VEGGIE-TABLE: DESIGNING AN INSPIRING TOOL TO ENCOURAGE THE CONSUMPTION OF LEFTOVER VEGETABLES AT HOME

MASTER THESIS
August 2017

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Veggie Table

save, inspire, create

PREFACE

This MSc graduation thesis contains the design of "Veggie-Table", which was executed from March to August 2017. The project was the conclusion of the Master's programme Design for Interaction at the Faculty of Industrial Design Engineering in Delft (TU Delft), in the Netherlands.

The project was conducted in three phases: user research, conceptualization and final design prototyping. Through the design process, a product resulted that consists of a leftover vegetable container and a mobile application, and seeks to reduce vegetable waste in Dutch households. The aim of the product is to encourage users to consider using half-used vegetables first when preparing ingredients, by providing a vegetable management tool with a combination guide of three vegetables groups (Root & Tuber, Flower & Seed & Fruit and Stem & Leaf).

I would like to thank my supervisors for their professional support and guidance during the project. I also wish to thank my university friends, who always listened to my concerns regarding this project and offered their critical opinions. Specially, thank you Youngsil Lee and Myrthe Büskens, for being with me at IO. You always cheered me up, debated on my research and design with me, and gave me so many inspiring ideas. I would like to mention the faculty's Model Making and Machine Lab (PMB) staff, without whom I would have been unable to build a prototype. I also want to thank all participants, without whose cooperation I would have been unable to conduct interviews and complete my graduation project.

I want to express my appreciation for Thomas, who stood by me no matter how difficult the moment and supported me during the entire graduation project. His wise counsel and kind words have been immensely valuable to me. Lastly, I would like to extend my gratitude to my mother in South Korea, whose trust, endless support and love have kept me going to eventually finish my master study.

For the past two years of study at TU Delft, I have learned about user-centred design and practical design-research methods. I have been able to polish my design-research skills through lectures and company projects within the university. Furthermore, I have tested my personal goal to become a social designer who considers creations' high sustainability and impact on society. In my opinion, I have gained sufficient practice in design-research skills and hope that I can continue to pursue my goal in my future career.

I hope you enjoy your reading.

Eunyoung Go

Delft, August 2017

EXECUTIVE SUMMARY

Food waste is the fastest growing issue of our time. Countries in the EU discard an estimated 89 million tons of food every year. Worse, the food waste will increase to about 126 million tons in 2020 if we do not take action (European Union Committee, 2014). Moreover, most countries are burying food waste in the landfills. This manner of disposal produces methane gas because of the high water content of wasted food, and even contaminates soil and water that we are relying on to live (Osteen, C., Gottlieb, J., & Vasavada, U., 2012). As solutions from food-related organizations and the government, many public campaigns and strict regulations have been carried out to decrease food waste at the production and consumption levels for years.

This graduation project started from the global interest: **the reduction in food waste**. Specifically, the project aims at the consumption level. The reason is that twice or three times more food waste is produced at the consumption level than at the other three stages, which are production, processing and distribution (European Court of Auditors, 2016). Furthermore, in the consumption level, consumers throw away various types of food at home every week for many reasons. To investigate the reasons in-depth, this project researched and analyzed the consumer's behaviours towards food. In addition, Dutch households were chosen as the focus group of this study because the Netherlands is the most wasteful country in the EU (Ivana, K., & Katsarova, I., 2014). For this reason, other country's food cultures were not taken into account to clarify the research scope.

The findings from the user research can be summarized in three points: **1) vegetables are the most wasted food, 2) leftover vegetables need to be more visible, and 3) an effective intervention in the vegetable preparation phase has to be created.** As for the first finding, Dutch households buy various vegetables every week and discard a lot of uneaten vegetables. This is because the price of vegetables in the Netherlands is lower than meat or fish, so people undervalue vegetables. Also, the first problem is related to the second finding. When some half used vegetables are stored with unpacked vegetables in the crisper drawer, they can be easily forgotten. It means the neglected vegetables will go to waste because of consumer's sensory perception. Thus, the vicious cycle should be resolved by the third point: an intervention in the food preparation phase. This insight is interpreted in the design statement: **"I want to make consumers feel in control by providing them an inspiring and supportive tool for preparing vegetables to reduce vegetable waste."**

Based on the design direction, five ideas were generated by group brainstorming and individual idea generation. Through the concept estimation (feasibility, aesthetics, usability and effectiveness), one idea was chosen as the final design concept called "**Veggie-Table**." The concept can be briefly described as an integrated vegetable container to encourage users to use leftover vegetables first by providing an inspiring guide of vegetable combinations. The structure, size, materials and intended use of the concept were elaborated upon during the concept development phase.

Next, the prototype was evaluated with three participants at their houses. They were asked to perform three major tasks and answer nine evaluation questions. The results of the assessment verified that the design concept fulfilled the primary goal of this project by showing the positive emotions of users: joy, pride and hope. The emotions were measured by PrEmo, which is developed by Design Institute of Positive Design (DIOPD), IDE in TU Delft (Desmet, P.M.A., 2003).

To summarize, although **all participants perceived that the prototype provides an overview of leftover vegetables and new perspectives on the vegetable preparation**, the designed prototype needs to be further developed in an iterative process between user tests and embodiment phases to prove the impact on reduction in food waste as well as design quality.

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Photography by AMBAliving.

1 | INTRODUCTION

Context

Food waste is the fastest growing issue of our time. Countries in the EU discard an estimated 89 million tons of food every year. Worse, the food waste will increase to about 126 million tons in 2020 if we do not take action (European Union Committee, 2014). Moreover, most countries are burying food waste in the landfills. This manner of disposal produces methane gas because of the high water content of wasted food, and even contaminates soil and water that we are relying on to live (Osteen, C., Gottlieb, J., & Vasavada, U., 2012).

As the focus of this project, households can be a main area to decrease the food waste since each household is highly related to the environmental impact and the awareness of food waste. For decades, many researchers show that the correlation between human's food management and food consumption situation are highly related to food waste (Aschemann-Witzel, J. et al., 2016). Consumers tend not to feel guilty and are careless when discarding food. At the same time, they want to do the right thing because of their social conscience (Stancu, V., Haugaard, P., & Lähteenmäki, L., 2016). This consumer food habit that is contrary to moral motivation has been a major contributor to an enormous amount of food waste in total.

Problem definition

The food journey by a consumer consists of several steps. Figure 1 shows that the journey has eight phases from purchase to waste. The storage level is complex between preparation and getting rid of products because they are closely interrelated to each other (Terpstra, M. J., 2005). Moreover, most problems can be found in the preservation phase such as spoilage or lack of knowledge of foods.

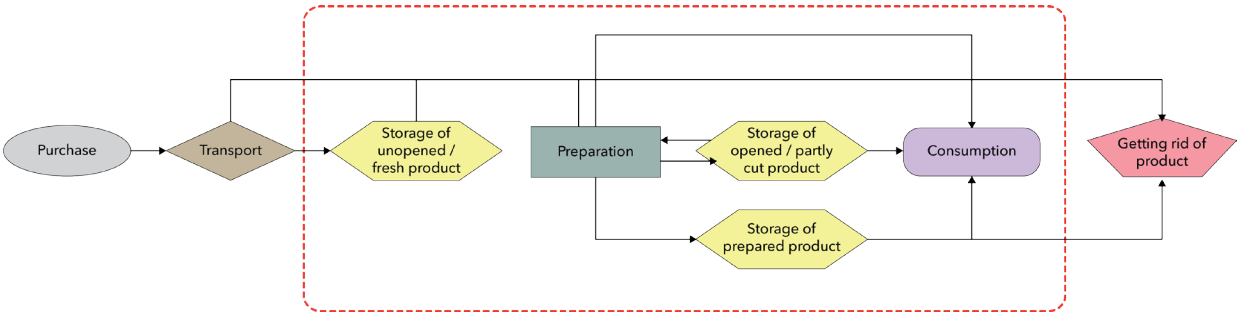


Figure 1. Food handling, food production and risk during domestic food preparation, Terpstra, M. J., 2005.

Thus, this project mainly focuses on tackling the following three problems:

- Consumer's false sensory perception

Most households have similar and unsolved problems in terms of preserving and handling foods. According to the Food waste report in the UK (WRAP, 2008), people routinely discarded unpacked or untouched salad, vegetables and fruits. This is because people regularly buy them in the supermarket or local market. Even though the food is still edible, they think that the food is not fresh anymore based on their incorrect judgement. For example, they think that the food looks unappealing or that it has been in the refrigerator too long.

- Poor food management

Householders trust the expiration date on the food packages as an indicator of freshness. The date labelling is not reliable because people are easily confused by 'use by' and 'sell by' dates (Aschemann-Witzel, J, et al., 2015). Furthermore, this problem is closely related to how to store food in the refrigerator. For instance, many consumers are using some plastic containers to keep half-eaten food or used vegetables. The disadvantage of the behavior is low visibility of food in the refrigerator which means that the food is likely to be neglected.

- Thoughtless behaviour for stacking uneaten food

Cooked food or processed food is relatively easily wasted after having a meal (Aschemann-Witzel, J, et al., 2015). There are two main reasons for the problem: cooking or serving too much food and storing leftovers in the refrigerator for next time without eating them (Natural Resources Defense Council, 2014). Although people want to save the uneaten leftovers, they easily forget about when it was stored and are not even sure that it is still edible. Thus, the leftovers will simply be thrown away if people cannot find out how to cook the leftover ingredients. Also, it should be considered about how to make people realize the remaining foods in their refrigerator to consume them in time.

Assignment

The aim of this project is:

"How to encouarage people to manage and consume uneaten foods to reduce food waste at home."

For the assignment,

- It is investigated what concerns are on the consumers' mind and what kind of foods are discarded.
- It is verified how a design product is able to form a new food behavior.
- A prototype is created as the final result, and evaluated with the focus group of people to verify the usability and feasibility of the design concept.

2 | LIST OF TERMS AND ABBREVIATIONS

- EU — European Union.
- FAO — Food and Agriculture Organization.
- FSA — Food Standard Agency.
- GHG — Green House Gas.
- IDE — Industrial Design Engineering.
- OECD — Organisation for Economic Co-operation and Development.
- U.N — United Nations.
- USDA — United States Department of Agriculture.
- Vegetability — The state or quality of being a vegetable or Vegetable character, quality, or nature.
- WRAP — The Waste and Resources Action Programme in the UK.


Dream Wallpaper.com

3 | FOOD LOSS AND WASTE

This chapter examines diverse issues, such as the fatal effects of food waste on the environment, regional waste situations and the overall food-value chain. In addition, the terms “food waste” and “food loss” are defined.
Lastly, the general food-supply system and regional food-waste factors are analysed together in order to better understand food loss and waste circumstances on a global scale.

Societal and environmental impact

Every year, one third of the food that is produced is either not consumed or thrown away. This serious circumstance has a negative environmental and economic impact on society, and takes place as a chain reaction. According to an annual report on the economic and environmental cost of food waste, about 1.7 trillion USD are spent on food waste each year (European Court of Auditors, 2016). Therefore, throwing away food can be interpreted as wasting energy, water, soil, arable lands and money.

Socio-economic food gap

In recent decades, there has been a worldwide fight against the lack of secure food and nutrition that 795 million people suffered (FAO, I. WFP, 2015). The number of hungry people dramatically decreased to about 500 million in the past 25 years, but there is still a long way to go. Each year, for instance, 1.3 billion tons of edible and fresh food is thrown away, which could feed about 868 million people. The per capita avoidable food waste in Europe is around 184kg per year, which is sufficient to feed approximately 200 million hungry people in Africa (FAO, 2011).

Contamination of natural resources

The most critical environmental danger that has consistently grown in recent years concerns the fact that we have to harvest food and utilize resources for human consumption. Hazardous agricultural materials can be found in croplands and fresh water sources. For instance, an enormous amount of the fresh water use at the level of industrialized agriculture releases hazardous pesticides into the

> "We simply cannot allow one-third of all the food we produce to go to waste or be lost because of inappropriate practices, when 870 million people go hungry every day."
> -FAO Director-General José Graziano da Silva-

> "A report out of the U.K. estimates that if food scraps were removed from landfills there, the level of greenhouse gas abatement would be equivalent to removing one-fifth of all the cars in the country from the road."
> -WRAP, 2011-

soil, which causes permanent damage in the form of soil erosion and low water quality (Osteen, C., Gottlieb, J., & Vasavada, U., 2012, OECD, 2016).

Emission of harmful gases

Global warming and climate change result from the tremendous emission of greenhouse gases (GHG) such as nitrous oxide and methane, caused by the overuse of various natural resources. The early stages of the food chain account for 28% of GHG emission by farming and raising live stock. Moreover, composting food waste is another serious problem. For instance, the EU consumes 261 million tons of resources for the disposal of 89 million tons of food waste per year. By wasting these resources, 170 million tons of CO2 are emitted (FAO, 2013). Due to its high water content, food waste decays faster than other types of waste in landfills. Furthermore, almost 90% of methane gas is emitted when food waste is buried in landfills during their first year (Gunders, D., 2012).

Definitions of terms

What are food loss and waste?

In general, 'food loss and waste' refers to the edible portion of plants and animals produced or yielded by farms and food facilities that are not consumed by people (Lipinski, B. et al, 2013). The terms 'food loss' and 'food waste' need to be specified to understand their exact meaning.

'Food loss' refers to the decline in quality and quantity of food by spoilage and damage, which means that it encompasses the agricultural and fishery products that are not consumed by humans and food that incurs degradation in food safety and nutritional and economic value.
It includes food waste and can occur in a phase of the food supply chain, such as production, handling, processing to distribution. During these four stages, technical limitations, inadequate stock management, uneconomical conveyance of goods and low quality of agricultural infrastructures are the main reasons for food loss.

'Food waste' is subordinate to food loss, and it is a crucial factor in food loss. Food waste means that the food is discarded after a meal, by careless behaviours or by human decision even though the food is still edible and of good quality - either spoilage.

Except in the case of food in poor condition, much food waste can be avoided if the foods purchased by consumers are managed well. It is in the final stage of the food value chain that the food is discarded by retailers or householders, after the pre-consumption stages (FAO, 2014).

Figure 2. Examples of food loss (top) and food waste (bottom).

The three categories of food waste

WRAP classified food waste into three categories (2008). There are examples of avoidable, possibly avoidable and unavoidable waste (see Figure 3).

- **Avoidable waste:** food items that could have been eaten had they not been allowed to spoil, had they not been past their food date or had they been wanted (e.g., food left on the plate after a meal).

- **Possibly avoidable waste:** edible food that was not eaten by humans because of improper storage methods or personal preferences (e.g., meat rinds or soft vegetables).

- **Unavoidable waste** (sometimes referred to as inedible waste): inedible food that could not have been eaten in any way (e.g., teabags, bones or hard fruit and vegetable peels).

Among the three categories of food waste, avoidable food waste is more important than the others. This is because avoidable waste accounts for approximately 61% of food waste, and if the foods are better managed in the households or restaurants, the foods can be eaten (WRAP, 2008).

On the other hand, possibly avoidable waste (19%) cannot be simply measured since it includes foods like breadcrumbs or potato and apple peel which may be eaten depending on the cooking method and an individual's food habits.

Furthermore, unavoidable waste will not be considered in this research. It is an inevitable type of waste that originates from human consumption even though it constitutes 20% of total food waste and can be measured.

Figure 3. Examples of an apple for explaining the three categories of food waste.

Food loss and waste circumstances

About 30% of food in the world produced for human consumption are wasted and lost annually. Countries in the EU discard an estimated 89 million tons of food every year. Worse, food waste will be increased to about 126 million tons in 2020 if we do not take action (Stenmarck, A., 2016).

In the world

A region's food supply chain can be a clear barometer of significant trends in food loss and waste. In middle- and high- income countries such as those in the EU, North America, Oceania and industrialized Asia, food loss and waste occur at the distribution and consumption stage. One of the reasons for this is that the specifications for food quality and safety are too high and foods that are still safe for human consumption are removed from the markets (Gunders, D., 2012). This usually happens when wholesalers and retailers attract customers by displaying regular shape of food products that look safe and good. Moreover, the consumers who live in these developed countries should improve their food habits at home to reduce food waste since the bulk purchase and no meal plan of householders have become the biggest trends of food waste in recent times.

On the other hand, in low-income countries such as those in Sub-Saharan Africa, North Africa, Western and Central Asia, South and Southeast Asia and Latin America, a large proportion of food loss and waste (40%) appears at the early stages of the food value chain: production and handling. Financial and managerial issues in these developing countries may be causing them to fall behind in the essential techniques for agriculture and distribution systems (FAO, 2014).

When harvested crops are stored in substandard storehouses, for example, fungus and pests can cause spoilage and damage. The lack of inadequate agricultural equipment and systems is also a significant problem making the production and handling chains inefficient and causing a large amount of food loss and waste.

Many researchers have calculated and compared the amount of annual food loss and waste between developed and developing countries. According to the FAO, the results are too serious to ignore. See the quotes from SAVE FOOD (FAO, 2017).

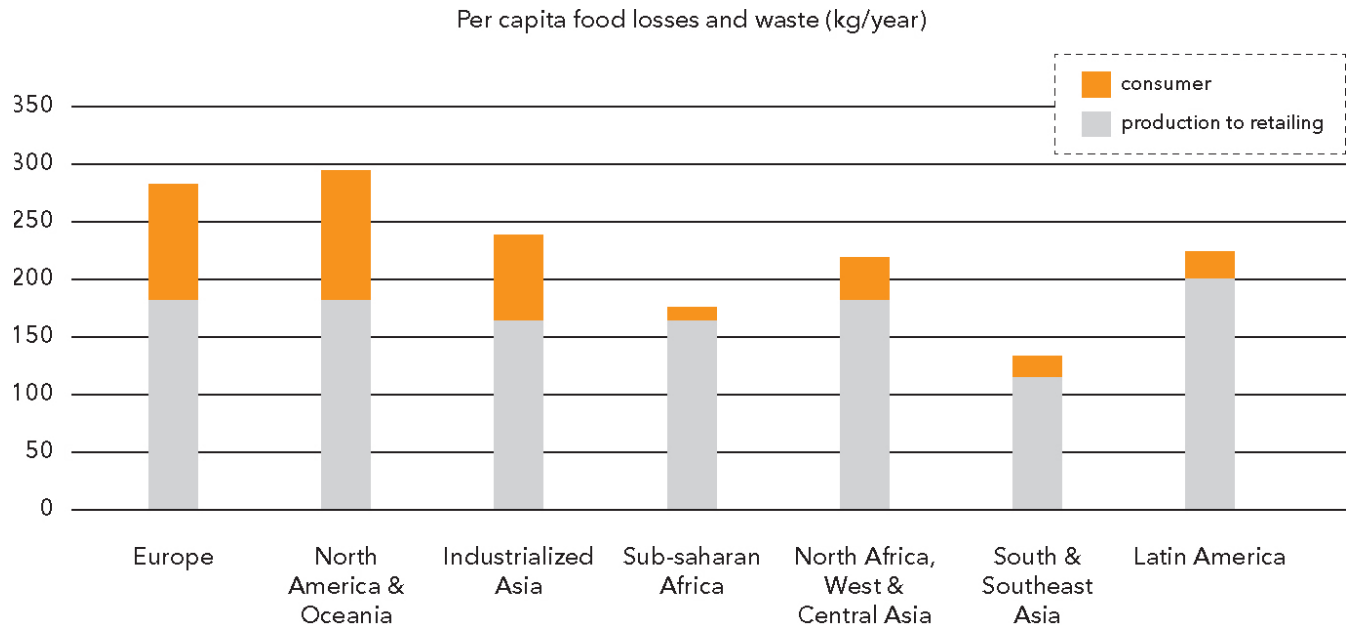


Figure 4. Per capita food loss and waste at the pre-consumption and consumption stages in the different regions, U.N. FAO (2014).

