7 Waste monitoring

The app should provide an overview of the user's waste in terms of food and money, as well as the repercussion of the food waste in the environment in terms of CO2/Methane emissions.

RF13: Calculate the amount of wasted food paired with money waste weekly, monthly and yearly.

RF14: Generate a report with the amount of GHG emitted per every product that was thrown out, as well as the money wasted.

RF15: Give the possibility for users to track their progress in a certain period or day.

Chapter VII: PROTOTYPE. Start to create solutions

Why is prototyping important? Taking on the words of Tim Brown (2009), the prototype speeds of the process of innovation. *"It is only when we put our ideas out into the world that we really start to understand the strengths and weaknesses".*

This section will contain the screenshots (UI = User Interface) of the different interfaces of the prototype with their respective explanations.

7.1 Design of the Interactive prototype

Building on the ideation sessions and the consumers' requirements, a high-fidelity prototype was built to turn all the ideas and solutions considered into a tangible, actionable and interactive product. This will facilitate testing the solution with potential users and spot the level of assertiveness of the whole concept.

UI # 1

"When you sell fire extinguishers, open with a fire" - said the advertising expert David Ogilby. This thought-provoking phrase reflects the logic behind making a first impression memorable by using a powerful attention grabber. In this case, UI 1 is the first interface consumers will interact with, which intends to awaken their pain of eating unhealthy food while at the same time giving them the relief of a cure to that pain. The combination of before and after images contrast the negative emotions with their aspirational vision; how painless and pleasant their lives would be if they engage with the solution. Branding also plays an important role here since the name (Mindfood) and the logo (a bowl with a plant) spread the sense of a mindful, green attitude towards food and health. This tactic will likely reinforce the power of anticipation, predicting a potential excitement or happiness provided by the interaction with the app. In parallel, the text in the centre aims to reinforce the effect of the visuals since it reminds users of their visceral pains -time scarcity and busy life.

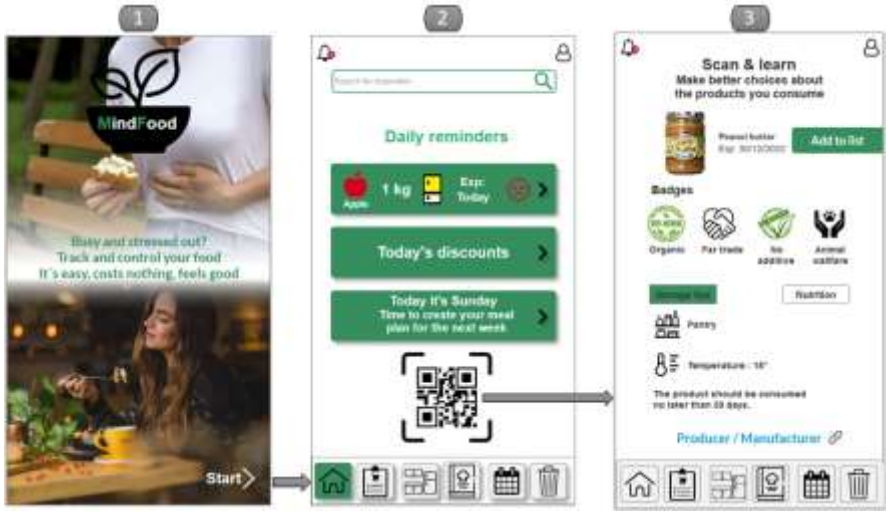
UI # 2

When the user clicks Start, she will land on the Home interface (UI 2), which shows permanently the daily reminders and the barcode scanner. The reminders are also sent as push notifications and are intended to keep the user updated about the expiring products, the supermarket's discounts of the day, which are tailored to her profile, create a meal plan and others. These are nudging elements that aim to persuade consumers towards the right decisions without forcing them. Each reminder is linked to an actionable interface, for instance, the expiring products lead to the inventory page so the user can choose what to

do with that particular product, whether find a suitable recipe or other combinations. The barcode scanner will capture the data encoded in the barcode (described in the previous chapter) and translate into a user-friendly interface.

UI # 3

When the user is at the store, she can scan the products' barcodes with the barcode scanner in UI 2, and see the information associated with that particular item in UI 3. In an easy-to-digest visual, the user will quickly grasp the most important data about the product she is interested in, like the nutritional values. The badges speak about the sustainability behind the production and other attributes. The storage tips teach how to store the product optimally to extend its shelf life as much as possible. In case the user wanted to know more about the brand owner of the product, she can access the link at the bottom, which will redirect to the manufacturer's website. When the user is convinced that she wants to buy that product, she can add to the shopping list.



UI # 4

The inventory (UI 4) offers an overview of what it is in stock, which the user can filter by category or storage. This is the main interface because it is the core that links to the rest functionalities. Therefore, it should remain updated to get the maximum value of the solution. For each product, the user has the option to input whether or not she ate or threw it out, as well as the amount remaining. This way the app can keep track of the available food in order to suggest recipes, update the automatic shopping list, and monitor the waste

over time. When the products are added through the barcodes or manually (for those loose items), the app will keep track of the expiration dates and will send reminders notifying or suggesting inspiring recipes with such products. The three-dot menu displays more options related to each product, such as suitable combinations, recipe suggestions and nutritional values.

UI # 5

From the inventory interface, the user will also be able to search for specific products in stock and choose them to create customizable recipes. The products will be listed in order of expiration date, making more visible at the top those which are closer to expiration and thus nudge consumers to choose them.

UI # 6

Once all the desired products or ingredients are selected, the user can then customize her recipe by filtering her favourite cuisine, available kitchen appliances, diet and more. The ML algorithms will search in the database and show five recipes that match the search criteria. Only a few options are advisable to prevent the user from decision paralysis. Such a thoughtful recipe engine will add quality and enjoyment to the users' life, as it turns cooking into an easier, convenient, and desirable experience.

UI # 7

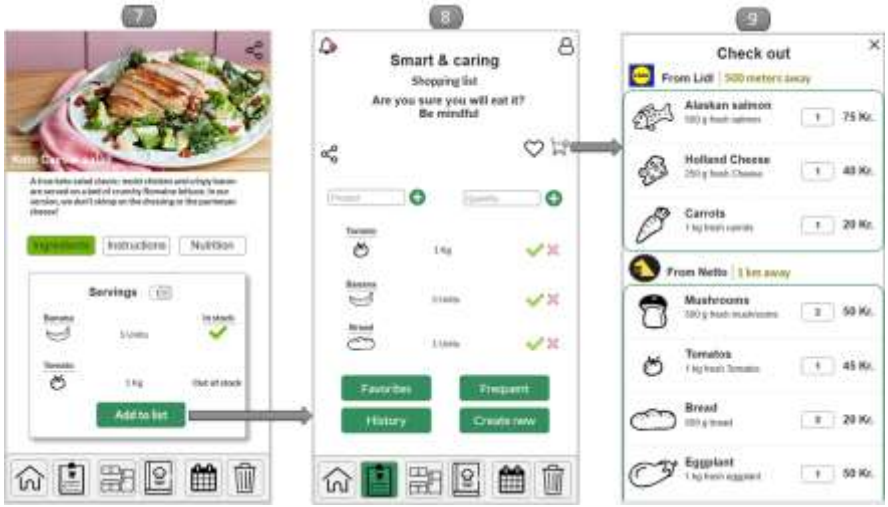
When the user chooses the desired recipe, the next interface provides useful functionalities that reduce friction in the moment of cooking. Besides the dish description, the nutritional values and the instructions, the app shows the availability of each required ingredient, allowing the user to add to the shopping list those ingredients that are out of the stock. Additionally, she can edit the recipe by changing ingredients for some of their homologous and the number of servings. Once tasted, if it is her wish, the user can save the recipe in Favourites as well as share it with the social network or phone contacts.

UI # 8

Smart shopping is another convenient feature that will ease consumers' lives. For those who already go grocery shopping with notes on their phones, this function is going to automate this process and optimise their purchasing experience. For those who shop by impulse or as they find appealing products in the stores, having a shopping list that is constantly updated according to the products in stock, will prevent them from buying unnecessary food. It is a precondition that the user keeps the inventory updated with the remaining food after eating or wasting it. While this might be perceived as a friction point since users do not want to input data, it certainly a minor needed action that will have a big positive impact in the household's eating journey. If the user does not want some of the products suggested in the list, she can delete it and add a new one. She also has the possibility to save that list into Favourites for future shopping. Only to make it even more helpful to the user, she will be able to search by History and Frequent for previous and recurrent purchases respectively, as well as create a new list. Finally, once she has accepted (by ticking) the desired products, she can confirm the list by adding it to the shopping car.

UI # 9

Once the list has been confirmed and added to the shopping cart, the user can see which supermarket she can find the products of her list in and their prices. This will reduce the friction of having to go to the supermarket just to find out that she cannot find all the products she needs there. With this overview, she can instead save a great amount of time by going to the supermarket where she can get the most of the needed food, or just plan the shopping more effectively and efficiently. This simple but bold feature will help her to save her most precious asset - Time.



UI # 10

Meal planning was one of the features most desired from the interviews, both for those who do not plan at all due to lack of time and for the ones who would like to plan but are too lazy to do it. Therefore, the meal planning function was considered in this solution to accommodate consumers' wishes. It is more convenient and wiser to plan the meals weekly, as the app can tabulate the total amount of ingredients necessary for the recipes and add them to the shopping list if the user commands so. To support consumers with this routine, the will app sends reminders on Sunday, suggesting to create the meal plan for that week. This is a little nudging notification that will remain as a reminder in the Home page unless they remove it. Additionally, the user can look into previous plans in the calendar (Old plans) provided she wanted to repeat them. In short, to plan a meal, the user will be able to allocate recipes for each suggested type (breakfast, snack, lunch and dinner) during the day, for the date they choose. To add a recipe to the meal plan, the user will have to click in the '+' sign to add.

UI # 11

Next after the "add recipe" command, the main interface for recipes will show up with some suggestions divided by categories; ready build recipes tailored to the user's diet restrictions, preferences, and goals. In addition, the user will have the possibility to search for ingredients or products available at home (UI # 12) and filter the recipes as she prefers (see UI # 5 and UI # 6).

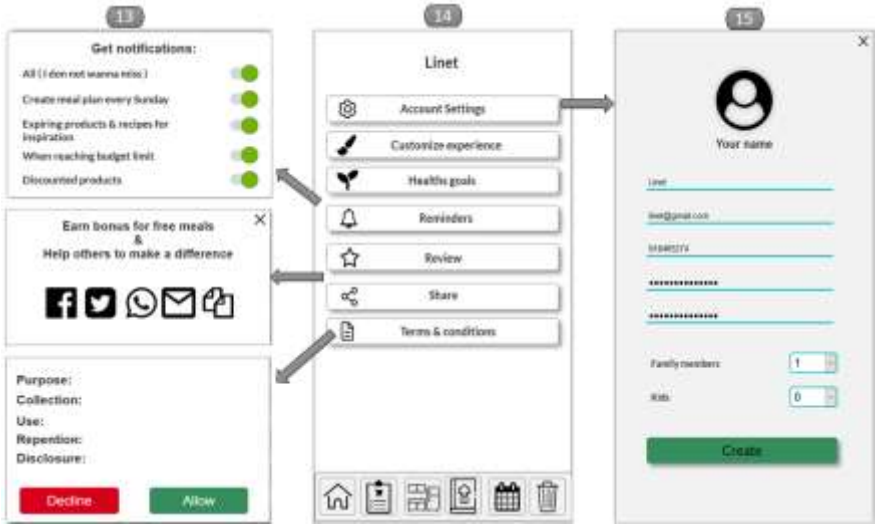
UI # 13, 14 and 15

In order to get the best out the features, the user is requested to complete her profile (UI 14). The first action required is the account settings (UI 15) where the user should provide basic personal information (i.e. name, email, phone and password) as well as the number of the household's members including children.

Additionally, the user can decide whether or not to receive notifications by deselecting the ones she does not appreciate (UI 13). Notice that initially, all of them will appear by default selected, a little nudging strategy to provide her with a better experience and at the same time help to prevent waste of food. That way, if the user really does not want notifications she should untick them manually.

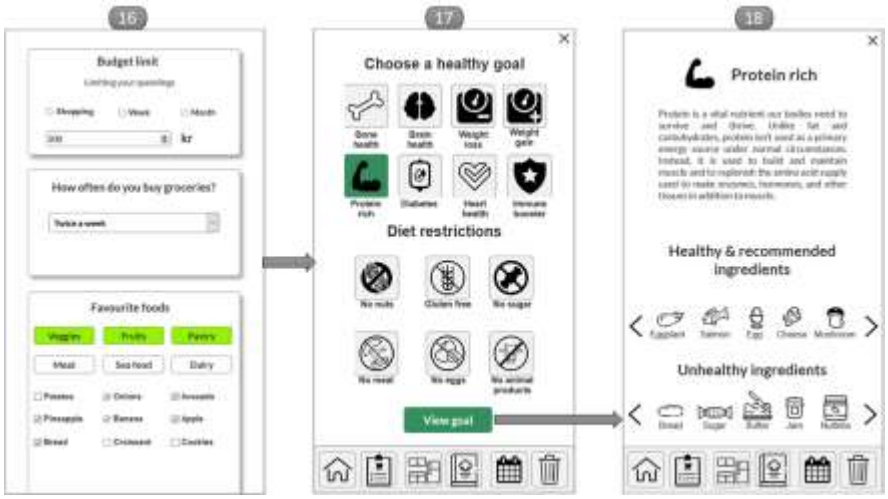
To motivate the user to share the app, the app will give rewards in terms of bonus or free items (UI 13) every time a new user creates an account through the link the user previously shared. This feature has to be agreed upon with supermarkets so the free stuff does not affect their profits.

Last but not least, the Terms & Conditions are outlined to ensure transparency and make the user feel safe with providing her data. This interface will explain the purpose for which the subject's specific data is being collected, what the data will be used for, as well as the period of retention and the disclosure agreement. After reading the conditions, the user has the right to decline or accept them.