"Food losses and waste amounts to roughly US$ 680 billion in industrialised countries and US$ 310 billion in developing countries."

"Industrialised and developing countries dissipate roughly the same quantities of food — respectively 670 and 630 million tons."

"Every year, consumers in rich countries waste almost as much food (222 million tons) as the entire net food production of sub-Saharan Africa (230 million tons)."

"Per capita waste by consumers is between 95-115 kg a year in Europe and North America, while consumers in sub-Saharan Africa, south and southeastern Asia, each throw away only 6-11 kg a year."

-FAO,SAVE FOOD, 2017-

Food loss and waste circumstances

In the food value chain

Every food-related domain inevitably generates food loss and waste (Gunders, D. et al., 2012; Lipinski, B. et al., 2013) (see Figure 5). Therefore, it is necessary to consider the reasons food is wasted in the entire food process so that this project has a context to resolve.

> "One industry consultant estimates that up to one in seven truckloads of perishables delivered to supermarkets is thrown away"
> -Beswick, P., 2008-

Production

At the production stage, fish, fruits and crops are discarded during the process of mechanical threshing, harvesting and facility operation. The food loss at this stage can also be caused by human negligence and ignorance, not by the intended action of producers and operators. For instance, unharvested crops can be left in the fields if workers have been trained to harvest selectively based on a minimum quality standard such as for shape, colour and size.

Handling

During the handling stage, the gathered food is transported to a warehouse or a factory. Fresh food that is still edible can be degraded by pests or fungus during transport and storage. In addition, some livestock can die during transport or rejected by a slaughterhouse because of its quality standards.

Processing

Factory machines filter inedible crops and fruits in the processing phase. Meat is trimmed by slaughtering machines or by a butcher to fit the product in a package. Many edible and inedible parts can be wasted during this phase. As for fish and fruits, the canning and peeling processes cause food loss from spoilage and damage. Research by WRAP (2010) found that up to 16% of unrefined materials is lost in the UK during the processing stage, and approximately 39% of total food loss in Europe occurs at the food manufacturing plants.

Distribution

Aesthetic quality and the expiration date on a package are indicators for the discarding of food during the distribution and marketing stages. This is because supermarkets do not want to display unattractive products on the shelf since customers perceive the uniform shape and colour of products as indicators of fresh and safe foods. The retail shops also discard products based on expiry date to manage product stock and give credibility to the store. Another factor in food loss at the retail level is that most products are perishable products such as fresh meat, fish, fruits, vegetables and many prepared foods. According to the United States Department of Agriculture (USDA), on average, the food product losses at American

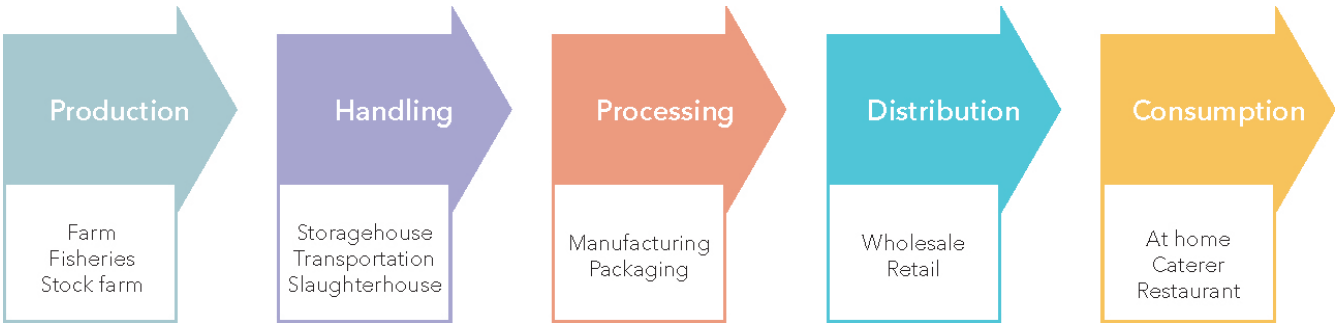


Figure 5. The five steps and contributors in the food value chain in terms of food losses and waste, Lipinski, B. et al. (2013).

Consumption

The last phase is consumption, which is closely related to customers. Figure 3 indicates that twice or three times more food waste is produced at the consumer level than at the other three stages (production, processing and distribution) of the food value chain (European Court of Auditors, 2016). Food waste happens mostly at home or in restaurants. Edible food is discarded during this stage since, in some cases, a household member or chef prepares more food than is consumed. In restaurants, unconsumed food makes up approximately 17% of food waste, and customers do not take out about 55% of food left on the plate (Bloom, J., 2011). Moreover, in the case of households in the UK, for example, at least 450,000 tons of edible food products is wasted annually due to a misunderstanding of the 'use by' or 'sell by' date (Lyndhurst, B., 2011).

Consumption as the most wasteful phase

In developed countries

Food waste at the household level constitutes more than 50% of the total amount of waste in Europe and an estimated 60% in North America and the UK (Stancu, V., Haugaard, P., & Läh- teenmäki, L., 2016).

Specifically, 25% of food waste in American households is from purchased food and drink products (Bloom, J., 2011).
In the UK, British households purchase 8.3 million tons of food and drink every year, and 330 kg of that (22%) goes to food waste (Quested, T., & Johnson, H., 2009). The Netherlands, which is the most wasteful country in Europe, produces 135 kg of wasted food, discarded by people, from the approximately 2 billion kg of the food they buy every year (Ivana, K., & Katsarova, I., 2014).

In summary, the significant quantity of food waste occurs at the consumption level especially in developed countries, according to the analysis of the food value chain (see Figure 6).
Thus, this project focuses on how to reduce food waste in the households of developed countries.

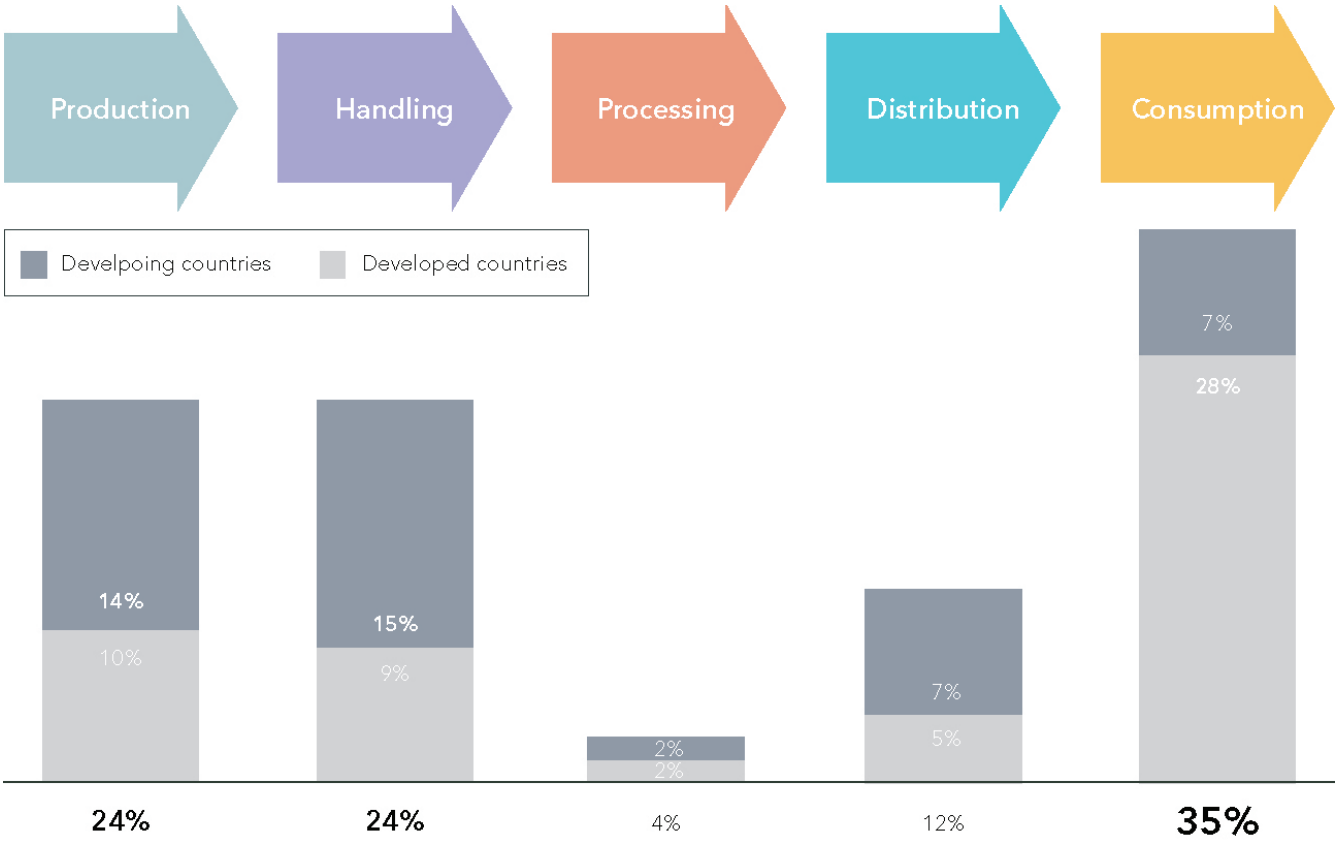


Figure 6. Proportion of annual total food loss and waste in each phase of the food value chain (Lipinski, B. et al., 2013).

Conclusion

The research shows that the food waste problem significantly impacts society, culture and the environment on the global scale. It is clear that reducing food waste must be seriously considered for the future food consumption for human as well as preserving the environment.

In this project, the household (consumption) level in middle- and high-income countries has been selected as a basic standard for consumer research. The reason is that consumers in developed countries play the largest role in producing avoidable food waste at home.

In addition, avoidable food waste is being considered at the exclusion of possible avoidable and unavoidable food waste. Much food is wasted by householders even though this food is still edible and uneaten. For this reason, it is essential to further investigate what influences people to discard edible foods. Figure 7 is the framework that this research chapter has followed.

The consumer research is discussed in the next chapter.

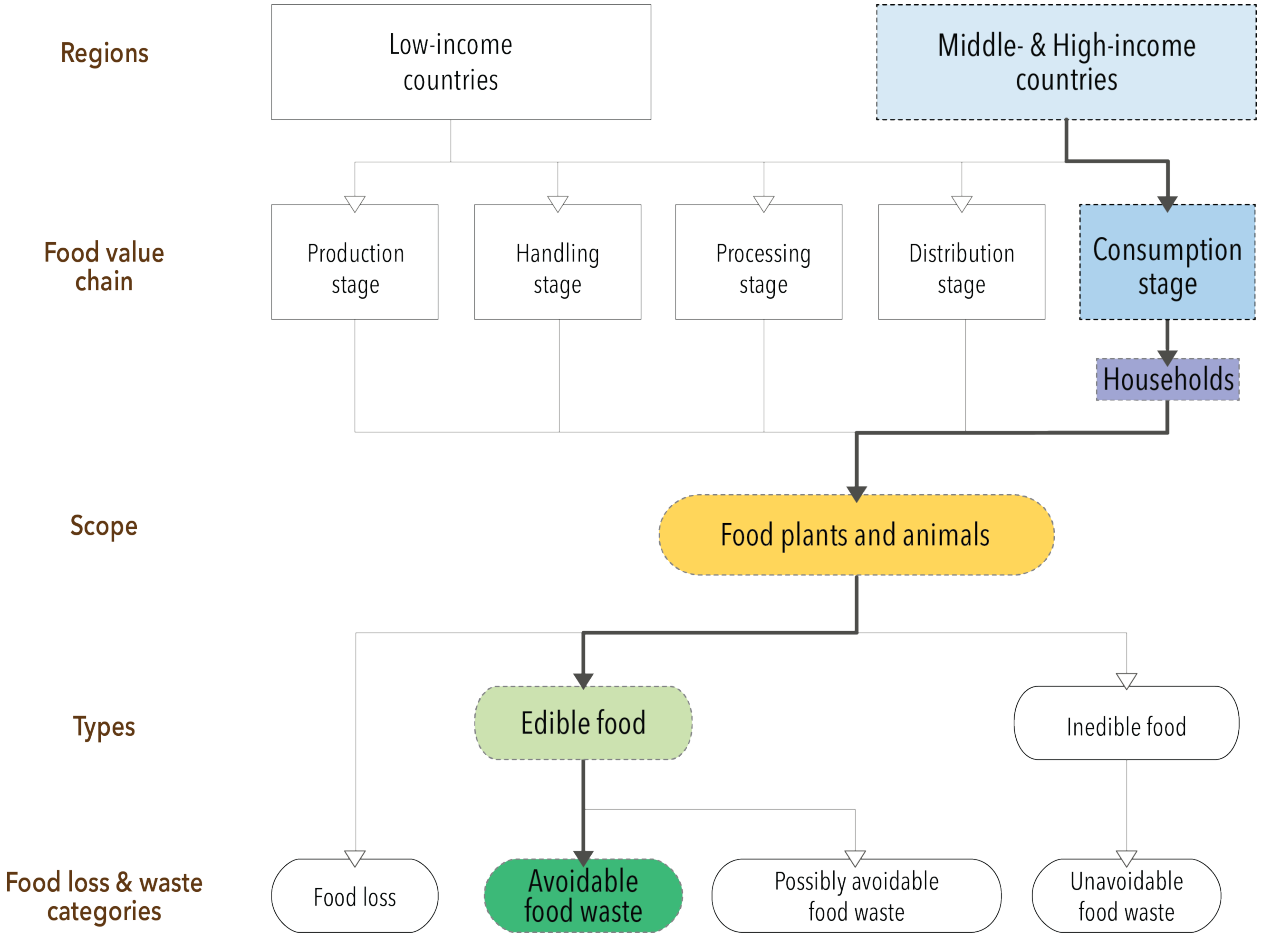


Figure 7. Framework of the scope of food waste research. This structure illustrates that the literature review about food waste is done, and the research scope is narrowed down in stages.

4 | CONSUMER BEHAVIOUR

For decades, many food waste organisations have argued that consumers' food behaviours deeply underlie the food waste problem. Consumptive food habits at home produce tons of avoidable food waste that results from not purchasing, handling, storing or cooking food properly. People may buy as much food as they desire, but they may not be certain they need it, know how to manage it or know what factors make them discard it. To answer these questions, motivational and inherent factors in consumers' decisions are discussed in this chapter.

Underlying factors of food waste behaviour

Food-related trends, habits, lifestyles and systems have been dramatically transformed in many ways for decades. Fresh fruits and vegetables are always available in nearby supermarkets, and the low price of products makes them affordable to people who can now consume food unnecessarily. Furthermore, consumers have various underlying reasons for wasting food. Many researchers have argued that moral aspects, social factors and socio-demographic factors are common influences on people's decisions, from choosing food to disposing of it (Hauser, M., Jonas, K., & Riemann, R., 2011; Stancu, V., Haugaard, P., & Lähteenmäki, L., 2016).

People do not consciously perceive these potential variables. A series of behaviours regarding consumer purchase and disposal of food are easily manipulated by inherent factors in people. Thus, understanding these aspects can be an approach to finding ways to reduce food waste at the consumer level as well as outlining the user research scope.

Moral dilemmas

Consumers tend not to feel guilty and are careless when discarding food. At the same time, they want to do the right thing because of their social conscience (Stancu, V., Haugaard, P., & Lähteenmäki, L., 2016). This consumer food habit that is contrary to moral motivation has been a major contributor to an enormous amount of food waste in total. For example, consumers are more likely to be concerned about their budget than the impact of their decisions on society and nature. For instance, when choosing products in the supermarket, consumers may buy cheap food in bulk even though they do not need the amount of food they have purchased. Moreover, if the consumers lose their appetite for a food, they may discard the food without thinking about the consequences of food waste (Lyndhurst, B., 2011).

Because of the food behaviours of people, local governments and organisations have launched campaigns to educate people on how to reduce food waste at the consumer level. Some examples are 'Save The Food', 'Think. Eat. Save' and 'Love Food Hate Waste.' Although these campaigns provide sufficient moral motivation and information on food storage, people do not seem to put more effort into practising it on their own to properly consume and save food (Stancu, V., Haugaard, P., & Lähteenmäki, L., 2016).

Social factors

Consumerism has led to a significant change in food habits and the modern lifestyle by stimulating people to consume more and desensitising consumers to ethical issues (Gjerris, M., & Gaiani, S., 2013). This has arisen from the industrial revolution, which facilitated mass production on a global scale. Mass production has made the low price of commodities possible in the food business.

Thus, having more food turns out to be easier in industrialised regions than non-industrialised regions since consumers in developed countries have constant access to superfluous processed goods in the supermarkets, as if enjoying a luxury. The consumers also tend not to feel uncomfortable about it since it has become a widespread social phenomenon. This consumption behaviour ultimately causes tremendous amounts of food waste every year.

From a moral standpoint, these circumstances are not ethical because they exacerbate the problem of food inequality in the world (see Figure 8). There are more than 1.9 billion obese people in developed countries, whereas, in contrast, 795 million people are still struggling with hunger in other parts of the world (WHO, 2016; Krzywoszynska, A., & Stuart, T., 2011). Because of these growing social problems, individual consumers need to have a sense of responsibility to their food-related actions in everyday life.

Underlying factors of food waste behaviour

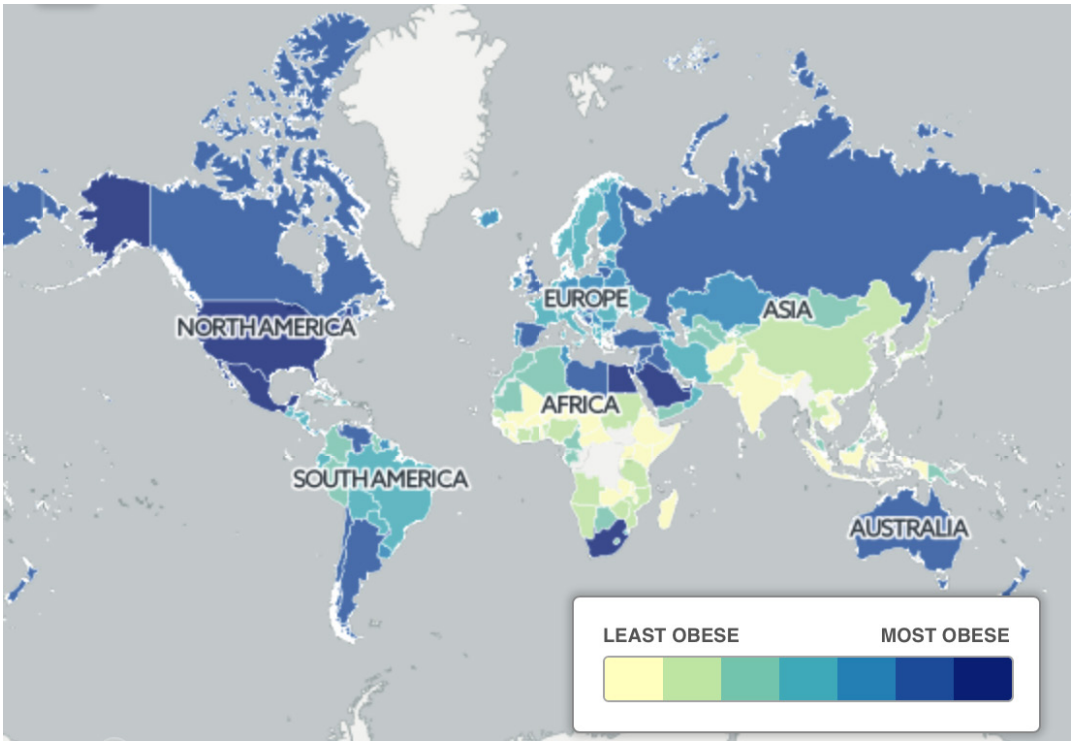


Figure 8. The obesity map in the world created by Telegraph (2016). The developed countries (North America, Europe) shows higher obesity rate than the developing countries (Africa, Central Asia).