UI # 16, 17 and 18

Customizing the user experience (UI 16) is fundamental to create a feeling of ownership, which may awake a sense of trust and cultivate the love for the product. Hence the user profile comprises a series of functions targeted to personalize the user experience with the app according to her needs and preferences. As such, the user will be able to set a budget limit, which will be reminded of as she reaches it when scanning the products at the store. The frequency of grocery shopping will be used for the smart shopping list and match the budget setting.



Additionally, the user will be able to select her favourite types of food, which will be used to suggest recipes and shopping lists.

To ensure that recipes are sufficiently tailored and will support consumers' health, the user will be able to choose her diet goals and restrictions (UI 17). For each goal, the app will show (UI 18) a description as well as the recommended (healthy) and unhealthy products associated with the goal/restriction chosen.

UI # 19

The waste monitor is, together with the inventory, one of the most relevant features from the viewpoint of engaging the user and triggering a behaviour change. The waste report shows statistics with the progress or degrees of the user in a certain period of time in terms of food and money waste. In addition, as well as the CO2 emissions associated with food waste. This constant feedback is meant to raise the awareness of consumers about her behaviour and motivate her to take action towards a more responsible attitude. That can help them to assess their eating habits in regard to the food they are wasting in bigger quantities. Because this feature is linked to the recipe engine and the automatic shopping list, consumers will be suggested recipes and purchases according to their consumption and wastage patterns. When they start seeing progress in their waste records and money savings, as well as the convenience of having an online inventory that makes their lives easier, they will most likely appreciate the value of this solution and as a result, engage in using it.

Notice that in every interface, there is a heading designed to implant a thought of self-responsibility and incentive in the user's head. Although texts need some cognitive effort, with regular use the message will most probably be assimilated.

Chapter VIII: TEST. Validate the solution

The testing was carried out in two phases with two different purposes.

1) Users' interaction with the app: Sought to evaluate the usability parameters as well as gather the participants' feedback.

2) Experts' validation: Aimed at assessing the extent to which the solution is aligned to the findings and the conceptual framework.

8.1 User's interaction

Once the prototype was ready to be tested, the same participants were contacted and requested their feedback of the solution that they helped to shape. On this occasion only three Single individuals showed their disposition to collaborate with the testing, thus no feedback from families or couples was possible to gather. Although initially, the intention was to conduct a focus group, due to logistics and time constraints, semi-structured interviews were the technique used once again. The questions pursued testing the nudges and emotional design elements, as well as the persuasion strategy. The ultimate goal seeks to validate with consumers and experts some of the most acknowledged principles (IDF, 2020) of human-centred UX design:

- *Usability*: Enables users to effectively and efficiently achieve their objectives.
- *Effectiveness*: It has the right functionalities.
- *Efficiency*: Requires minimum cognitive effort and time to learn and operate.
- *Satisfaction*: The interaction experience is pleasant.
- *Findability*: The features must be easy to find.
- *Desirability*: Is emotional, with good aesthetics and branding.
- *Usefulness*: Provides a purpose for the target audience.

8.1.1 Procedure

Once the participants agreed to take part in the interview, they were invited to an online meeting on Zoom where their interaction with the prototype was recorded. The prototype was uploaded online, using a feature in Axure RP 9 for easy access by the testers. After a brief recap about the nature of the research and the purpose of the test, the interview was split into two parts:

1) The participants were presented with the design of the app and requested to interact with it for about 10 to 15 minutes. As they navigated through the different interfaces,

they were requested to speak aloud to follow their thoughts in a more explicit manner. No specific set of tasks was given to participants since the intention was to observe their genuine performance as if they were using the app for the first time.

2) When participants finished the interaction, they were asked a set of questions with the combined purpose of testing the persuasive elements, UX principles and obtaining their feedback about the solution in general. As such, the interviews comprised the following open-ended questions:

A. What caught your attention when you saw the prototype?
B. What was your first impression, emotions?
C. How did you feel as you interact with the prototype? Why?
D. Would the app fulfil your expectations? Why?
E. Did you find it useful?
F. Were you able to navigate the prototype effortlessly and quickly?
G. What would you say to a friend about the app? Why?
H. What challenges do you hope to solve with the app?
I. Which features you appreciate the most and which not? Why?
J. How would you improve the app if you could?
K. Would you be satisfied with such an app? Why?

8.1.2 Participants' feedback

Part 1

As the participants interacted with the prototype, they would ask about the features whose function were not clear to them. Those questions shed light on the weaknesses of the design which needs improvement on next iterations. For instance, one participant was not sure about the purpose of choosing the health goals and what the app would use it for. She was also confused about the functionality of reviewing the app, which she initially perceived as a possibility to review her progress in the app. Similarly, she did not quite understand what were the bonuses or rewards. For a second iteration, these components need a revision.

Part 2:

When asked for the question 'A', one participant expressed that her first guess pointed to a vegan or vegetarian app that promotes mindfulness of eating, showing appreciation for the logo and the name, as well as the background visuals. That perception created an expectation (referring to question 'D') that would change when on the home page: *"[...] Instead of a more meditative experience it is more practical, a tool"*. This could be a two-edged sword as the surprise factor may either create excitement or disappointment,

depending on what the user is looking for. Another participant highlighted that the combination of the logo, warm colours, clean design, and background images gives a feeling of cosiness and sets the expectation of helping to improve her life. *"[The expression of the woman's face caught my attention the most, giving me that warm feeling. Seems like she is now enjoying her food after having some stomach pain because of bad food]".* The top picture caused a similar impression on another tester, who anticipated that the app could be about solving food allergies or health problems.

As a participant interacted with the prototype, in response to question 'C' and 'F', she recalled having felt excited in the beginning and comfortable alongside while navigating as it was easy to understand. *"[...]I felt curiosity, cuz immediately perceived it was a lot there. All the functions are interconnected which I appreciated"* - she asserted. Another participant coincided with feeling curious about how much the app could actually do, especially because there are many functionalities in one place: *"[...] I can replace several apps with this one, which is very convenient"*. While this interconnectedness of different functions might be highly valued by some people, others can find it overwhelmed without a proper introduction. *"[...] If there are a lot of features, I need guidance, a little walk through in the beginning to understand what we should do",* pointed a participant. For one of the attendants, the icons allowed her to explore the app effortlessly since she found them intuitive and self-explanatory. However, another person struggled with some icon representations, such are the cases of the trash bin for the waste report, the three-dot menu in the inventory, and the barcode scanner. For the last one and the former, *"[...] it did not seem clickable to me, nor easy to guess".*

When talking about the usefulness (question 'E'), a respondent expressed to have found the app very useful for her current routines: *"[...]This would probably replace my former shopping list, and add the meal plan which I was missing". Another respondent, however,* pointed out her appreciation about how useful the app would be for certain kinds of people, but not for her: *"[...]It is useful but I don't think I would use it. Because the main feature is the inventory, which I wouldn't use because I'm too lazy to keep track of what I eat or trash."* This observation may indicate a need for redefining the target audience in further iteration of the design thinking process. Aligned with this, *"[...] I would recommend to friends that are very schedule oriented, to busy people with no time, people who want to change their diet, and those who don't know what to cook. And I would promote the recipe, the meal plan"* - she stated in response to question 'G'. Another participant' accounts somehow support the previous argument by affirming that *"[...] the functionalities are very practical. Because I am the kind of person that likes planning then is very good".* For her, the highest value she

would convey to a friend is the integrated functionalities of suggesting recipes and suitable combinations with ingredients available at home. Likewise, another participant would promote the solution as *"[...] a great app to track your products, and nicely integrated with recipes, to change the way of cooking experience"*.

Among the common challenges that participants perceive the app could help to solve are:

- Make better decisions when buying food products.
- Prevent impulsive purchasing,
- Use all the products in stock by planning better.
- Keeping track of the products, especially the expiring ones.

When answering question 'I', the most appreciated functionalities among participants were the meal planning, the creation of recipes from the ingredients in stock and the reminders of expiring products. Talking about satisfaction, one participant emphasised: *"[...] If I was to use it, I would be satisfied, especially for the nice combo of recipe and inventory"*. Similarly, another person highlighted her favourite features as being *"[...] barcode scanning, the waste monitor, and the integration of the recipes with the inventory and meal planning"*. Some also welcome the storage tips for each product. Another feature welcomed by one of the participants was the product information that is presented after scanning the barcode.

Some general comments were given as recommendations to make the app more appealing. Among the most relevant improvement suggestions, participants highlighted:

- Co-create shopping lists with other users in the app, which would make room for people to interact within the same space.

- Share the progress on the waste record with other people in and outside the app, *"[...] So I keep motivated by getting some recognition while showing off how good I´m doing"*, which can also motivate others to use the app. This is a clear example of how the social comparison bias can trigger individuals to action.

- Reduce the information in the inventory interface; having fewer lines per product would help it to look less crowded and easier to grasp. *"[...] I might not need to know from the app where the food is stored"*

- Highlight the barcode scanner and make it easier to find from every interface. The icon is not intuitive enough, *"[...] I didn't know it was clickable"*. Additionally, *"[...] I would like to have the scan feature linked to the product I accept in my shopping list*

when at the supermarket, to make it more convenient" That indicates room for improvement of reducing friction with the affordance of some design elements.

- The three-dot menu icon is not very easy to guess because *"[...] usually, the menus appear in the upper right side of the interfaces".*
- The message on the front page is too long and does not make any change, so perhaps the text is not needed.
- It would be more intuitive to have a graph icon instead of a trash bin to represent the waste statistics. *"[...]The trash bin icon is usually used to delete items, and this is what I thought it was for"*, emphasised a participant.

8.2 Experts' validation

Some of the experts interviewed during the Ideation stage were contacted again for validating the proposed solution. This section will outline the feedback gathered from the perspectives of GS1 barcodes and retailers, the persuasive strategy, the UX design.

8.2.1 GS1 barcodes. Integration of retailers and consumers

Mads Kibsgaard (E10), on behalf of GS1, reaffirmed his interest to collaborate with such a project if it was to be implemented. However, he did point out three major preconditions that should be taken care of to materialize this project: 1) a strong business case for retailers, 2) customer demand, 3) legislation support. Beyond the benefits outlined in previous sections, there should be a proof of concept that demonstrates the economic viability for retailers.

When asked to E10 (from Salling Group), about the feasibility of this solution, he answered with another question: *"Why would a retailer like Fotex or Netto need that consumer app if they already have what they need with their app?"* According to E10, the swift to 2D barcodes will not change the manual work of visibly placing the products in the shelves unless they use RFID (Radio-frequency Identification) tags for automated location and optimised replenishment. *"[...]This would be too expensive to be profitable".* Furthermore, Salling Group already uses an ERP (Electronic Resource Planning) system to control the food waste by registering the expiration dates and automatically reducing the prices of expiring products. What is more, from their loyalty program they know what consumers are buying and with ML algorithms running behind they can learn consumptions patterns. From E10's feedback, retailers in such an advanced stage might not see a business case in the solution here proposed, as they will most likely claim that they do not need it. He rather

confirmed the concern of E7 about the unlikelihood of retailers sharing their sales data (captured on the point of sales) with a third party organisation referred to in the second variant of this solution (see section 6.2).

While all the aforementioned is a fact from the retailer point of view, E7 stands that customers have the power of demand. Therefore, as soon as consumers become more demanding in terms of transparency and traceability, as well as better customer experience, brand owners and retailers with the more competitive advantage will set the path towards new ways of doing.

When it comes to big corporations, however, there is no major force than legislation in place. While the entire FSC may choose to ignore a good business case and customer demand, no one can neglect government regulations. In this line, E7 suggested that engaged consumers' movements like "Stop Spild af Mad" and government organisations, may act as a catalyser to accelerate a complex change that involves such big players like retailers chains in Denmark. Overall, E7 remarked that the value of this solution stands for *"[...] expanding the supply change to the consumers"*.

8.2.2 The persuasion strategy

The expert in Neuromarketing, Professor Antonio Casals (E4) revised the prototype and found it attractive and simple. However, he detected two weaknesses: 1) a hook that motivates users to remain engaged and 2) a social utility. As such he asked: *"How are you going to ensure retention?".* One thing is to spark high motivation in consumers to start using the app, but after some trial and some required effort of interaction, that incentive will tend to decrease, E4 emphasised. As discussed in the conceptual framework, it is not enough to grab attention, there must be a reason to stick to it, *"[...] some link that creates addiction"* - in words of E4. Therefore, to avoid that a great idea is forgotten or even disregarded, there must be a strategy of retaining that incentive.

The professor agreed that the waste report may figure as a hook element since consumers can follow their own progress which can be a good motivator. However, he pointed to another dimension for that missing incentive. *"How might make that food waste serve a greater good".* For this, E4 suggested some mechanism to connect the app with NGOs dealing with food insecurity or hunger landscapes, such that part of the money saved as a result and the food not wasted, can be donated or redistributed to less privileged individuals. That way, not only consumers will have the double motivation (personal and social repercussion), but also will the food saved have a greater end. The latter, according to E4, adds viability to the solution since the benefits transcend to a bigger scale that might be of

interest to a potent force, such as the Estate. *"[...] A combination of waste and health could be a good attention grabber for the government as a responsible institution to provide social welfare".*

The key is to find a glue that links food waste with health and enjoyment. As such, the professor masterfully differentiated three powerful claims: *"More Health, More Wellness, Less Waste"*, which can be supported by visuals and messages that revive the pain and communicate the cure to that pain. Those claims clearly communicate the value of the solution not only for consumers but also for a greater good of society. To take the persuasive message even farther, E4 recommended that the claims are also present in the waste statistics where there may be a graph for the three dimensions. This way, consumers can monitor their health, wellness and waste progress, which can serve as proof of gain. Once again the professor reiterated "Less is more", to which he recommended to improve the welcome page of the app, by replacing the current message for the three claims and three icons that communicate each claim. Overall, he evaluated the persuasive strategy as noteworthy, with room for improvements in the areas of retention and proof of gains that link the consumer's motivation to a greater good.