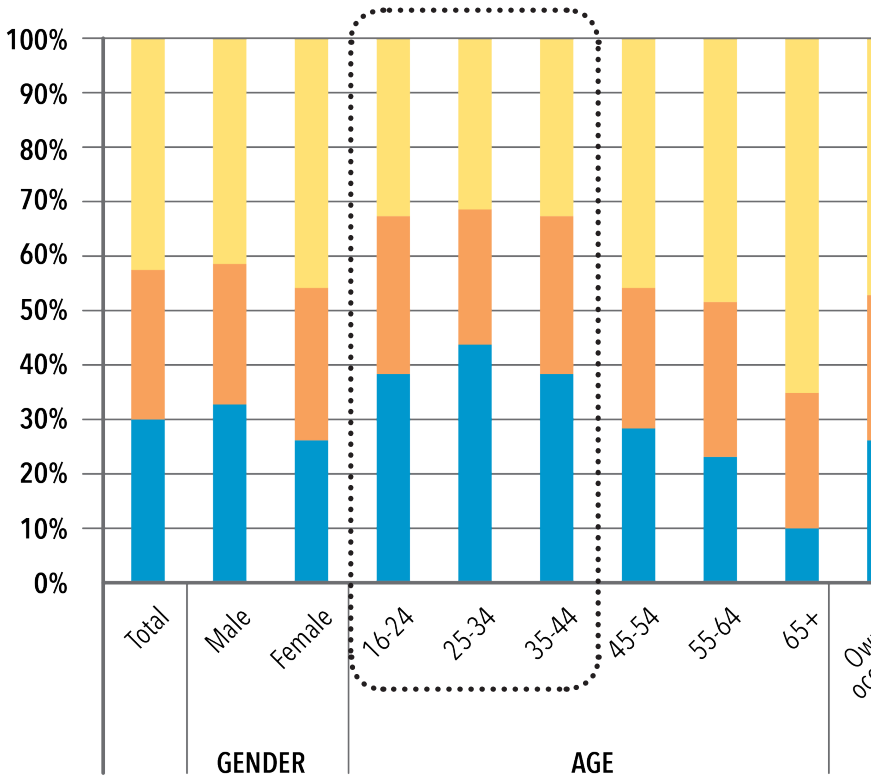


Figure 9. Analysis the proportion of food waste in the UK by seven socio-demographic factors (gender, age, social class, accommodation, occupation, number of people and children), Lyndhurst, B., Cox, J., & Downing, P. (2007).

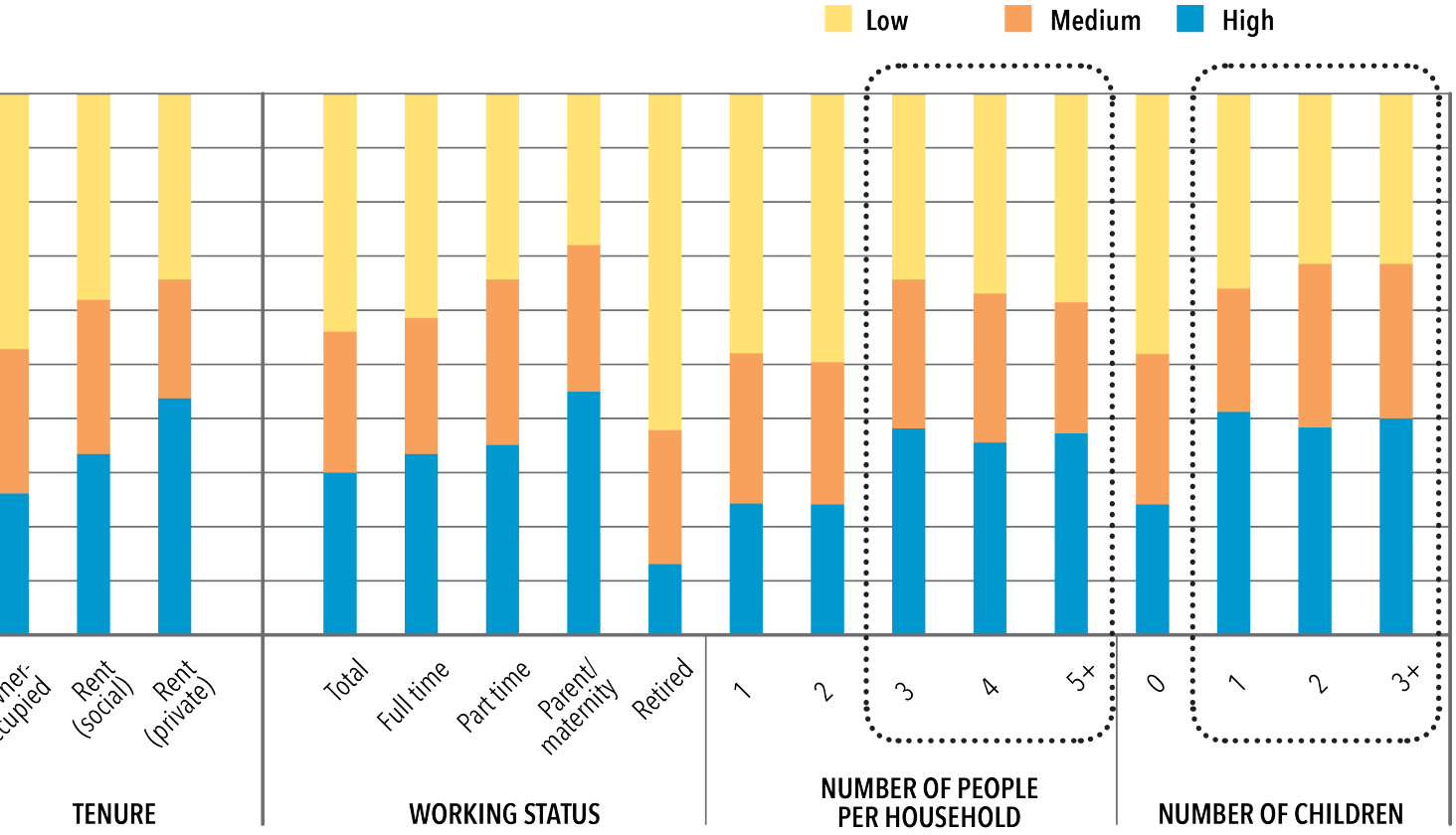
Socio-demographic aspects

Food waste from households is closely related to household characteristics, such as the age of family members, household size, the number of children and social class. The characteristics of households that often waste uneaten foods can be summarised as the following: full-time workers aged 22 to 44 years, stay-at-home parents with children in young families, and people with large socially or privately rented houses (Lyndhurst, B., Cox, J., & Downing, P., 2007).

A family with children discards a larger portion of purchased food than a single occupant, accounting for 40% and 17%, respectively (WRAP, 2008). The reason is, of course, because the families with children purchase more food so they have the potential to produce more food waste than other types of household.

As for age groups, householders aged 22 to 44 years produce about 40% of food waste, while retired people or householders aged 65 and above account for only one quarter of the young age group's waste (see Figure 9).

Additionally, personal economic status also affects the food waste behaviours of householders. One of the reasons why low-income consumers produce more food waste than high-income consumers is the lack of personal interest and awareness (Lyndhurst, B., Cox, J., & Downing, P., 2007). When they discard food, they do not think it is a problem. Although they may think it can be avoided, they may not know exactly how.



The most wasted food in the home

Recalling the Food loss and waste circumstances section in Chapter 2, the most wasted food at the agriculture level is fresh vegetables, fruits and cereals (see Figure 10). The chart can be found in Appendix A.

If this is the case, it needs to be researched what kinds of food waste are generated at the consumption level. Analysing the waste trends of two regions (North America and the UK) is informative since these regions contribute approximately one third of the world's food waste at the consumption stage (Lipinski, B. et al., 2013).

Although the categorised food groups of the two regions vary, North America and the UK, which both produce a large amount of food waste, show nearly the same trends on avoidable food waste.

Food waste trends in the two developed regions

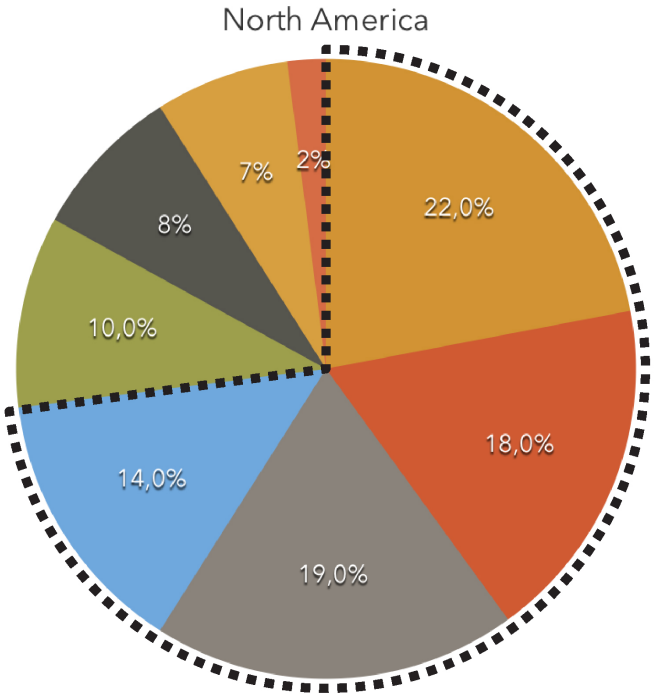
Figure 10 demonstrates that North American people often waste 22% of fresh fruits and vegetables, 19% of meat and fish, and 18% of dairy from their purchased food. The food research conducted by WRAP (2008) defines many detailed categories, but the research found that fresh vegetables and fruits including salad are the most wasted foods, at 46.6%, and baked and mixed food accounts for 13.4% and 10% respectively in the UK.

The tendency to waste fruits and vegetables corresponds to European food waste trends even though British householders discard twice as much fresh produce as North American householders.

Another finding is apparent in the categories of meat and fish, dairy and grain products. The sum of the percentages for these categories is approximately three quarters of all food waste in each region: approximately 73% for North America and 79.4% for the UK.

The high percentage of discarded fresh products implies that consumers in developed countries attempt to eat fresh ingredients, but they may not know how to better manage and store their food.

The proportion of food waste groups varies from region to region and from country to country. This is because food culture and ethnic diets influence the consumption habits of a nation. These aspects are crucial to understanding why the people of a country discard foods.



However, this research focuses mainly on specific food types that are most often wasted. The primary concern of this project is to discover the food most often wasted by householders who are deeply linked to specific propensities for treating food, not to discuss the food cultures of various nations.

Finally, for further study, section 3.1 is considered along with the most wasted food types in the user research phase because people's food choice, consumption and waste behaviours are significantly manipulated by these underlying factors.

THE MOST WASTEFUL FOOD "FRUITS, VEGETABLES, MEAT, FISH, DAIRY, GRAIN PRODUCTS"

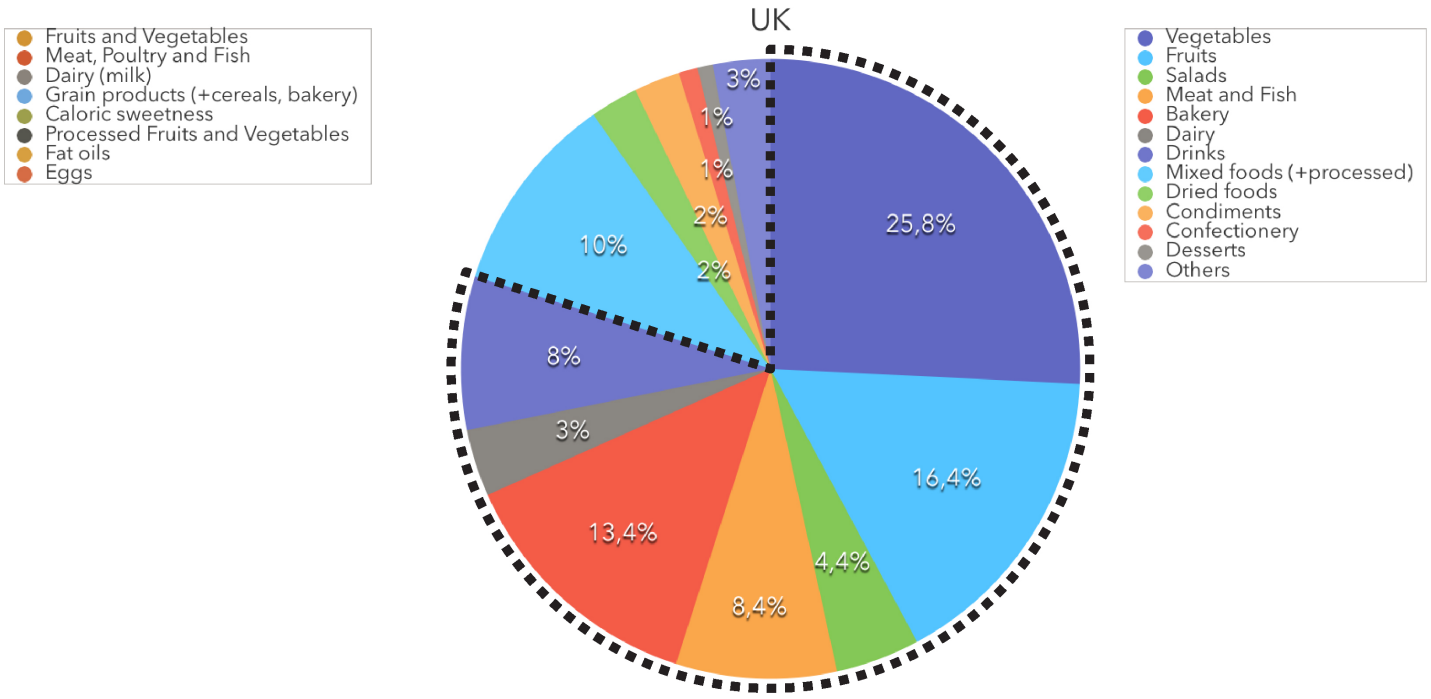


Figure 10. Share of food waste by food categories in North America, Buzby, J. C. et al., 2011 (left), and in the UK, WRAP, 2008 (right).

Four triggers for food waste

Here is a simple scenario of a consumer's food habit.
A man does not have a grocery list at a supermarket so he impulse purchases certain foods. After some time passes, this additional food is neglected in the refrigerator or cupboard after cooking or partial consumption. The food that is stored for too long spoils or passes its expiry date, which causes the man to perceive that it is no longer edible. For this reason, he eventually discards the food. Many motivations that generate food waste can be discovered in this scenario, and these motivations can be described as four triggers: the lack of awareness of grocery list and meal planning, misinterpretation of label dates, improper food storages and misjudgment of food quality by consumer's perception.

The lack of awareness of grocery lists and meal planning

A lack of meal planning and a shopping routine is considered one of the causes of food waste at the consumption level. These factors affect each other positively and negatively. If consumers perceive that they purchase the exact amount of food their household needs, this perceived control of behaviour positively influences a planning routine (Stefan, V., van Herpen, E., Tudoran, A. A., & Lähteenmäki, L., 2013).

To think in this way, householders must check their cupboards and refrigerators in advance and calculate which foods they already have and can be consumed, so that they can make a grocery list before going to the supermarket. This grocery planning practice leads to planning meals that guides householders to consume the foods that they have at home.

On the other hand, the lack of awareness of grocery lists causes the impulse in consumers to buy more foods than they need. A shopping routine without meal planning causes food waste when an unintended purchase is combined with personal demands of food freshness and healthiness. For example, consumers want a healthy diet, so they buy healthy food regularly, such as fresh salad, vegetables and fruit. However, this intention does not mean that they will eat healthy food (Evans, D., 2012).

Therefore, planning meals by managing purchased foods and making grocery lists before shopping are the first steps in reducing food waste in the home.

Keywords
"grocery list, planning meals, impulse purchase, shopping routine"

Misinterpretation of label dates

WRAP, a professional food research organisation in the UK, report that 255,000 tons of food is wasted annually in the UK because of the lack of consumer understanding of 'use by' and 'best by' labels and lack of guidance on label information. Moreover, the researchers stress that 380,000 tons of food waste can be avoided if householders cook or freeze the edible food before the 'use by' date.

Consumers consider a date label to be a guideline of the product's quality and safety even though that information is not officially regulated (see Figure 11).

Additionally, the date information affects house-holders' decision-making in terms of the disposal of foods at home. However, manufacturers and retailers also use the date information, such as 'sell by' or 'display until', to control stocks and to manage risk and trust in the stores. Because of the confusion of label meanings between retailers and shoppers, people must rely on their own judgment skills and take all responsibility for purchasing and cooking food.

This circumstance decreases consumer confidence towards food selection because health issues such as food-borne illness or food poisoning are directly related to misunderstanding of food-related information (Defra, 2009; Lyndhurst, B., 2011).

In addition, consumers interpret a 'use by' date as food safety and consider the label more for meat or dairy products, while a 'best by' date has a different meaning to them, involving taste, appearance, texture or colour. If the 'best by' date is passed, they tend to think that the food in the package is not dangerous to consume (FSA, 2011).

Keywords
"used by or best by label dates, food quality and safety, consumer's confidence"

Figure 11. Current label systems showing 'used by', 'best by' and 'sell by' date on food products. Most food organisation recommend to display 'Best until' label date to decrease confusion of consumers.

Four triggers for food waste

Improper food storage

Most householders want to store partly used ingredients after cooking to reuse them later. Leftovers from excess food preparation are also one of the major types of food to be preserved in refrigerators since people intend to eventually reuse uneaten leftovers (see Figure 13). Moreover, the householders who prepare and cook meals require a habit of handling food safely since food that is not managed well causes food-borne diseases as well as food waste.

According to an in-depth interview conducted by Wageningen University in the Netherlands (Terpstra, M. J. et al., 2005), five out of nine respondents keep their leftovers in the refrigerator for longer than 2 days even though leftovers and prepared meals should be kept in the fridge for only 2 or 3 days. These food-safety guidelines were developed by FAO and the World Health Organization (WHO), but the information is not yet widespread at the consumer level (Koppel, K. et al., 2016).