8.2.3 UX design and ethics

Trine Falbe, Design consultant, teacher and author of the "The Ethical Design Handbook" in her review of the prototype did not find any problematic or manipulative design patterns. Her first impression however, was that the purpose of the app is not evident at first sight since *"[...] reducing food waste doesn't come across very clearly".* In fact, this perception corroborates that the persuasive strategy could be successful, as the intention is precisely not to present food waste as the main purpose of the app.

In spite of that, the icons in the bottom are intuitive to some extent, *"[...] for usability and accessibility purposes you could even add a label to each of them".* Like some of the participants, Falbe coincided with the confusion caused by the garbage bin *"[...] which I assume most people would read as -delete".* Hence, adding labels is a good idea, unless considering changing the icon. Additionally, Falbe called for consistency when she noticed that *"[...] there is no heading on the waste statistics screen, whereas all other screens do have a heading".* She also showed appreciation for the statistics on the week, month and year, *"[...] That's a super helpful and motivating feature".*

Along with the UX design feedback, Falbe's insights touched upon ethics in behavioural design when answering two major questions:

1) What are the ethical implications of a persuasive, emotional design that is targeted to a behavioural change?

Despite the fact that *"[...] wasting food would commonly be seen as problematic",* Fable pointed out that *"[...] utilising persuasive design patterns for any kind of behaviour change comes with ethical risk"*. Gamification is an example of how a fair intention can turn into an unwanted result -digital addiction. Addiction, beyond the shadow of a doubt, this word is as controversial as ethics. And thought-provoking enough is that two experts reviewing the same product have such antagonistic standpoints. While the professor Casals called for finding a hook that keeps the users motivated, Falbe's observation encourages to take a pause, and think critically to what extent it is ethical to *"[...] seizure people seizure-inducing design elements/ triggers (e.g. "buy now! "the last one!", "you're wasting too much food!").*

One can argue that, depending on the context, 'the end justifies the means'. However, how far can we go with this claim and what is the line that bounds an ethical design from a non-ethical one? Whichever the case is, the design thinker bears total responsibility of reflecting about the types of patterns used in a digital intervention. Yes, emotions as we know by now, are *"[...] very powerful as a catalyst to change behaviour",* but, to what extent is permissible and reasonable to stir people's mental states in the name of behaviour change for a greater cause?

Landing at a more tangible arena, yet not less controversial, Falbe's insights about privacy respond to:

2) How can privacy by design be embedded and noticeable in the prototype?

According to her, this can be done by following a few rules:

A. Only ask for information that is actually needed. This is applicable to profile information as well as the data for the ML algorithms.
B. Only send to the cloud the data that the ML algorithms need to operate, leaving the rest on the device.
C. Communicate to users what data is being collected and for what purpose.
D. Place the Terms & Conditions should be embedded in the signup process, so users can accept them or decline them before creating their accounts.
E. Make it easy for users to delete their account and data. It should be as easy as signing up.
F. Do not sell or share the data with a third party. This means avoiding using Google products in the building of the app.

Provided that these basic rules are respected, one can argue that the app has embedded privacy by design. This first iteration of the prototype complies with statute C; the rest cannot be seen at this point since A, B and F are to be regarded in further stages of development. The latter, nonetheless, is a principle that is embraced from initial stages since it was also pointed out by consumers as a concern. Although the design does have a section for Terms & Conditions, it does not appear as part of the signup process, so this is also to be amended in future versions. Rule E is simply a matter of adding an option for users to delete their profile in the account settings, therefore, this defect is quick to amend.

Overall, Falbe highlighted, *"[...] user privacy can only be ensured as long as the data cannot be pinned to an individual, and when it's not shared with a third party who might use it for purposes like marketing".*

Chapter IX: DISCUSSIONS

This chapter contains a dissertation of the main findings as they relate to the purpose of this research, the State of the Art and the theories. Here it is where all the previous chapters converge to make sense of the whole research and discuss the implications of the results as well as the limitations of the solution proposed and the study. Recommendations for future research are stressed at the end.

9.1 Summary of findings

The empirical work of this research builds on the sociological frame of food consumption, which explains what influences the relevant routines that consumers carry out to acquire, prepare and eat their food. As outlined in section 1.1, individuals' values, interests and personality traits shape their consumption habits. This is relevant because we cannot persuade people to avoid food waste without first understanding the human relationship to food. This implies the combination of nutritional, symbolic and social aspects of food, which vary according to people's beliefs and behaviours.

The findings confirm these precepts through the accounts of the interviewees, which suggest that the eating and wasting habits of consumers are shaped to a great extent by values from their upbringing, their social concern and personal relation to health. As a result, people with high appreciation and respect for food as well as empathy for social differences tend to be more conscious about food waste. This, unfortunately, does not always correlate with less *wasteful behaviour*, as opposed to what some of the previous research contend (Stancu & Lahteenmaki, 2018; Boks & Hebrok, 2017).

In Denmark, previous research discussed the major causes of food waste, such as inappropriate planning, impulsive purchases, poor inventory management and people's motivations. My findings support these claims to a great extent, however, they do not agree with studies that find 'money-saving' to be the greatest motivation to avoid wasting food (Stancu and Lahteenmaki, 2018). Instead, individuals' ingrained values are more important than financial concerns in most of the accounts, as incentives to save food.

While previous studies have focused on triggers to domestic households and acknowledged behavioural factors as one of the major causes of food waste, little has been written about what *drives* certain behaviours. As pointed out in section 2.1: before aiming to change behaviour, we need to understand *why* people do what they do. Henriques' (2019) study indicates that people's beliefs speak to their values, which is supported by my findings. It is important to remember, however, that the analysis of the present data is subject to

interpretation bias of the researcher. Moreover, interview accounts should be taken as just that -- verbal descriptions that open a window into people's belief systems and mental models, but not necessarily the full picture of their motivations. Therefore, the findings provide a partial revelation of the data captured through the lens of the conceptual framework and the State of the Art.

I structured interviews to gather data regarding food-related practices (planning, purchasing, storing, cooking and discarding) as well as the characteristics of individuals and their relation to technology. I have kept a close eye on what other researchers have previously found, as well as new patterns or correlations. In particular, my results support the studies of Stancu & Lahteenmaki (2018) and Boks & Hebrok, (2017) in that:

- Individuals who purchase their groceries without proper planning tend to waste more food more often.
- Storing food without keeping track of products' expiration dates is a secure cause for waste. People tend to neglect what they already have.
- Big size packages in supermarkets do not accommodate single individuals.

However, my findings do not confirm that exclusively families are the type of household that tend to waste more. Even though it might seem that families tend to buy more food and therefore waste more, single individuals with an unplanned and busy life, with no consistency in their behaviour as it relates to food consumption, tend to waste as much as families do. What is common among singles, however, is the desire to eat healthy, tasty and varied. Although not precisely the mainstream, environment-friendly decisions seem to be transforming into a popular mindset.