The refrigerator temperature and shelf placement are also important factors in preserving food longer. The temperature inside the refrigerator needs to be above 0°C and below 7°C, but two thirds of people use a higher temperature than the recommended, especially people above the age of 60.

There is also a temperature gradient in a refrigerator,but it is not clear to most householders (USDA, 2015; Koppel, K. et al., 2016). For example, 8 out of 10 French participants put salads on the 0°C to 4°C shelf, which is an area for meat. Salads should be stored in the crisper drawer because bacteria in meat or fish can easily contaminate other organic foods (Masson, M. et al., 2017).

Keywords
"improper storage, leftovers,spoilage refrigerator, partly used food"

Figure 12. Is the refrigerator management of users efficient enough to see and use all foods?

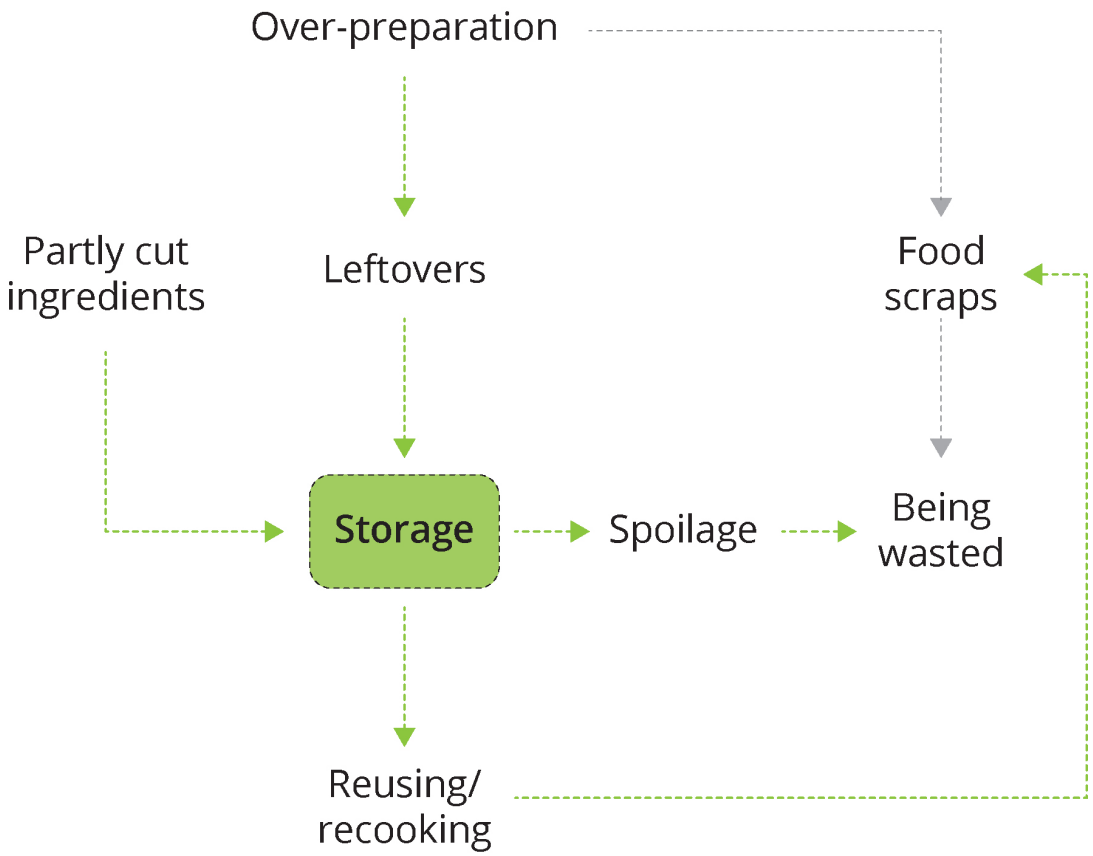


Figure 13. Process of food usage by householders at home. Over-preparation, leftovers and partly cut ingredients are potential food waste if not stored well.

Last, poor visibility in the refrigerator can cause food spoilage and eventual waste (Gunders, D., 2012). Partly eaten food is sealed in plastic bags and placed somewhere in the refrigerator or freezer. This food management may cause a lack of awareness of the used food. This hinders using all stored foods before expiration. People can even put themselves at risk by unknowingly using spoiled food from these containers (see Figure 12).

These food-storage behaviours are easily routinized, which means householders with improper storage behaviours are likely to generate food waste regularly. Thus, a well guided storage practice is a practical key to reducing avoidable food waste at home.

Misjudgement of food quality by consumers' perception

One of the major triggers for food waste at the consumption level is the judgment of food quality based on consumers' sensory perception. Other food behaviour research and interviews have discovered that householders discard still edible food often because it smells and looks spoiled. For instance, in the UK, approximately 1 million tons of food is avoidably wasted annually due to human sensory modalities, and the wasted food can be mostly found in fresh, dairy and prepared food. Also, 78% of German householders discard fresh fruit, vegetable and dairy products if they perceive that the food is mouldy (WRAP, 2008; Jörissen, J. et al., 2015).

This is because sight plays a main role among the five senses (sight, hearing, touch, smell and taste). When a consumer judges food quality, colour, size, shape and surface clarity are generally considered first, and then the other senses follow (Kilcast, D., 2011).

However, if a consumer ultimately decides that the food quality is poor based on visual information, the other senses are easily ignored, and the food goes into a trash bin. In the case of bananas, for example, some bruises can appear on the skin of a banana, but people are prone to think the banana is no longer fresh, and the smell is foul before the skin of the banana is peeled off.

Figure 14. Consumers do not prefer the deviant foods at supermarkets, so retail supply system has been adjusted to the shopper's demands on the standard shape of foods, Photographs by Brian Finke.

Conclusion

However, if a consumer ultimately decides that the food quality is bad on the basis of the visual information, the other senses are easily ignored, and the food goes to a trash bin. In the case of banana, for example, some bruises can appear on the skin of a banana, but people are prone to think that it is not fresh anymore, and even smell is stinky before peeling off the skin of the banana.

A large amount of unattriactive food is also discarded at the consumption level, mostly at stores, due to the misconception of consumers. Consumers do not select misshapen carrots even though the taste and quality are the same as well-shaped carrots. Kevin Moffit, who is the President of the Northwest Pear Bureau said, 'People will say they'll take fruit that's a little rough, but in reality, they buy with their eyes. The consumer says one thing and, frankly, does something different' (Bloom, J., 2011).

The gap between the retailer's view and a consumer's attitude towards imperfect foods has encouraged food supply chains to reject imperfect foods. Moreover, the discarded imperfect food weighs about 6 billion pounds a year, which accounts for 20% of the agricultural products for human consumption (Gunders, D., 2012).

Keywords
"sensory perception, food quality judgment, deviant food, acceptability, undervaluing food"

This research aims at understanding what kind of factors cause consumers discard food.

The food-related decisions of consumers are complicated by internal and external factors. Subjective norms and social matters affect consumers, and specific food behaviours are formed by these factors. People can purchase food conveniently in current times, so they may become less mindful of food, especially in developed countries.

Undervalued food is easily discarded by householders, which means that the wasted food has no chance to be useful again even though it is still edible.

Before discarding food, people tend to rely on visual and smell sensations to judge a food's condition and quality, but these are not always reliable. This is because people may have a personal understanding and perception of food formed by limited food experiences and unskilled food management.

Confusion over the shelf life of food is also a pervasive problem in the home. The date information on food packages, such as 'sell by' or 'best before', is not clear to consumers. Thus, consumers need information on how to properly understand the label date so that they can discipline themselves to consume their foods in time.

In conclusion, an investigation is required, based on the key findings in this chapter, into how householders manage foods and what underlying reasons make them waste foods.

5 | IN-DEPTH USER RESEARCH

This chapter focuses on the interactions between consumers, food, the most wasted food and the reasons behind wasting that occur the particular behaviours of consumers, according to the chosen focus group and context.
For this study, face-to-face interviews and Food Diary surveys were conducted based on the research questions. The user research data was analysed in several directions. Lastly, the three main findings were described in the conclusion section.

LIMITATION OF THE RESEARCH

Focus group

There are generally four household types: single-person, couples, adults with children and the elderly households. According to the previous research in chapter 3, a family that is composed of more than three people throws away much more food than single-person or couple households.

Additionally, the elderly tend not to discard food as much since they experienced the Second World War. Because of the suffering from food scarcity during the war, they have a strong belief that wasting food is a sort of unethical behaviour (Lyndhurst, B., Cox, J., & Downing, P., 2007). Thus, single-person, couples and elderly households were excluded, and family households were chosen for the in-depth user research.

The other criterion was the nationality. People who have the Dutch nationality were selected as a focus group. The reason for that is that people who came from other countries have different food cultures and behaviours, and they do not have many common aspects regarding food consumption. This study does not aim to investigate different dynamics of food cultures, so only Dutch people were interviewed about their typical food patterns.

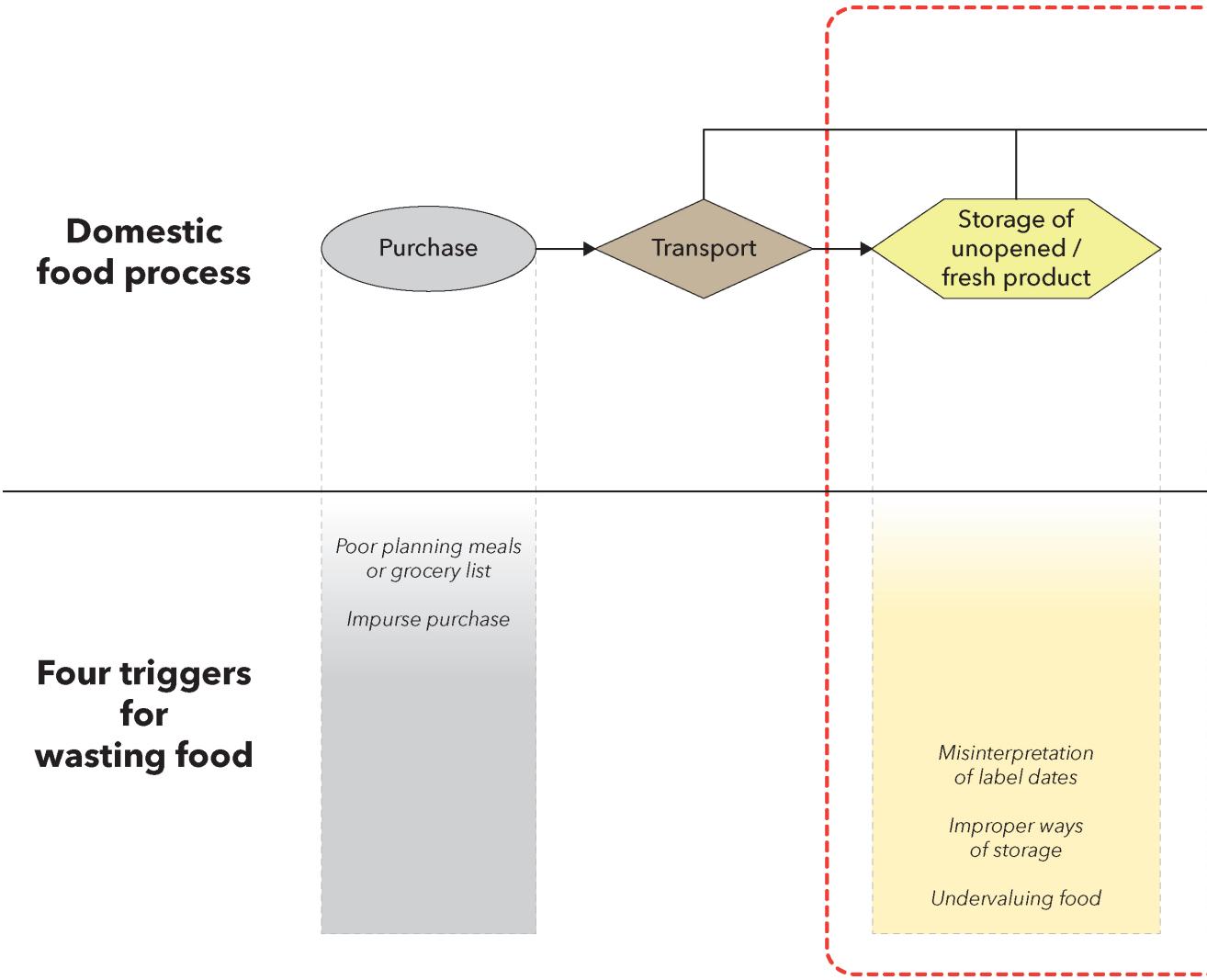
Limitation of the research

Focus on the middle part of the process

Figure 15 demonstrates that food Storage and Consumption phases are much more complex than Purchase and Transport phases, and the two processes are closely interrelated to each other.

When the four triggers for food waste are overlapped with the domestic food process, it becomes evident. Consumers usually have what is called the 'Two times holding' process that stores partly used and surplus foodbefore disposal (Hetherington, K., 2004). During this storage phase, food can be easily contaminated and spoiled if not managed well.

In addition, it is crucial to discover the food types that are mostly eaten as well as frequently being thrown away by householders. Therefore, a challenge to the stages would be relevant to prevent food from becoming food waste.



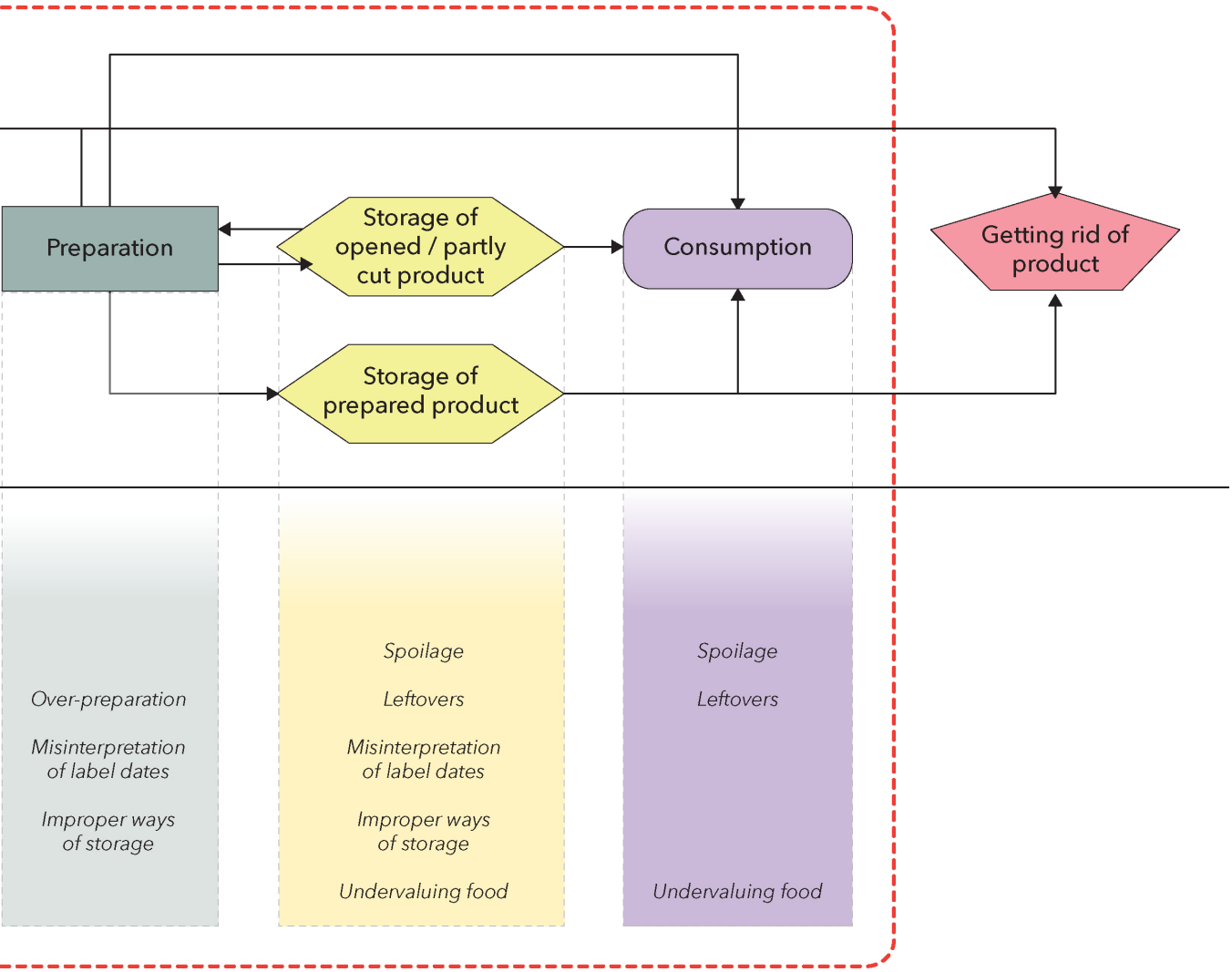
Context

The assumption of this project was that many people who live in modern society might have similar consumption patterns in terms of breakfast, lunch and dinner. Although it can differ from each country's cultures, breakfast or lunch are relatively likely to be less formal and sophisticated than dinner.

Additionally, dinner is cooked with diverse ingredients and a cook's attention, so there are more chances to produce food waste.

Thus, dinner can be an inspiring and challenging context to dig deeper into the problems of the middle part of the food process.

Figure 15. Categorisation of motivational factors occur food waste by domestic food process (Terpstra, M. J., 2005). At the storage stages, some same problems appear, and the phase has multiple connections between preparation and consumption stage (Eunyoung, G. 2017).



Food-related concerns of consumers

Modern consumers consider various factors such as price, nutritive substances or diet when selecting food products in the supermarkets. Some influences not only affect the consumer's food choices subconsciously, but also build a person's food behaviors towards specific foods on the basis of an individual's food-related concerns. It can be called 'Personal food system', and the conceptual food choice model was developed to understand consumer's concerns about food, see Figure 16 (Furst, T. et al., 1996).

The model shows a holistic view of each food choice process from universal factors to personal factors, and they were categorised as the four hierarchies: Life course, Influences, Personal food system and Strategies. In this project, 'Personal food system' is mainly dealt with because ethics, safety and quality values on the 'Influences' level were already researched in Chapter 3 and 4.

Besides, the six primary values in the personal food system always conflict with each other in a consumer's mind, see Figure 17. The source can be found in Appendix B. It is a fundamental guideline to understand consumers in general. Therefore, for this project, the internal value negotiation aspects should be involved in the questionnaire of the in-depth user research to investigate the households in the Netherlands.

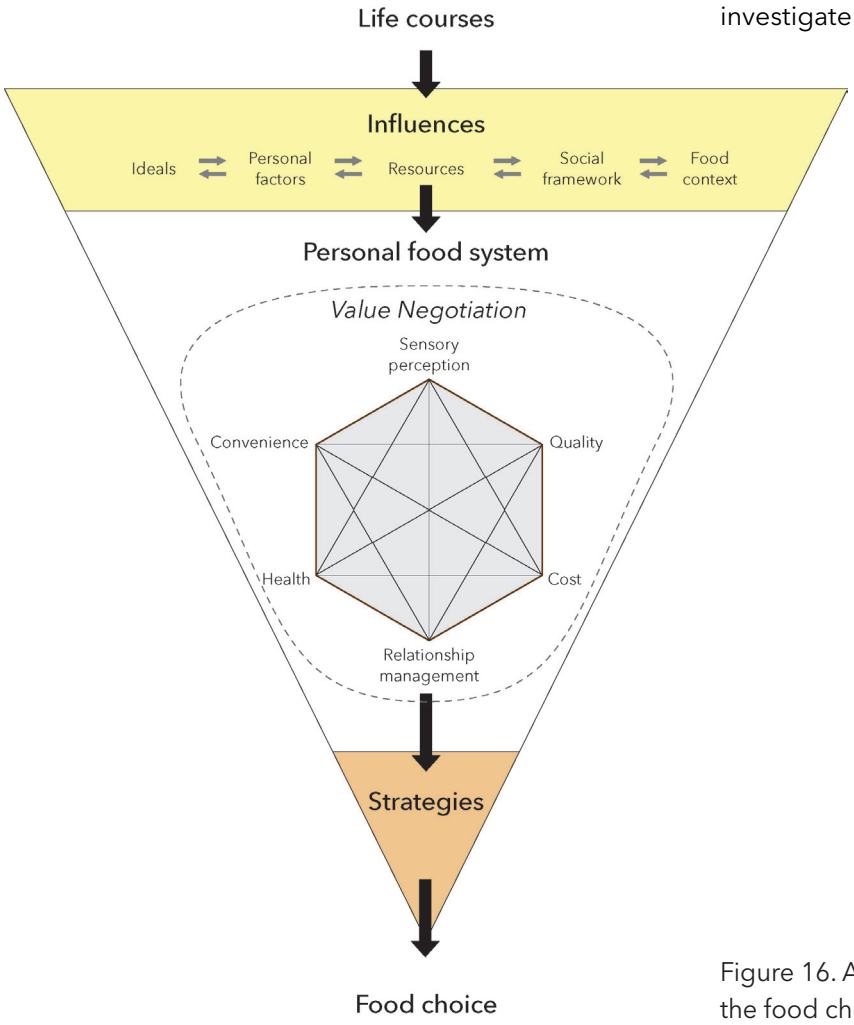


Figure 16. A conceptual model of the components in the food choice process, Furst, T. et al. (1996).

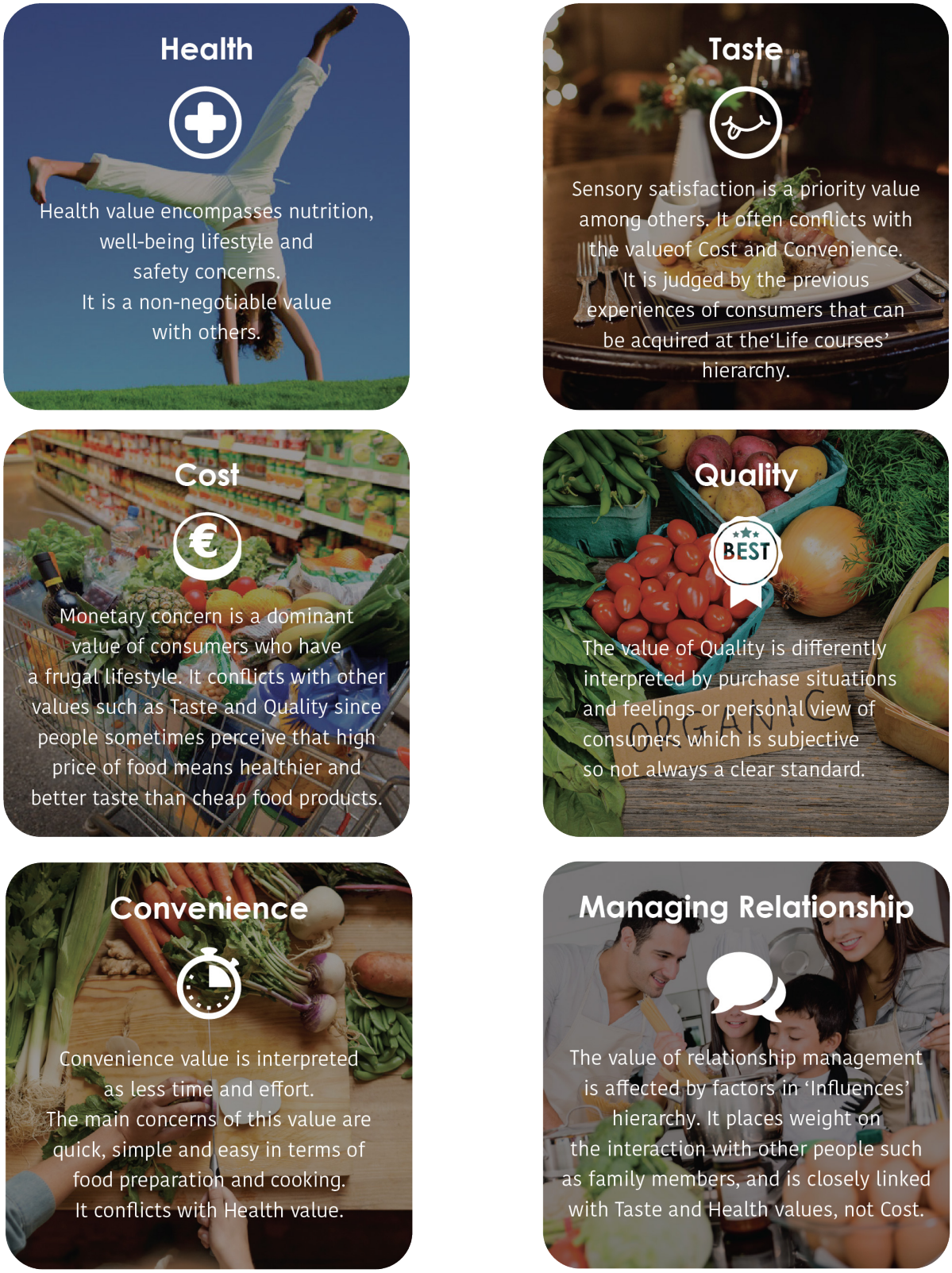


Figure 17. Summary of food-related concerns of consumers regarding purchasing or consuming food.

Research setup

Research questions

By considering above-mentioned aspects, Research Questions (RQs) of the in-depth user study were made. The research questions were interpreted as a questionnaire for interviews and food diary.

RQ 1.
What are the current interactions between food and consumers?

RQ 2.
What consumer's concerns are decisive to eat food?

RQ 3.
What kinds of foods do people mostly waste?
sub-RQ 3.
How do people judge the food quality and safety?

Methodology

The user research was accomplished by face-to-face interview and online food diary. The goal of these research activities is to uncover doing, saying and thinking in relation to food on the consumer level.

Participants

A total number of seven households participated in this design research. As mentioned in the Limitation of the research section in this chapter, the common factors of participants were the Dutch nationality and the size of the household being three or five family members.
The only difference was the age range, which was between 35 and 55 years old. Most participants were full-time workers and had children under the age of 12. Aside from that, the participants were people who are in charge of deciding the dinner menu and purchasing groceries.

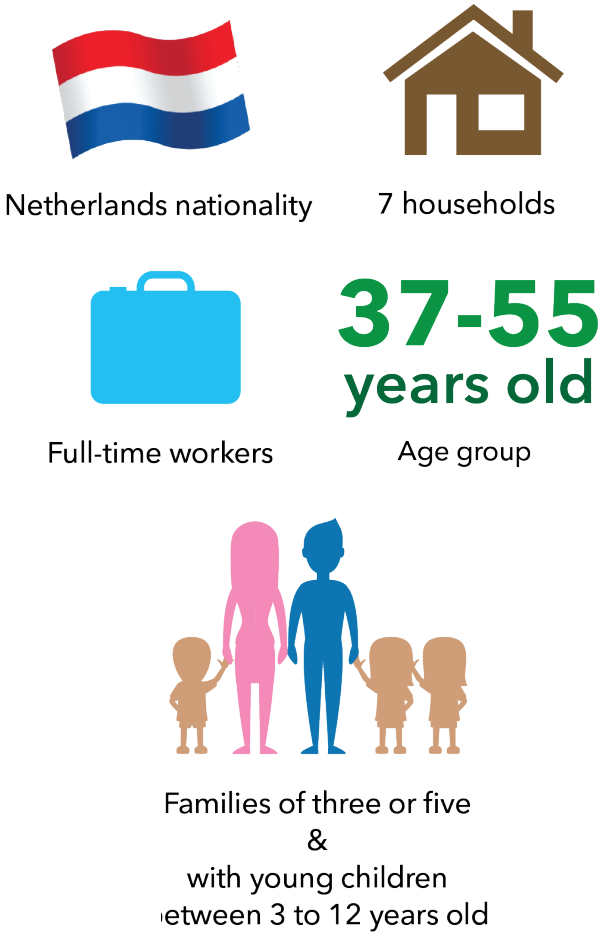


Figure 18. Demographics of the participants.

Interview

Out of seven households, four participants were interviewed at their houses. During the interviews, participants showed their leftovers, partly used foods and the insides of their refrigerators to the researcher. By having informal conversations in a real context, participants were required to express as many ideas as possible using foods that they had and checking food storage conditions in their kitchens.

The primary goal of the interviews was to discover the correlation between the food waste and food consumption patterns of participants as well as their concerns towards food.

In addition, the participants' knowledge of food storage in the refrigerator was tested with a card tool. Participants were asked to arrange food cards on a printed picture of a refrigerator. The categories of food cards were defined by a list of foods Dutch consumers buy and consume often (Voedingscentrum, 2016). The aim of the card test was to discover the participants' general knowledge about food preservation and their typical behaviours.

The food cards were also used as an inspirational tool when interviewees needed to answer questions about what food they regularly buy and discard every week. The interview questionnaire and sources can be found in Appendix D and E.

Figure 19. (top) Four participants of the in-depth interview. (from right) participant A, B, C and D.

Figure 20. (bottom) Food cards and a refrigerator image. Those tools were utilised to test the participant's knowledge of how to store certain foods in the shelves of the refrigerator.

Research setup

Food diary survey

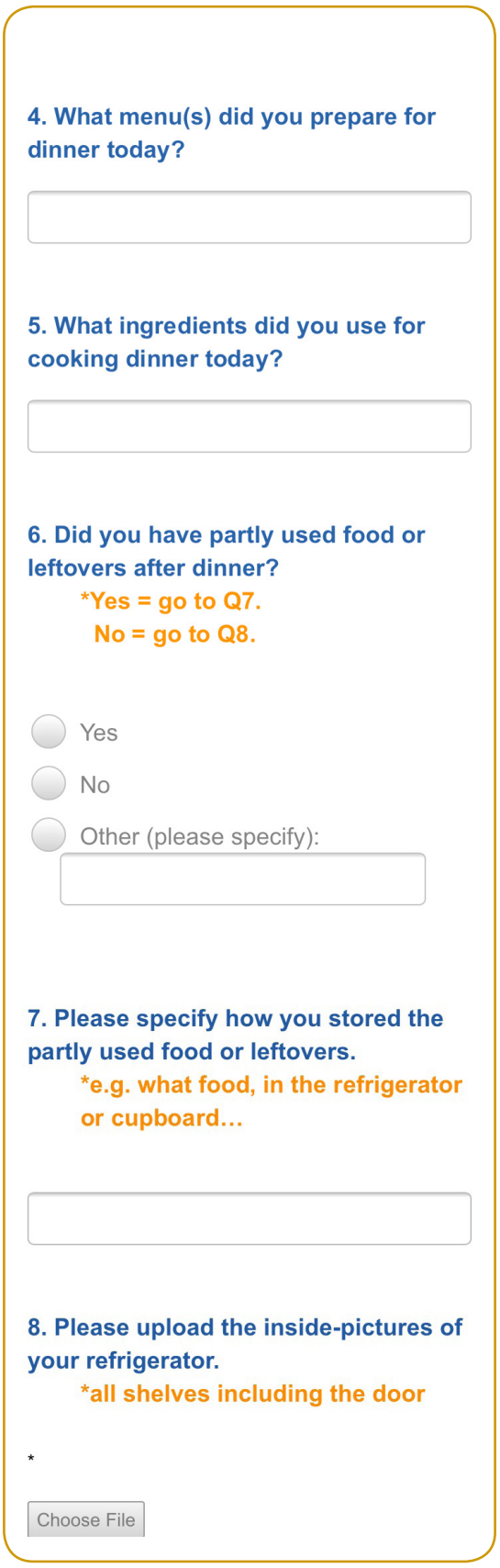
Another method used to interview participants was the food diary. An online survey tool was chosen for the sake of participant convenience, and it was completed by three of the participants over 7 days.

The researcher sent text messages with the online survey link to the participants at 8 PM on each of the 7 days so that they could complete the questions through their mobile phones within 5 minutes.

The participants were asked to fill in the questions in the evening, which is usually after dinner. During the survey on each day, they had to take photos of the insides of their refrigerators and answer eight descriptive questions (see Figure 21).

The questions were mainly focused on what ingredients they had used that day, what food they had cooked for dinner and what food they had discarded after dinner and why. The summary of the food diary can be found in Appendix F.

Before doing the food diary survey, there was no sensitising period since the context of this project is dinner and food management, and candid responses and pictures from participants needed to be obtained.



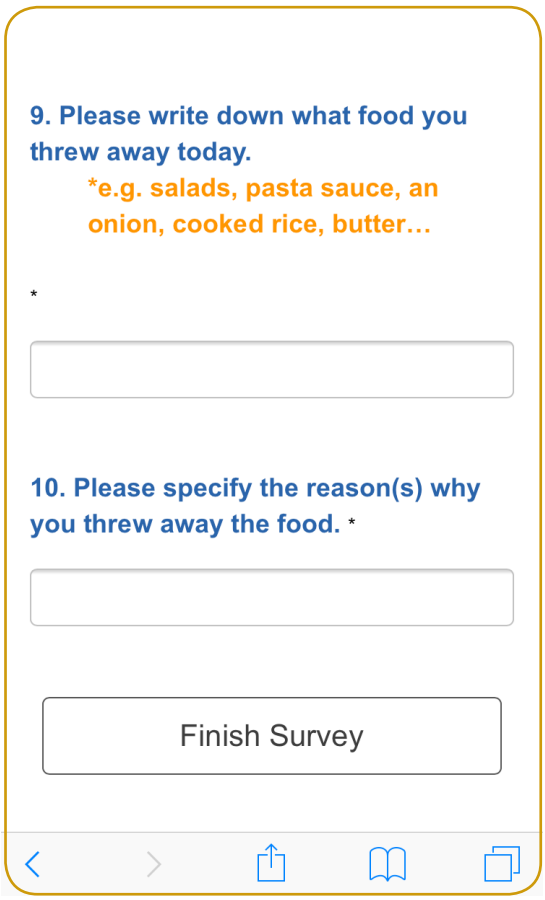


Figure 21. Food Diary survey. Participants could fill in the daily survey via their smart phones for seven days.

Results

All interviews and videos were transcribed for analysis, and valuable insights from participants were collected. The collected data were interpreted in the qualitative sources, a map of consumer concerns, picture mapping and a food-type chart.

Picture diary

It was important to observe the photos of the insides of participants' fridges since a single photo has a number of sources of information, such as food management status, leftovers, food consumption patterns and the most purchased foods by a participant. A total of 55 images were collected from the interviews and food diary surveys.

The researcher took 12 pictures during the interviews, and those were made of the insides of refrigerators and leftovers at the participants' houses.

The other participants of the food diary survey took 43 pictures over 7 days, which did not include pictures of leftovers. When they had leftovers after dinner, they were required to mention the ingredients and reasons the food was uneaten. The analysis on all data can be found in Appendix G.

A B C D

- In-depth interview - four participants A, B, C and D.

The pictures showed the participants' regular patterns of food purchase and consumption as they are. For instance, most of the participants filled the crisper drawer and lower shelves of their refrigerator with various vegetables. The following were sauces in jars and dairy products such as cheese, milk, butter and yoghurt. Leftovers after dinner were found in plastic containers, but few leftovers was showed in the pictures for the following reasons:

1) Partly eaten leftovers could not be consumed again because of a risk of food-borne diseases.

2) Leftover portions too small to be eaten were discarded.

3) Leftovers stayed in the fridge for a long time, so it looked unappealing.

The other finding was the level of knowledge about storing food in the refrigerator, discerned by the food card test. Interestingly, most participants had similar behaviours in terms of food preservation. For example, they kept vegetables on the lower shelf, leftovers on the middle shelf, and opened jars on the upper shelf, which are the correct locations. Therefore, it can be concluded that consumers know how to use the refrigerator properly.

- Food Diary survey - participant E.

Day 1 Day 2 Day 3 Day 4 Day 5 Day 6 Day 7

- Food Diary survey - participant F.

Day 1 Day 2 Day 4 Day 5 Day 6 Day 7

- Food Diary survey - participant G

Figure 22. Inside-pictures of participant's refrigerators. (from top) participants A, B, C and D of in-depth interview and participant E, F and G of Food Diary survey.

Consumers' concerns about food

Through the in-depth interviews, the concerns of participants were discovered, and this study focused on two situations: choosing ingredients and cooking dinner. Four interviewees were asked to rate six concerns on a scale of 1 to 5 (see Figure 22). The Personal Food Choice was cited to make the six categories (see Figure 23) (Furst, T. et al., 1996). As a result, Convenience had the highest average score at 4.75, followed by Quality and Health, both having an average score of 4.25.

First, all participants recognised the CONVENIENCE factor as important. Two participants mentioned that they sometimes use frozen leftovers to prepare dinner since they want to take up less energy and time cooking dinner after work. Meanwhile, all participants responded that they never buy convenience food in the supermarkets.

The QUALITY factor can be explained as having two meanings: food freshness and personal satisfaction with food quality. This concern is highly affected by the Sensory Perception factor. This is because food quality can be judged by consumers' senses on whether the food is spoiled. When the consumers consider the food quality to be low or not valuable, they tend to lose their appetite. Consequently, people are likely to discard uneaten or still fresh food.

Most participants perceived HEALTH to be the underpinning factor in cooking and having dinner. They believed that healthy choices are directly connected to cooking healthy dinner. The participants mentioned that they usually consider this factor while purchasing food at the supermarkets or local markets.

In addition, in the case of food preservation, Health can be associated with the Quality factor since aiming for health at the consumer level means consuming fresh food before it expires, and discarding spoiled food before consuming it.

SENSORY PERCEPTION, with an average score of 3.0, represents how people judge food quality. Participants considered two specific reasons to discard foods before or after dinner: the food's appearance and their judgment of the amount of remaining food.

As for food appearance, participants perceived loss of freshness in food from mould, softness and discoloration.