The findings provide new insights concerning the food consumption chain, demonstrating the interconnectedness between all the stages; one influences the other, creating a domino effect. Ideally, a solution to domestic food waste has to consider all the phases in the chain, as opposed to having separate tools with isolated functionalities that are not connected.

Another contribution to the research literature is the analysis of consumer biases. Among the most common emotional triggers that can be either counteracted or exploited are social norms, the sense of community/belonging, the social comparison, the self-control, loss aversion and status quo bias. Much of the previous research that addresses the causes of food waste in households report on individual traits and behaviours, but involve little discussion of the reasons *behind* such behaviour. The interviews highlight the struggles,

the challenges and frustrations that consumers experience in their private lives, that leads them to waste food. Compared to lack of time, or concern for eating healthy food, food waste does not figure as a problem *per se* for participants. This insight must be the baseline for any attempt to address food waste.

9.2 Defining the problem

Understanding digital nudging was crucial to identify consumers' biases and to design a choice architecture that can be able to influence their decision-making while preserving their freedom of action. Plutchik's wheel of emotions together with Norman's three levels of emotional design provided a recipe for a persuasive strategy that encouraged people to make better decisions for them. As such, I worked on a design that meant to spark a cocktail of negative (i.e fear, regret) and positive (i.e anticipation of joy) feelings. As suggested by Morin and Renvoise (2018), that is an effective blend to create predictable choices. Once the attention is grabbed and the decision to use the app is made, it is a matter of providing the consumer with a reason strong enough to stay committed and consequently change their attitude. When individuals can keep on track of their own behaviour, and reflect over the values derived from interaction, a virtuous circle emerges, and sustained behavioural transformation results. People can even become ignited to influence *others* because their experience fits their self-identity and a vision they can relate to.

Single men and women are the target audience that matches the ideal user. Singles tend to have less planning and consistency in their shopping, cooking and eating routines. Additionally, compared to families and couples, they were more enthusiastic about the idea of trying a tool that supports them with their health goals and contributes to the greater good -- a less wasteful world. As such, this Persona is a representation of a young busy, single professional, with a mindful attitude towards food consumption and the environment.

The combination of consumers' accounts, experts' insights and the backup of the theoretical constructs that support this research allowed me to build empathy and gain a better understanding of consumers' needs which can be translated into the following problem statement:

Busy working professionals need an easy, time-efficient and convenient way to eat healthily because they often lack time to plan how to shop and cook tasty plant-based meals.

If busy working professionals start using a desirable, usable and convenient tool that helps them to eat healthily, they will change their behaviour towards more responsible consumption, and as consequence, prevent food waste.

In sum, the most relevant contribution that emerges from the findings is that food waste does not represent a problem *per se* for consumers in Denmark, nor a need that they directly relate to. In order to be efficient, interventions to prevent food waste in Danish households should not seek to appeal to the abstract goals of environmental ethics, but rather direct themselves towards the consumers' own goals. That is why understanding people's frustrations and motivations is so crucial. Finding ways to nudge people to take action, and to consequently change their behaviour as they interact with the proposed digital tool, has been the mission of my research.

9.3 Solving the problem

Drawing on Holzwarth's (2019) insights regarding 'fuel' and 'friction' as forces to change human behaviour, I designed a solution to reduce the barriers between the motivation of preventing food waste, and the consequent action. A desirable, usable and compelling design is most likely to encourage consumers to use a solution for their needs - a convenient tool that will make their lives easier. Aligned to what previous research suggested in regard to solutions that could impact consumers' behaviour, participants overall agreed on needing help with meal planning, recipe suggestions and track of products in stock. A convenient, desirable and usable tool that supports consumers to achieve their health goals while adopting a responsible attitude, should be able to:

- Provide a customizable user experience.
- Suggest recipes with the products available at home.
- Create weekly meal plans.
- Turn recipes and meal plans into shopping lists.
- Create automatic shopping lists according to regular purchases, actual consumption and preferences.
- Provide an overview of products in stock and update availability.
- Monitor the waste of food and money over a period of time.

On a broader scope, and in line with the main research question, the present study considers the GS1 2D barcode as part of the solution. The inclusion of a 2D barcode scanner in the app would expand the supply chain to consumers, creating a new channel through which producers and retailers can directly communicate with shoppers. This will generate data points that can be used upstream in the value chain to improve the demand forecast and customer loyalty. Since the 2D barcode will contain the expiration date and the batch number of products, both retailers and consumers can optimise their inventory management. Beyond tracking their products in stock, householders can access more

information about the products they buy, which adds transparency and better decision-making in moments of uncertainty. Additionally, they can benefit from tailored discounts.

The process of coming up with a solution that matches consumers' needs, required knowledge about the State of the Art of relevant research, a solid theoretical framework, as well as the data collected in the interviews with consumers and experts. This study has explored previous research on the topic, as well as ICT-based initiatives with similar missions, and provided initial hints of what needs to be in focus when researching the causes of food waste.

The theoretical concepts provided the foundation to empathise and understand consumers in order to find the pains beneath their behaviours. Equally important, the concepts of emotional and digital nudging guided me to design a tool with the potential to work, and to change users behaviour over time.

Consumers interviews vastly confirmed previous studies, and provided the primary source upon which to draw assumptions and potential solutions to their needs. Last but not least, experts' insights corroborated the theories and even provided new directions to explore, as in the case of the persuasion code of Neuromap and the importance of communicating the message to the primal brain.

Moreover, the data captured by the 2D barcodes and through the users' interaction with the app, can provide crucial data, stored in the Cloud and processed by machine learning algorithms. The cocktail of digital nudging, emotional design, persuasive strategy and barcodes can be combined and embedded in a neural network of machine learning algorithms. These can be trained to learn users' habits of eating, shopping, and cooking, in order to find the best options tailored to consumers' preferences.

9.4 Limitations

Limitations of the solution

Although many are the benefits of using a 2D barcode, according to GS1 experts (see section 6.1), there are noteworthy challenges and barriers that might hinder its inclusion on this solution.

1) Since the inclusion of 2D barcodes might slow down the production speed (for reasons previously explained in section 6.1), it would be challenging to convince manufacturers of the 2D barcodes' advantages.

2) At the retailer level, scanning 2D barcodes would require new equipment that might be costly thus used as an excuse to retain the current status quo.
3) The consumer's willingness to scan the new 2D barcodes on the products in the stores.
4) Without a strong business case for producers and retailers, customer demand and legislation support, it might be difficult to make them adopt this solution.

The insights from the IT consultant in Salling Group endorsed some of the burdens above, while diverged with the relevance of the 2D barcode promoted by GS1. For big retailers that already have implemented loyalty programs and self-scanning systems, the proposed solution might not be so attractive from the business perspective. They might not see a need in changing their current mechanisms to manage their inventory under the goal of preventing food waste. Likewise, consumers, it is not such a pain for them. Hence, unless it is possible to demonstrate the economic viability of this idea, there is a risk that the concept will need a redefinition. For instance, disregard the integration with retailers may be an option, or consider scenario '3' of the solution (see section 6.2), which would involve smaller retail companies on the way of developing similar initiatives. For those cases, having the prototype of the consumers' app can represent an attractive option that impulses them to build an integrated system like described in section 6.2.