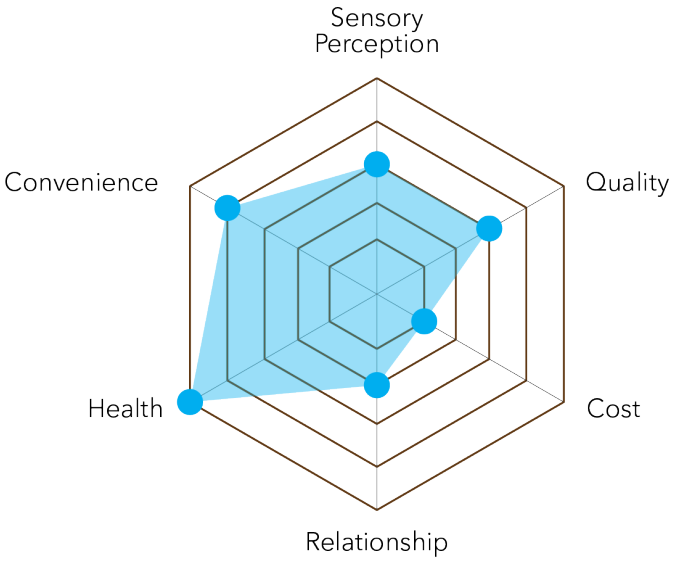
Additionally, all participants of the food diary survey thought that it was acceptable to discard a small portion of food since they considered partly eaten food or partly cut ingredients to not be enough to serve again.

The RELATIONSHIP factor refers to communication and strategies for purchasing and consuming food in the home. However, this aspect scored 2.5 because most participants displayed a common feature in which one household member acts as a food handler and makes most decisions about buying foods and the dinner menu. In the case of special occasions or special requests, the decision-maker buys the food intermittently.

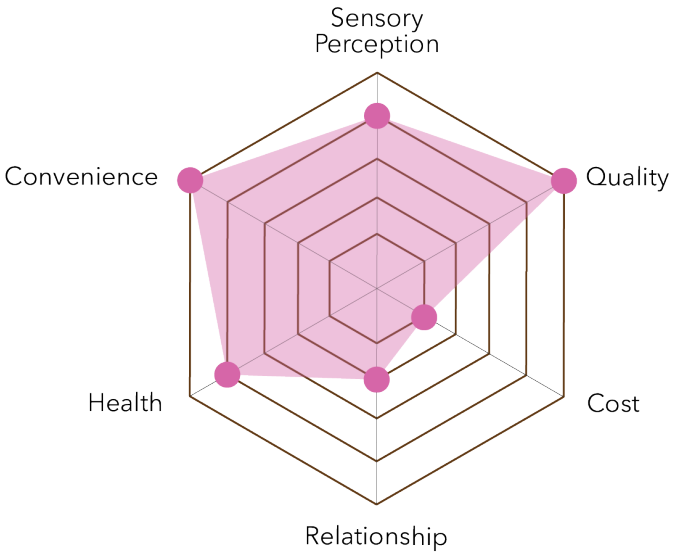
The COST factor, meanwhile, recorded a score of 1.0, which is the lowest score among the six concerns of customers. This value conflicts with the Quality factor since interviewees perceived that relatively expensive foods are high quality.

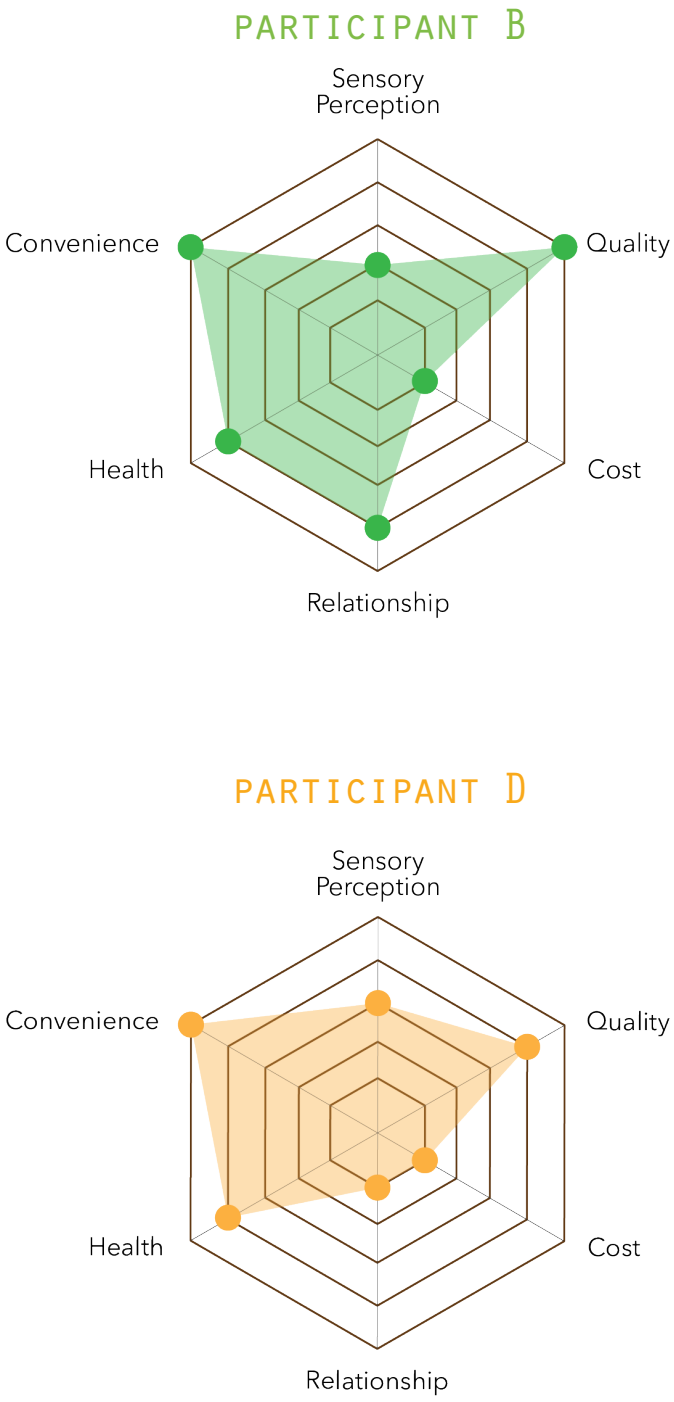
Moreover, the participants were upper-middle class, so they did not feel a high price of food products is a burden. In the case of participant C, for instance, she had been receiving fresh fruit and vegetable boxes, a service provided by a local farmer, every Friday for 6 years. She believed that the food's quality was excellent and the place of origin gave her a feeling of trust, even though the price was much higher than at the supermarkets, such as Albert Heijn or Jumbo.

PARTICIPANT A



PARTICIPANT C





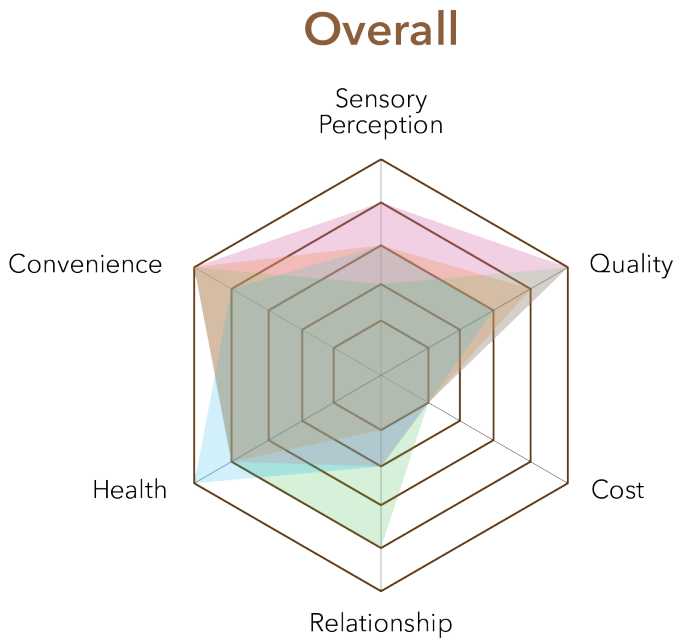


Figure 23. Map of consumer's concerns made by the data of in-depth interview. Four participants gave marks on the six concerns.

Food-type chart

The consumers' habits regarding food purchase and consumption were clearly apparent from the in-depth interviews and food diary survey results. Eighteen food types were found in general, and these were classified according to four categories: mostly purchased, mostly wasted, sometimes purchased and mostly desired foods. The data were analysed in a frequency chart of food types and combined with all data of the seven participants (see Figure 24).

Most of the participants said they have a grocery shopping day once a week and tend to purchase fresh foods such as vegetables, fruit, bread and dairy products, but they answered that they never buy convenience or frozen food (kant-en-klaar maaltijden). This is because most interviewees perceived that these foods are not healthy and are of poor quality. On the other hand, meat and fish are sometimes bought only if someone wants it or there is a special occasion. Participant c said, 'I tend to have meat one or two times per week because eating meat is bad for the environment and for our health as well. So I try to cook fish and eggs with vegetable.'

The most wasted foods were discovered to be vegetables, fruit, bread and leftovers, and sometimes pasta sauce (see Figure 23). The main reasons for these foods being wasted were mould, being in the fridge too long, looking bad, being past the expiry date, not having a pleasant texture and being forgotten in the refrigerator. In addition, people were more inclined to discard leftovers and pasta sauce when the amount of uneaten food left was too little to serve again.

Furthermore, the participants commonly mentioned that they preferred to consume and save vegetables more than the other most wasted food types. The participants bought various vegetables for their family's healthy diet. However, they discarded vegetables frequently because they forgot the vegetables in their refrigerators or did not consume fresh vegetables before expiration.

Figure 24. The chart of food types filtered by four categories. This chart represents the frequency of 18 food types that the participants mentioned during the interviews.

Interview - participant A

	Meat	Fish	Veget-ables	Fruit	Eggs	Milk	Bread	Butter	Cheese	Convenie-nce food	Jam	Pasta (sauce)	Pasta (noodle)	Frozen food	Rice	Salads (pack)	Seasoning (sauce)	Leftovers (cooked)
Mostly purchased foods		■	■	■		■	■	■	■		■	■	■				■	
Mostly wasted foods			■	■			■					■	■					
Sometimes purchased foods	■				■					Never				Never	■	■		
Mostly desirable foods			■	■			■		■									■

Interview - participant B

	Meat	Fish	Veget-ables	Fruit	Eggs	Milk	Bread	Butter	Cheese	Convenie-nce food	Jam	Pasta (sauce)	Pasta (noodle)	Frozen food	Rice	Salads (pack)	Seasoning (sauce)	Leftovers (cooked)
Mostly purchased foods	■		■	■		■	■	■	■		■	■	■		■	■	■	
Mostly wasted foods			■	■			■					■	■					
Sometimes purchased foods		■			Never					Never				■				
Mostly desirable foods			■	■			■					■			■			■

Interview - participant C

	Meat	Fish	Veget-ables	Fruit	Eggs	Milk	Bread	Butter	Cheese	Convenie-nce food	Jam	Pasta (sauce)	Pasta (noodle)	Frozen food	Rice	Salads (pack)	Seasoning (sauce)	Leftovers (cooked)
Mostly purchased foods		■	■	■	■	■	■	■	■		■	■	■		■		■	
Mostly wasted foods			■	■			■										■	■
Sometimes purchased foods	■									Never				■		Never		
Mostly desirable foods			■	■			■											

Interview - participant D

	Meat	Fish	Veget-ables	Fruit	Eggs	Milk	Bread	Butter	Cheese	Convenie-nce food	Jam	Pasta (sauce)	Pasta (noodle)	Frozen food	Rice	Salads (pack)	Seasoning (sauce)	Leftovers (cooked)
Mostly purchased foods	■	■	■	■	■	■	■	■	■			■	■		■			
Mostly wasted foods			■	■			■					■						■
Sometimes purchased foods										Never	■			■		■	■	
Mostly desirable foods	■	■	■				■		■			■						

Food diary - participant E

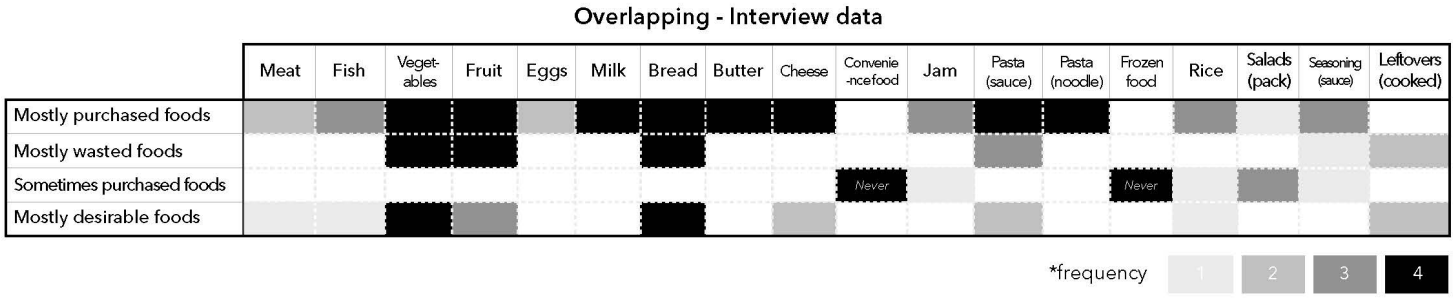
	Meat	Fish	Veget-ables	Fruit	Eggs	Milk	Bread	Butter	Cheese	Convenie-nce food	Jam	Pasta (sauce)	Pasta (noodle)	Frozen food	Rice	Salads (pack)	Seasoning (sauce)	Leftovers (cooked)
Mostly purchased foods			■	■	■	■	■	■	■		■	■	■				■	
Mostly wasted foods			■				■											■
Sometimes purchased foods	■	■								Never				Never	Never	■		
Mostly desirable foods			■									■	■					

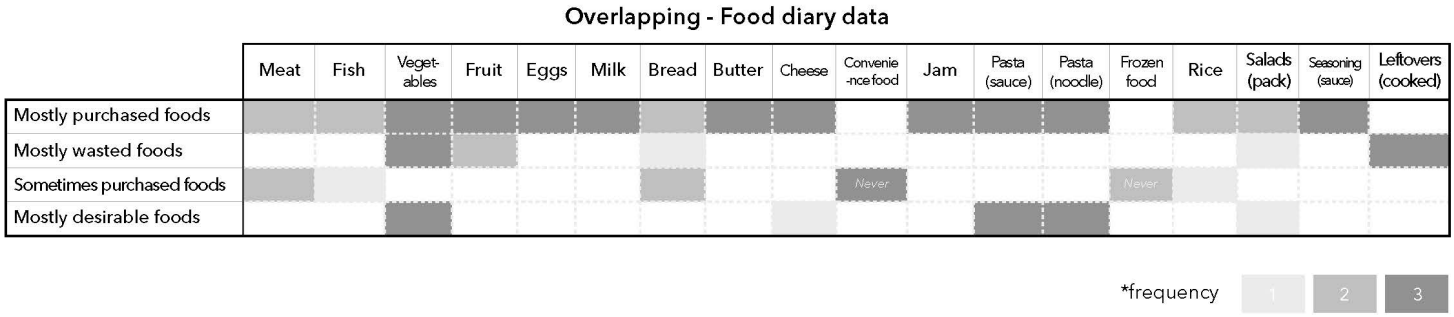
Food diary - participant F

	Meat	Fish	Veget-ables	Fruit	Eggs	Milk	Bread	Butter	Cheese	Convenie-nce food	Jam	Pasta (sauce)	Pasta (noodle)	Frozen food	Rice	Salads (pack)	Seasoning (sauce)	Leftovers (cooked)
Mostly purchased foods			■	■	■	■		■	■		■	■	■		■		■	
Mostly wasted foods			■	■												■		■
Sometimes purchased foods	■	Never					■			Never				Never				
Mostly desirable foods			■									■	■					

Food diary - participant G

	Meat	Fish	Veget-ables	Fruit	Eggs	Milk	Bread	Butter	Cheese	Convenie-nce food	Jam	Pasta (sauce)	Pasta (noodle)	Frozen food	Rice	Salads (pack)	Seasoning (sauce)	Leftovers (cooked)
Mostly purchased foods	■	■	■	■	■	■		■	■		■	■	■			■	■	
Mostly wasted foods			■	■														■
Sometimes purchased foods							■			Never				■	■			
Mostly desirable foods			■						■			■	■			■		





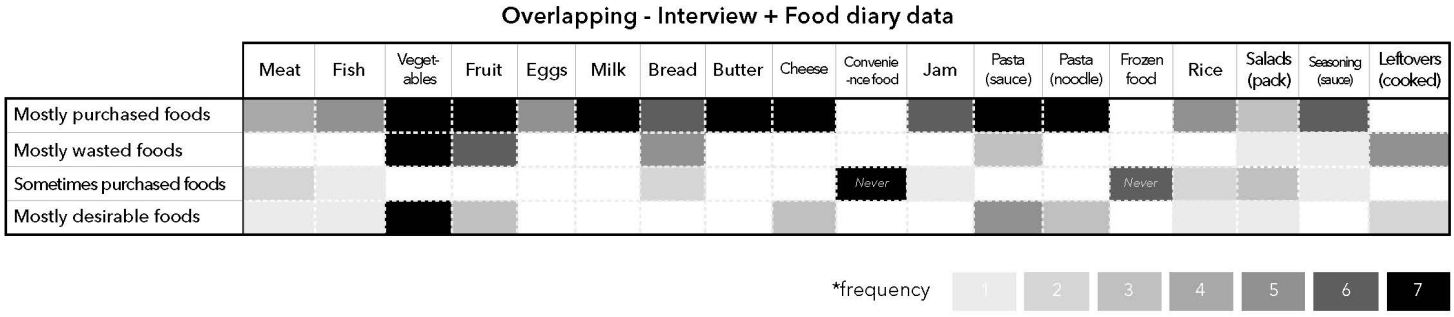


Figure 25. The overall result of the food type chart based on Figure 24.

Conclusion

Overall, this section answers the three research questions:

RQ 1.
What are the current interactions between food and consumers?

RQ 2.
What consumer's concerns are decisive to eat food?

RQ 3.
What kinds of foods do people mostly waste?
sub-RQ 3.
How do people judge the food quality and safety?

All data from the in-depth interviews and food diary surveys are summarised in Figure 26. The mind map shows that participants gave more interesting insights about dinner than about breakfast or lunch. Also, much information was gathered, such as what types of food are frequently wasted and what the underlying reasons are. The three most important conclusions unfolded from the user research and are described in detail.

Vegetables as the most wasted food

RQ 3. What kinds of food do participants mostly throw away?
sub-RQ 3. How do people judge the food quality and safety?

In the user research, vegetables, dairy, pasta and bread were the most purchased food as well as the most wasted food every week (see Figure 25). As in a typical Dutch person's diet, dairy products, sliced bread and cereals were eaten for breakfast or lunch, but pasta and vegetables were cooked for dinner.

In addition, vegetables were consumed through a variety of meals, such as salad, soup, pasta sauce and stir-fried dishes, over 7 days. This means that participants prepared dinners that contained vegetables almost every day. This consumption pattern may have a high possibility of producing vegetable waste before or after dinner. In addition, there were a few reasons for wasting vegetables:

1) mold and looking unappealing
2) forgetting about vegetables, so it stayed long in the fridge
3) too little amount of vegetable to cook next time.

Conclusion

Food waste by sensory perception

RQ 1. What are the current interactions between food and consumers?

As mentioned in Chapter 4, the sensory perception of consumers is a dominant factor when interacting with vegetables (see page 36). Furthermore, the user research in this chapter shows that people tend to discard foods depending on the texture or visual appearance of food products rather than an expiry date (see Appendix **). In the cases of leftover vegetables and partly eaten food, a food-wasting behaviour is more evident.

Also, the reasons for discarding vegetables form a cycle. Imagine the following scenario. A consumer uses some spinach leaves and then stores the remainder in the refrigerator. He or she is likely to forget about it if it is in the corner of a crisper drawer. Eventually, the spinach's texture and condition become poor, and the consumer may perceive that it is no longer fresh. Therefore, the edible spinach is discarded.

Judgment of food quality, which relies on sensory perception, is too personal for each individual consumer to be educated on it through standardized instruction. Moreover, people can simply access the proper information online, such as how to store partly used food or how to understand the freshness of food, but implementing the methods in real situations could be a different matter.

Thus, to resolve this problem, guiding consumers to use the available food or providing them with recipes they can cook from it may be a practical solution before sensory perception interferes with the interaction between consumers and food.

Compatibility of convenience and quality

RQ 2. What consumer's concerns are decisive to eat food?

As a prevalent food trend, the market size of convenience food (kant-en-klaar maaltijd) is growing every year because of the global consumer's needs and busy lifestyle.
Nevertheless, to the participants of this research, 'convenience' does not mean low-quality convenience food, but a 'convenient way' to cook dinner. This implies that minimising energy spent cooking dinner is of fundamental interest to consumers.

On the other hand, a cook needs moderate cooking time, effort and high-quality ingredients to cook a decent meal. It can be stated that the quality factor not only stands for the excellence of foods, but also a cook's satisfaction with the cooking journey. Ironically, these aspects conflict with the convenience factor in terms of cooking dinner.

This project presents a solution to the challenge of how to make the two values compatible, which means that decent food quality and advanced cooking experience should be achieved in parallel. The level of taste and freshness of food, which are the other concerns of consumers, should be fulfilled with a convenience factor. Also, these features provide room to further explore how consumers can cook high-quality meals.

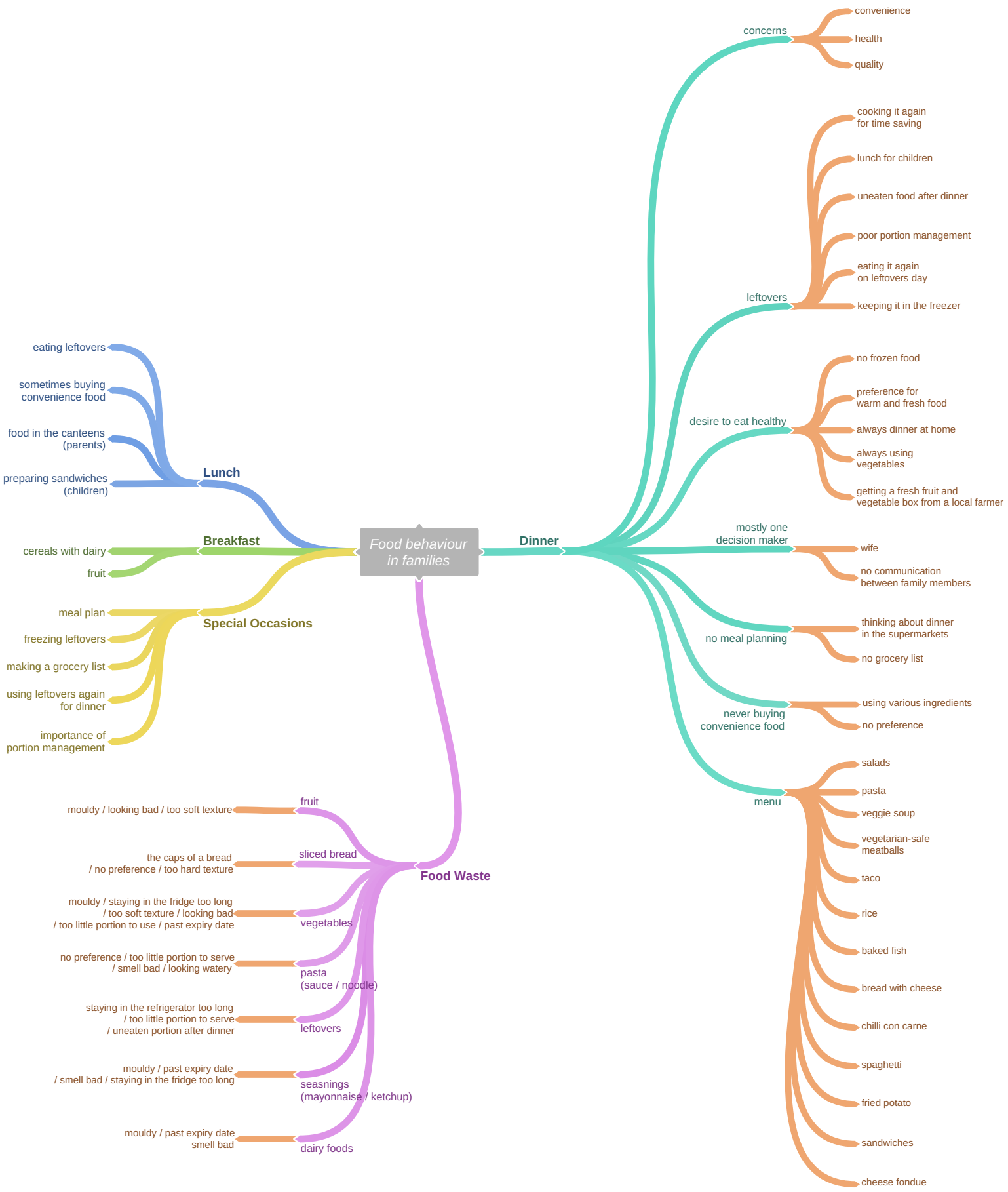
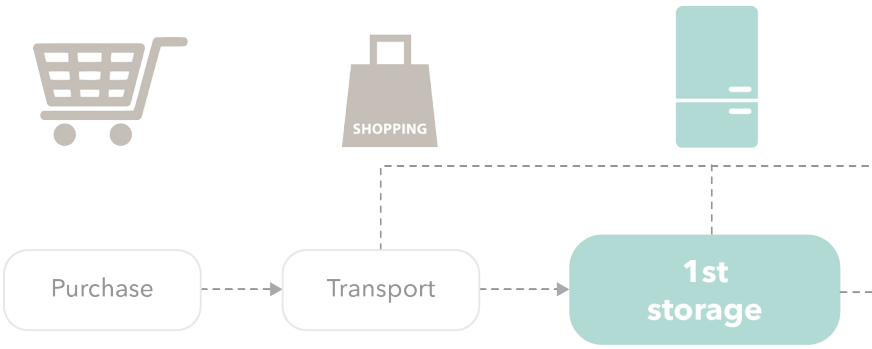


Figure 26. The summary of food behaviours in the families. The bigger size of Figure 26 can be found in Appendix H.

6 | Design Direction

This chapter discusses the design opportunities that have resulted from the literature review and user research. According to the analysis of food processing at the consumer level in Chapter 5, two stages among seven were used to generate the design challenges.
By doing so, the stages involving the most wasted food and the most problems were combined to outline a design statement and analogy. Furthermore, the interaction and product qualities were defined as the inspiring guides.



Findings from literatures	*Misinterpretation of label dates* *Improper ways of storage* *Undervaluing food*
New findings from user research	*Forgetting about food* *Staying too long* *Looking bad* *Too soft or hard texture*

EXPLORING DESIGN OPPORTUNITIES

Connecting the findings

According to the conclusions of the previous chapter, this design project will attempt to solve the problems involving vegetables in the reduction of food waste.

Figure 27 demonstrates that the first hypothesis from the research setup phase is correct, since the participants of this project mentioned many reasons to discard vegetables when storing and preparing them. For this reason, the storage and preparation phases should be combined with the findings from the user research to discover design opportunities.

A closer look at the new findings indicates certain details that are relevant to the vegetable storage and preparation phases. It can be clearly summarized that the first and second storage stages have issues as not being mindful of food and judgment of food quality when discarding food. Moreover, it seems participants had a particular problem in the preparation phase, which is a lack of knowledge of food combination.

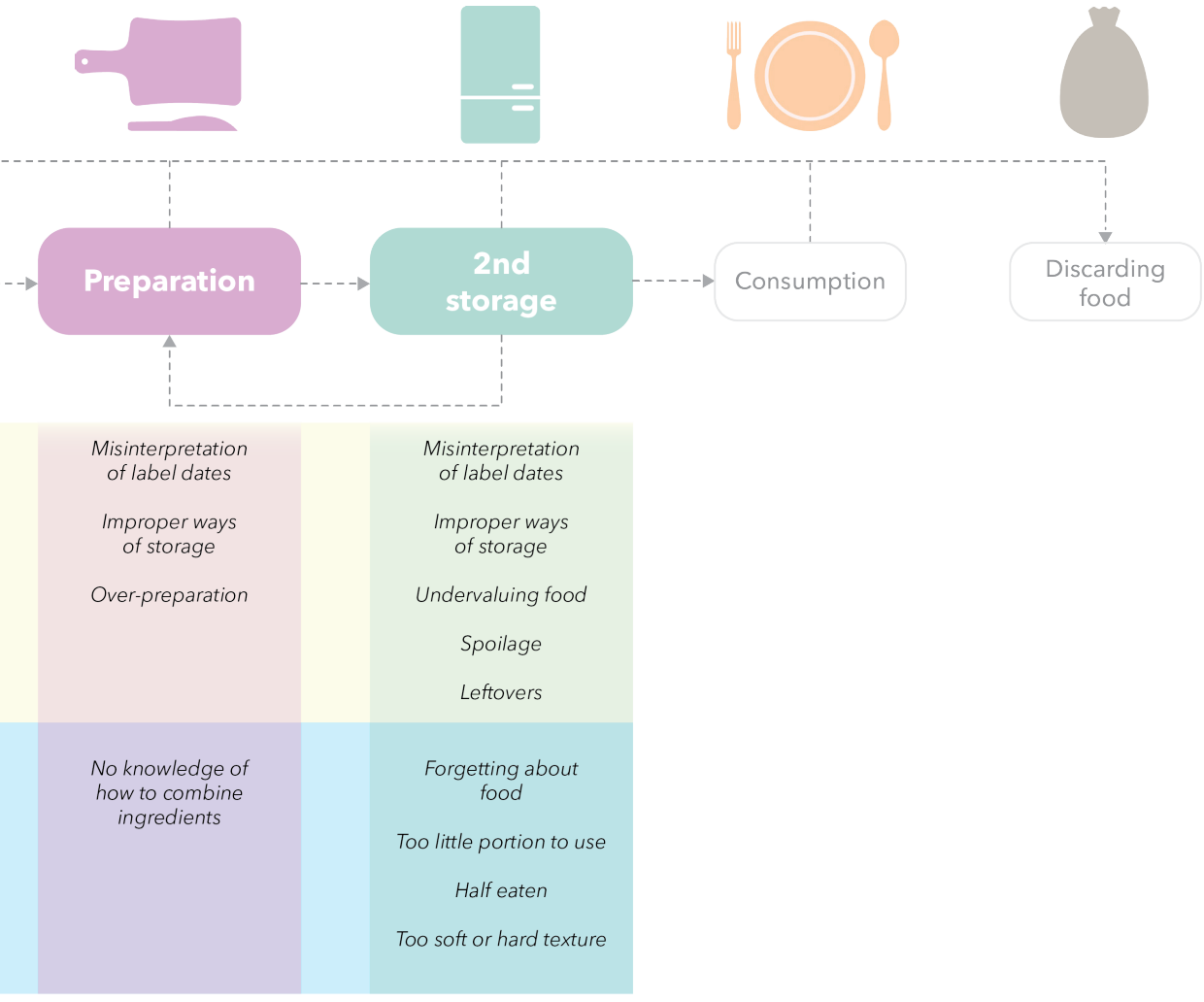


Figure 27. The triggers for food waste researched from literatures (top). The new insights of vegetable waste from the user research of this design project (bottom). The new findings cover the previous findings.

EXPLORING DESIGN OPPORTUNITIES

Two focused directions

Based on exploring the design opportunities, two directions were considered: vegetable management and vegetable preparation.

The two directions affect each other in food behaviours. Therefore, it is reasonable to integrate the two directions to optimize design opportunities. For instance, when a person buys a pack of mushrooms to eventually use, they are stored in the refrigerator first.

Here, two problems can occur after storage:

1) A PARTLY USED VEGETABLE IS FORGOTTEN IN THE REFRIGERATOR, SO IT SPOILS.

2) THE COOK DOES NOT KNOW HOW TO USE A VEGETABLE WITH OTHER INGREDIENTS.

In case 1), the vegetable either may be in the refrigerator for many days until it becomes inedible or it is likely to be discarded immediately. The two issues eventually produce food waste, and they could possibly be solved through supportive managing skills and methods.

In case 2), a variety of vegetables can be prepared at the same time. Therefore, partly used vegetables probably remain after preparation. If so, it is possible to remain only some vegetables that are not enough or cannot fulfill a recipe. To efficiently consume the remaining vegetables in time, a cook can access and use the ingredients by quickly determining the possibility of food combinations.

To sum up, the two directions are defined as vegetable management and vegetable preparation (see Figure 28). Each direction has three essential requirements that should be fulfilled at the conceptualisation phase.

VEGETABLE MANAGEMENT

Definition

Vegetable Management embraces the meaning of storage and quality check-up of vegetables. The vegetable's status is to be stored in the fridge or cupboard for being consumed for later use that is generally before preparation phase. While vegetables are stored, they are likely to be judged by a person's sensory perception to be discarded. In addition, the negligence of a cook is one of the problematical behaviors in this matter. This behavior leads to vegetable waste by situating vegetables in being forgotten or kept in the backside of the refrigerator.

Requirements

- *Convenience*

It is a core value for the sake of a cook and also represents facilitative manners for vegetables that make a user spend reasonable time and energy.

- *Iterative process*

It can form a cook's habit of vegetable arrangement. It should be intuitive and understandable to iterate so that he or she can acquire a new routine naturally.

- *Reminder*

It provides a way to organize vegetables by the latest expiry date. A cook is instantly able to recognise the date on the vegetable packages or mark the ideal date using other materials to consume the vegetables in time. By doing so, he or she can be mindful of the vegetable use.

VEGETABLE PREPARATION

Definition

Vegetable Preparation stands for inspiring a cook to challenge on the previous food experiences by combining other partly remaining vegetables.

It situates pre-cooking phase, which probably requires an ability to ideate some vegetable combinations. The most important matter is that a cook does not need to learn about the food harmony, but being confident when designing an unique meal with vegetables.

Requirements

- *A sense of control*

It stands for having a feeling of autonomy and of deciding how or what to do in one's way. To do so, this value should give a cook a sense of confidence so that he or she can challenge to every possibility of vegetable preparation.

- *Being a creative cook*

It offers a cook some inspiring guidances or hints on how to combine partly remaining vegetables. By doing so, he or she is likely to feel a sense of accomplishment and to invent a new dish willingly.

- *Quick start*

A cook is able to setup the mindset towards preparing various vegetables without hesittion.

Figure 28. Summary of two design directions.

Design vision

Design statement

This design statement illustrates three values; an interaction goal, the ultimate impact and how to achieve the goal and impact.
Moreover, it embodies the two focused directions and will be a solid guide for the next ideation phase.

Another vision of the designer is to inspire people in terms of vegetable preparation. Among the users' insights, people wanted to cook dinner as quick as possible since cooking dinner after work can be unpleasant.

"I want to make consumers feel in control by providing them an inspiring and supportive tool for preparing vegetables to reduce vegetable waste."

The primary goal of this project is to reduce food wasted by Dutch household members who mostly cook dinner at home. The focus group of people mentioned several types of food waste, the reasons to discard food and difficulties in managing vegetables (see Chapter 5).

One of these collective valuable insights was that the research participants were not certain of the quality of food in the refrigerator. For this reason, the researcher wants people to have a feeling of autonomy by disciplining themselves at the beginning of the food process. The more they become accustomed to a management system, the more they improve their food-managing skills, which can eventually decrease the amount of discarded edible food waste.

Convenient cooking tools may save some time and effort, but they cannot ensure that the quality of the cooking experience itself is satisfactory. While cooking in the kitchen, people can be creative and even enjoy the moment because they can switch from tedious tasks to worthwhile moments such as broadening their food horizons, learning ingredients' features and creating their own style.

Analogy

To deliver additional value to the design statment, an analogy is made below (see Figure 29).

"Drawing a colourful picture in many different paints"

Drawing a colourful painting is an enjoyable moment and a great achievement for a person. Imagine that before a painter starts drawing a picture, he or she first thinks about what to draw.

The artist needs some inspiration, many colours of paint and tools to depict ideas from scratch. Some painters may plan by sketching and colouring or mixing paints to create their colours. To do so, support such as a colour guide or a guide on how to use art supplies could be useful to a painter to complete a picture.

On the other hand, some professional artists may immediately begin drawing. In this case, they may feel fun and confident since they can discover a new art style or colour combination.

Therefore, the analogy of drawing a picture in various colours stands for a confident journey of creation by using many different materials.

Figure 29. Analogy image. Drawing a colorful picture in many different paints.

Interaction vision

Interaction and product qualities

The interaction and product qualities are defined as the additional guidelines to accomplish the design statement.

Interaction qualities

• Mindful: Mindful interaction means users willingly use and cherish vegetables to cook dinner.

• Inspiring: This interaction quality is able to arouse user's creativity regarding vegetable combinations.

• In control: Through this interaction quality, users are allowed to manage various vetetables confidently and freely.

Product qualities

• Targeted: The product would fulfill the goal of advancing the user's vegetable experiences as well as reducing edible vegetable waste.

• Supportive: This quality would help users to use leftover vegetables as well as saving user's time and energy.

• Informative: The product would deliver useful information of vegetables to users such as 'how to use' and 'what to do' through simple texts or images.

‘Mise en Place’ technique.Photography by Shutterstock ID stockfoto: 271173683


EDIBLE / AVOIDABLE
FOOD WASTE
POSSIBLLY AVOIDABLE
FOOD WASTE
INEDIBLE / UNAVOIDABLE
FOOD WASTE

7 | CONCEPTUALISATION

In this phase, individual brainstorming and a group creative session were conducted to produce some design concepts based on the design statement and interaction and product qualities. There are two focused directions in the previous chapter (p. 67), and during the idea generation, it became apparent that the two directions significantly affect each other like a chain reaction. Thus, six specific requirements for the two directions are considered in the final design concept (see Figure 27).

IDEATION

Group creative session

A group session was held with six IDE students to obtain fresh ideas on the topic. The group consisted of students in three different master's courses: Design for Interaction, Strategic Product Design and Integrated Product Design. A facilitator gave them two 'How to (H2)' questions, and session participants were asked to discuss and generate as many ideas as possible for 100 minutes; see the creative session plan in Figure 30.

The two H2 question were:

1. *How to remind people of vegetables in their refrigerators.*

2. *How to support people to prepare vegetables before cooking.*

The first H2 statement represents vegetable management and the second one represents vegetable preparation, which are the design directions from the previous phase.
The participants were given about 25 minutes for each H2 question to be discussed and to visualise ideas on post-its and A4 paper.

Moreover, participants were required to speak out loud during the session because it is efficient for producing creative ideas together in a short time. Also, the facilitator intervened in the discussion to guide participants toward the right topic using some inspiring images and key insights from the previous research (see Figure 32).