In the worst-case scenario, not having the barcode-scanning feature would signify for consumers that they will need to input the products' expiration dates and quantities themselves. This might represent a reason for discontinuing the use of the app in the long run as it will not be perceived as convenient and time-efficient.

Summing up, the solution proposed in this research requires retailers on board and the inclusion of 2D barcodes to be effective to the goal here pursued -preventing domestic food waste while benefiting both consumers and the supply chain. The absence of one of those factors will implicate a distinct product, which will need a different approach and consequently a different research objective. Yet, chances are that with the right collaboration of the government organisations and the masses, this solution can find a way out and thrive.

Limitations of the study

The results of this work have been to some extent shaped for a worldwide phenomenon that disrupted everyone's life in the spring of 2020 - COVID19. Due to the unprecedented circumstances, the methodological choices initially planned were constrained and had to

adapt to the current possibilities. The first repercussion affected the recruitment of the sample population for the qualitative interviews. What initially was meant to be an organic face to face recruitment at the supermarket venues, switched to reaching out to consumers through Social Media and worth of mouth. In addition, consumer hoarding during the pandemic meant that retail managers were even busier than usual and unavailable to attend student projects in the middle of the pandemic. Therefore, the study was not able to gather much insight from these actors.

The pandemic also shifted the intended setting of the interviews, which were intended to be held in a warm, trustful environment where participants felt comfortable to speak openly. That was replaced by ZOOM, Skype and Facebook Messenger calls, in some cases without face contact, as this was requested by some interviewees The online alternative did not allow much proximity. This shift inspired me to adopt a somewhat more sceptical approach to interpreting the data, based on the sense that interviewers spoke more in “front stage” mode. However, the theories and the experts’ insights served as a solid point of reference whenever a reliable source was needed. The wider triangulation of data - between lay participants, experts and research literature - created the basis for achieving genuine discoveries.

COVID19 also limited the methodological tool kit in another sense: I had intended to conduct focus group interviews for testing the prototype. With regulations of social-distancing, and people’s fear of contagion, it was no longer possible to gather groups for a workshop. Hence it was necessary to resort to online interviews once again. The link with the prototype was sent to participants, who shared their screen with me while interacting with the design and spoke loudly their impressions. While this option lost out on the dynamic advantages of a focus group, the one-on-one conversations nonetheless allowed more focus on what every participant reacted to, and more time to explore different scenarios and alternatives.

It is beyond the scope of this study to dig deeper into the technicalities for implementing the digital solution, including the front and back-end algorithms. Moreover, the financial dimension that would explore this solution as a business case has been left out. In other words, anything that falls beyond the testing of the prototype, which is the last stage of the methodology, is not included in this study. Nonetheless, the knowledge here presented can serve as a foundation for further research to build upon a human-centred solution that contributes to the fight against food waste.

9.5 Recommendations and future work

The scope of this inquiry sets the groundwork for further research. A number of actions are recommended in order to move forward:

1) As suggested by the design thinking approach, several iterations should be carried out before obtaining the last version of the prototype that will be implemented. Therefore, the feedback of users and experts should be revised and, where possible, included in further iterations. As regulations of social distancing are eased, a new version should be tested through the focus group technique with a purposeful sample.

2) Secondly, the prototype can be tested with a larger sample, after the functionalities of barcode-scanning and inventory management are implemented. In a pilot test, a group of individuals/families can be granted barcode generator software, so that they can generate barcodes, print them and put them on their products. Next, they will be able to scan the barcode with the demo app and see whether the products are added to the inventory, which they should be able to update by marking products as eaten or discarded. This pilot test is doable and practical, and does not require collaboration from manufacturers or supermarkets. The support of GS1, and a larger sample that can provide feedback for other features, could at a later stage inspire retailers to take action, and serve as a proof of concept that inspires government / civil organisations to collaborate.

3) Further research could expand the scope to analyze the internal situation of the retailers, their inventory management process, as well as the challenges they face with the food waste issue. That might reveal other angles from which to understand the problem and therefore widen the spectrum of alternatives to solve it.

4) A financial analysis should be carried out in order to explore the economic viability that the solution here proposed represents for retailers and manufacturers. This kind of study would fill the gap in this research and move the potential implementation to the next level.

5) The government could help by legislating regulations that impose or incentivize the inclusion of the 2D barcodes, and a mechanism that connected consumers with the rest of the food supply chain as a means to prevent food waste.

6) Given that all players in the food chain contribute to the problem of food waste (albeit some more than others), there should be more collaboration among the different agents, based on a common goal to prevent food waste. If NGOs, government organisations and consumers who fight food waste join forces, chances are that they will succeed.

CONCLUSION

Much of the recent research points to behavioural factors and individual characteristics as major triggers of domestic food waste. On the other hand, it also highlights the disconnection between the supply chain and the consumption chain, whereby once food is sold, there is no way to concretely monitor what happens to it in households. Consumers are entitled to decide how much they use the food that they purchase and how they dispose of it. As there is no way to control private spaces, the way in which food is eaten and wasted, is entirely up to consumers' attitude. Therefore, understanding how to change that behaviour has been the mission of this body of work. According to sociologists and psychologists as described in section 1.1, human behaviour is usually shaped by personal beliefs, motivations, values that are situated in the specific social context. Hence, this thesis project explored the household environments together with individual characteristics in order to find the causes behind certain types of behaviours. By diving into consumers' universes it was possible to understand their needs, in order to find a common ground in which the issue of food waste can be addressed while resolving consumers' challenges.

As such, this research pursued to answer the following three research questions:

- Main RQ: How can a digital intervention nudge householders to prevent food waste while benefiting the food supply chain in Denmark?
- RQ1: How can the design of the application engage consumers to use the technology, while influencing their behaviours?
- RQ2: What are the challenges and barriers that affect the feasibility of the proposed solution?

Answering the research questions

The main research question led to exploring ICT-based interventions that had previously been implemented with the objective of preventing food waste, especially at the household level. That included mostly mobile applications since everyone nowadays has a smartphone, therefore the affordability and easier adoption is more likely. Knowing what is already out there helped identify the features that people are familiar with, and which are bearing impact on their food routines.

The current state of the Art provided the context to formulate the interviews' questions that gave birth to consumers' insights. As the core issue of this study revolves around human behaviour, machine learning as a subset of artificial intelligence was integral to exploring

the realm of ICT. There is no other technology that simulates the human brain better, while learning behavioural patterns to improve decision-making and make significant predictions.

The GS1 barcodes were considered for the second part of the question, as a bridge to connect consumers and retailers, in order to provide the latter with more data to improve demand forecast and inventory management. This would in turn help prevent food waste since they will be better able to predict future sales from the consumption patterns, and therefore reduce the amount of food unsold and thus wasted.

The RQ1 led the research towards theories of emotions and behaviours, which culminate into emotional design. The concepts explored in this domain together with 'digital nudging' theory, provided the knowledge to apply towards the design of a tool capable of engaging consumers and influencing their behaviour. Although this needs to be tested in order to claim the effectiveness of the theories, this first iteration laid out the groundwork for further research and practical actions to take new steps.

Both experts' interviews and State of the Art brought new insights to answer RQ2. In order to prevent food waste, accuracy and transparency in the food supply chain must happen in the earliest possible stages. The challenge lies in finding a way that does not interfere with the economic interests of the bigger stakeholders - the retailers. The findings reveal that any change in the supply chain may have a ripple effect, whether positive or negative, depending on the perspective.

From the consumers' perspective, having a tool that supports their health goals and makes their lives easier while avoiding waste of money and food, will most likely be welcome. However, including a 2D barcode and integrating a consumer app to their existing systems, could be regarded as disruptive by retailers. Manufacturers may also see little benefit from it. However, a holistic view of the problem of food waste in the FSC, shows that one small change can create a win-win situation, even though it may require some initial disturbances. Nonetheless, long term progress is not possible without experiencing inconveniences in the beginning. Digital disruption was a part and parcel of every big innovation that positively impacted humanity, such as the proliferation of mobile phones and the world wide web.

Methodology

Answering the research questions with the consumers as a central focus, required a methodological framework that provided a human-centred design approach which challenged initial assumptions. For instance, this study began with some expectation that consumers were attentive to the environmental consequence of food waste and would be

keen to consider a digital intervention that aimed to reduce such harm. However, the discovery that consumers do not seem to consider food waste a problem in their own lives, would not have been possible if the research methodology had not been open to new insights grounded on the data inductively analysed.

For human-centred research, the design thinking method was a perfect match. This framework provided a structure to walk through consumers' explicit accounts and "step into their heads", to understand their context, empathise with their pains, and find the cure to make their lives easier and more enjoyable. Through qualitative semi-structured interviews, consumers shared their motivations, desires and frustrations, which helped to build empathy and understand their context using the Empathy map. When the most essential needs were identified, using the Personas technique helped to define and present the target audience, which for this first iteration happens to be the single individuals.

With that knowledge as a foundation, it was possible to define an actionable design problem that described the users, their needs and the insights derived from the data analysis. With the user and the problem statement defined, experts' insights were gathered through qualitative semi-structured interviews that substituted the brainstorming technique in ideation sessions. The questions were directed to explore the different areas of expertise related to the conceptual framework. As such specialists on food sociology, customer behaviour, sales, neuromarketing, GS1 standards, UX and interaction design shared their insights about how to address the problem and the research questions from their field of competence perspective. As suggested in the ideation stage, all ideas were welcomed, analysed and synthesised towards a potential final solution for this first iteration of the design thinking process. This phase included the definition of the user requirements, which were to a great extent formulated based on consumers' needs and their desires as captured during the interviews.

In phase four, all the pieces of the puzzle were assembled to create the prototype. The creation of the prototype not only took into consideration the user requirements and experts' ideas, but also the nudging and emotional design elements discussed in chapter II. Before creating the high-fidelity prototype presented in chapter VIII, I revised the tech initiatives listed in chapter I and others not mentioned, to gain inspiration from similar solutions. After that, I sketched the different interfaces on paper (see Appendix 5), with the respective explanations of the functionalities and texts. The low-fidelity prototype was very similar in appearance to the high-fi except for the absence of colours and clickable interactions. This step facilitated the design of the interactive prototype that the user tested.

The testing procedure included the users' interaction with the prototype and a review by some of the experts previously interviewed during the ideation phase. In this stage, usability parameters and user requirements were evaluated, as well as the effectiveness of the emotional design and the persuasive strategy. As for the validation, the review from GS1 barcode, retailer, neuromarketing and UX design perspective, spotted some opportunities for improvement and provided a critical reflection of the solution. Besides the small visual changes in the prototype and in the persuasive message, a major concern about the feasibility of this solution is the retailers' reluctance to adopt initiatives that disrupt their status quo. Introducing GS1 dynamic barcodes and integrating a consumer app to their ERP systems, will require operational changes that they do not seem to be willing to undertake. Unless major government legislation or public pressure including consumers' demand push them forward, there is a risk that this solution will be neglected from their side.

While both users' and experts' feedback were highly valuable at this stage, the ultimate goal of the test was to evaluate the extent to which the users were satisfied with the solution. In this regard, consumers showed a high level of acceptance and enthusiasm, which implies that the usability principles and emotional design parameters are achievable in practice.

Results

After examining the State of the Art, the theories, and executing all the steps of the methodology, the results are consolidated in an interactive prototype that applies the principles of digital nudging, emotional design, and persuasive strategy, as a response to the main research question. A convenient tool with a desired, user-friendly and compelling design that helps consumers to eat healthily, might drive them to adopt a more mindful attitude towards food consumption and waste. The other dimension of the solution encompasses the integration of an image-based barcode reader able to scan the 2D barcodes of retailers' products. This feature would connect consumers and retailers in a way that benefits both. Consumers at home would be able to better monitor and manage their products' expiration dates, leading to less food waste, while retailers optimise their inventory management and demand forecast.

Relevance

Having this bridge that merges the supply and the consumption chain, opens a new communication channel to increase transparency and accuracy throughout the FSC. By connecting these stages, it will be easier to access data points to inform producers and retailers about the actual consumption and therefore improve demand forecast. The ML

algorithms that run behind the proposed app would help suppliers to understand consumers' habits and thus make better predictions to avoid overproduction and overstocking.

With this tool, householders will be assisted in all the practices related to food consumption. From shopping to discarding, they will have guidance towards responsible purchases, mindful cooking and minimal waste. The fact that they can track and monitor their own waste might raise their awareness, serving as a mirror of their own behaviour. Turning the use of the app into a habit will most likely influence them to adopt a more responsible attitude, which in turn will decrease their levels of food waste. Although behaviour change cannot be tested that same way as a prototype, the drop in that 50% of today's domestic households will incrementally demonstrate the validity of this research.

The expansion of the supply chain to include the consumption stage might change the paradigm of the current food system. This will lead to more collaboration and synchronization among all the actors, which in turn translates to more transparency and a shift towards a more human-oriented approach. Until now, the food value chain stops at the retailers' checkouts, and from that point on, consumers are entitled to handle their food with no guidance or monitoring to help them adopt the right attitudes. This solution will change that by providing the missing connection between two forces (suppliers and consumers) that can work together to contribute to a greater good - preventing food waste.

As both consumers and retailers are important links as well as the major contributors of food waste in Denmark (see Introduction), whereby household waste accounts for 50% of the total, this research considers them key pieces in the proposed solution. Wherever there is a food chain, a consumer and a mobile phone, this solution can thrive, provided the involved parties collaborate towards a common cause. Food waste is not a local or regional problem; it is a global problem. Most importantly, it is a human problem and hence applicable to different contexts. Whereas the key stakeholders might change, linking and mobilising them is the only practical approach to minimising food wastage.

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