After the session, more than 25 idea papers were collected, and the ideas were then clustered by similarity.

Creative session

Time	Min.	Action	How
12:00	5	Introduction of project context and problems	statement, problems, keywords
12:05	5	H2 remind people of vegetables in the fridge	
12:25	20	Think about tools or storages in other fields.	first ideas
12:30	5	H2 support people to prepare vegetables before cooking	
12:55	20	Think about guidances or information of foods that are useful to cooks	second ideas
13:05	20	Sharing ideas and converging few ideas together	• combining ideas • post-its+paper+pens • 3 ideas
13:25	20	Developing each idea based on participant's preferences	• 2 people in a group • 3 final ideas
13:35	10	Sharing the final ideas together	presentation by participants
13:40	5	Closing	

Figure 30. Creative session plan.

Figure 31. Creative session with six IDE master students.

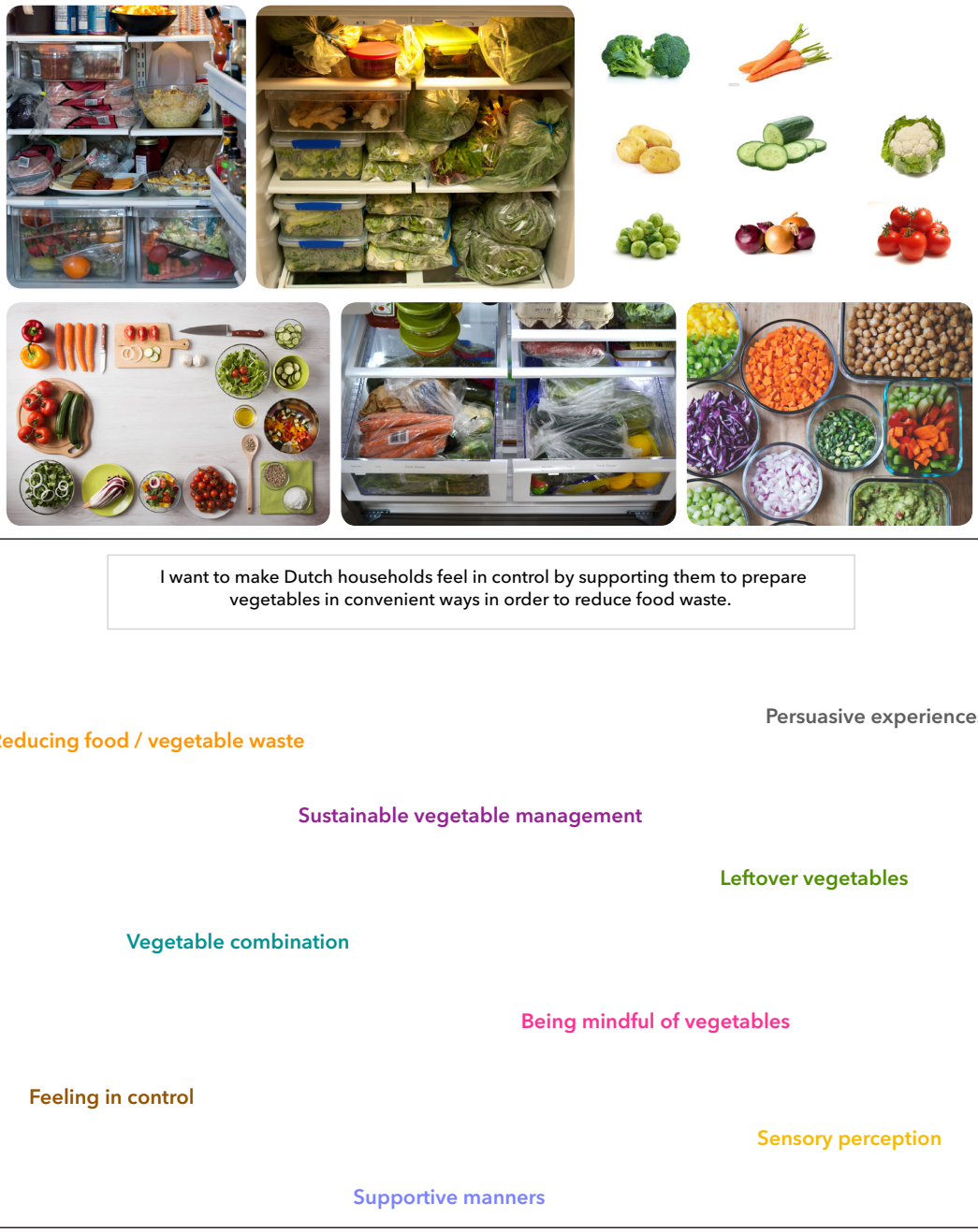


Figure 32. Inspiring images (top). The design statement and key insights from the in-depht user interview (bottom).

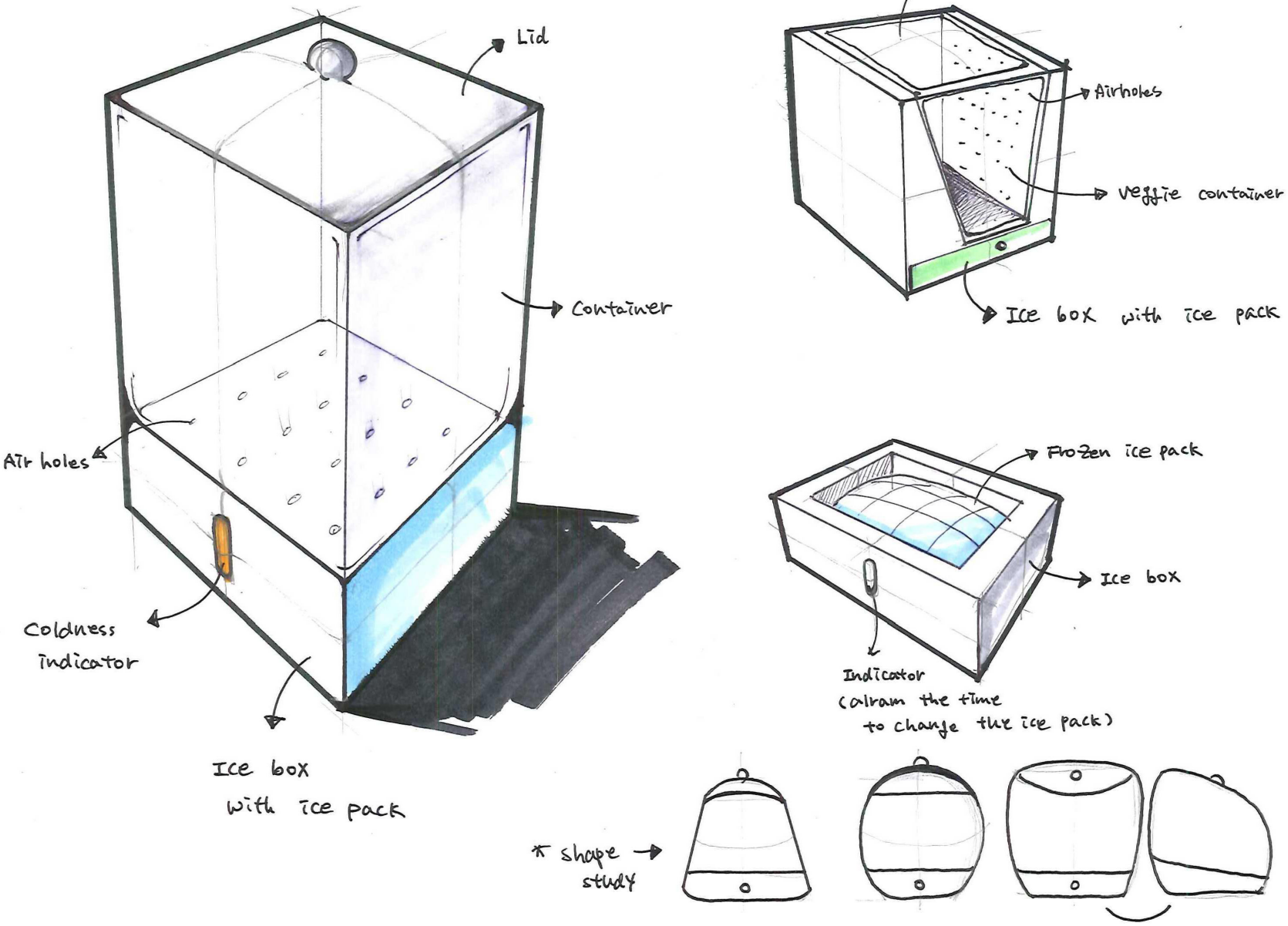
Individual ideation

The creative session gave interesting and fresh views on the subject. After clustering the ideas, some design concepts were created and developed by an individual idea generation.

To integrate ideas and make promising concepts, various types of study were performed at the same time.

- material, structure and shape study
- estimation of each concept
- quick prototyping with papers and card boards
- advantage and disadvantage analysis

CONCEPT 1. VEGETABLE'S HEAVEN



Description

The more people encounter vegetables, the more chances they will get to eat vegetables. The concept of Veggie's Heaven stays outside of the refrigerator. It can be located on the kitchen counter which is at the eye level of users. Users can see the fresh vegetables every time before cooking. It can be said that there will be less abandoned and hidden vegetables in the crisper drawer.

Components

- a glass container
- a glass lid
- ice pack box (cool box)
- ice packs (Techniice)
- temperture sensor

Advantages

- easy to keep quickly perishable vegetables
- a reminder of edible and fresh vegetables
- visible vegetables like a show window, not in the crisper drawer in the fridge

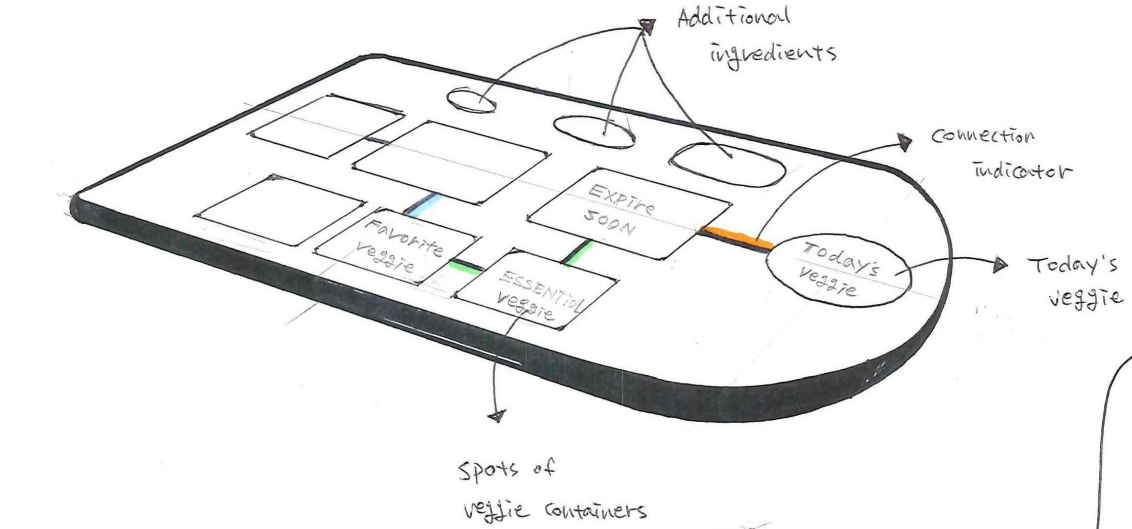
Disadvantages

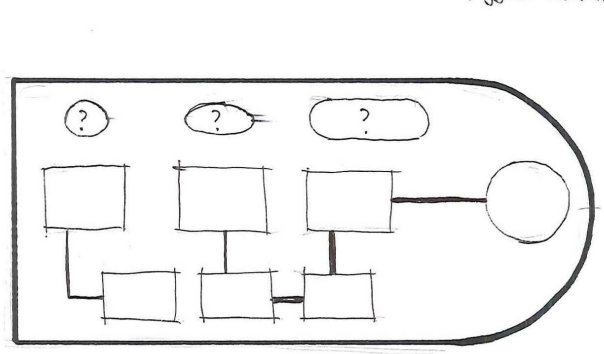
- regular replacement of ice pack every three days
- still possible to forget about stored vegetables in the container
- a possiblity to occupy much room on the kitchen counter

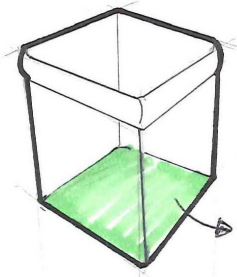
Estimation

- Feasibility ★★
- Aesthetics ★
- Usability ★
- Effectiveness ★★★

CONCEPT 2. VEGGIE MAP







- ✓ Favorite veggies (single)
- ✓ Favorite veggie (several) Combination
- ✓ The latest expiry date (single)
- ✓ Today's veggie

- ✓ Additional ingredients
  - meat / fish
  - neutral
  - oil / sauce

Description

How can a product inspire users to cook as many vegetables as possible for dinner? How can a product help users to organize their vegetables before cooking? Veggie Map supports users to be a creative cook by considering the vegetable combinations with other ingredients. This product shifts the paradigm for vegetable status by stimulating users to think of vegetables first. This concept is derived from chef's technique called 'Mise en Place' and 'Platter of nine delicacies' that is a traditional Korean food culture which help you see every ingredients at a glance.

Components

- map on a wooden plate
- transparent vegetable containers
- guide booklet

Advantages

- repositioning vegetables as a primary ingredient to cook a meal
- easy guidance for users on combining vegetables with other ingredients
- education Dutch consumers about food pre-preparation techniques

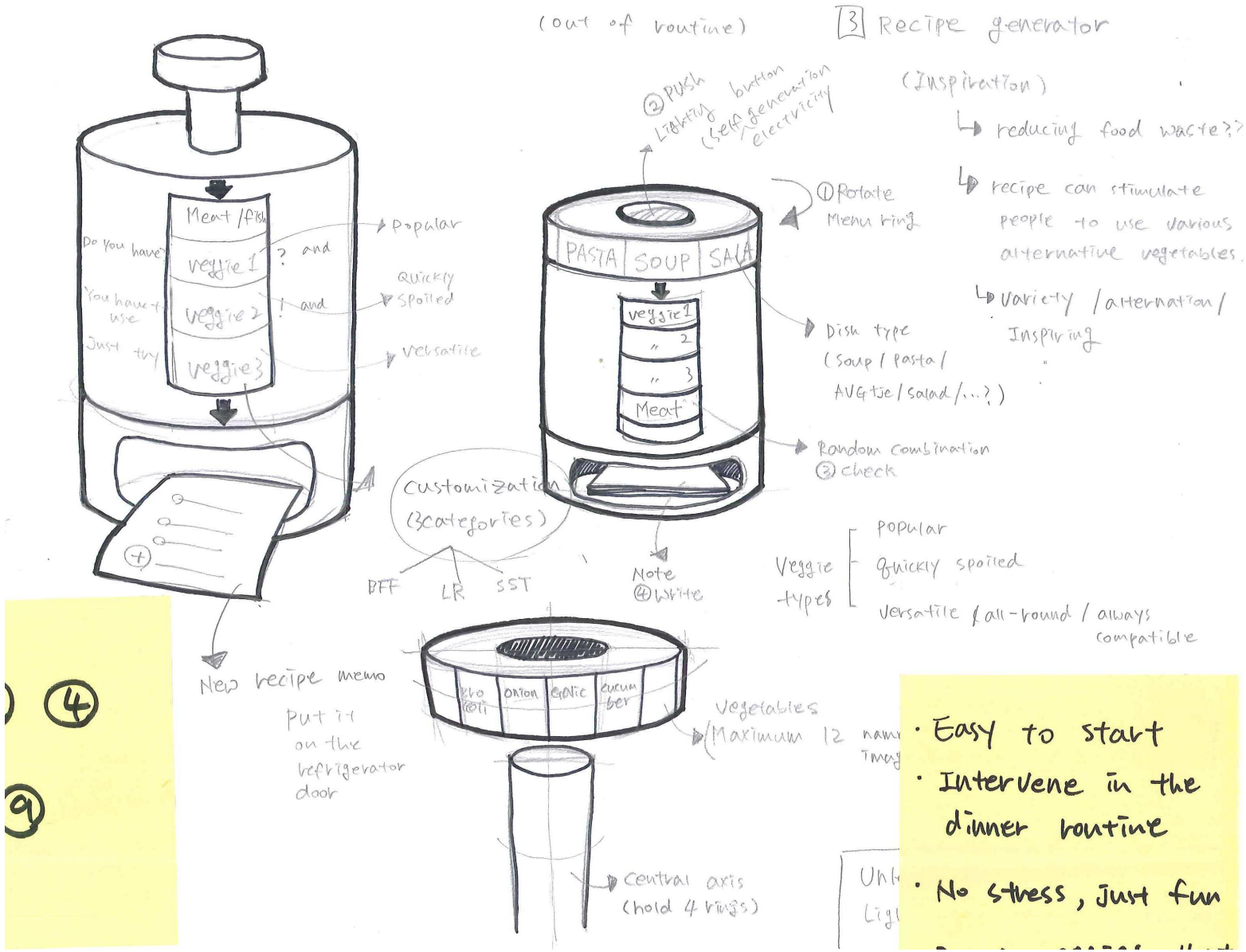
Disadvantages

- less quick method to start cooking
- asking users to put much effort to pre-prepare vegetables
- a big size and heavy weight of the wooden plate

Estimation

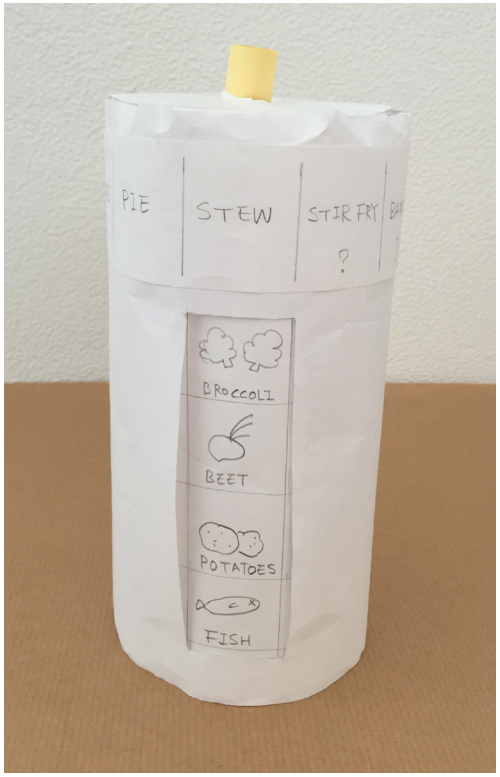
- Feasibility ★★★
- Aesthetics ★★
- Usability ★
- Effectiveness ★★

CONCEPT 3. RECIPE GENERATOR



Description

There are numerous of various recipe books and websites in the world. However, do people actually use the books or video clips to cook something on a daily basis? It turns out that most people are accustomed to cooking a meal that they already tried before. It might be a safe zone of a cook in the house and make a family's food experience boring. The Recipe Generator will break the boring meal plan by randomly showing the combination of vegetables with an alternative ingredient. Moreover, the goal of this concept is to inspire users to challenge a new menu by just pushing a button before cooking. By doing so, it naturally guides users to use vegetables that they already have in the fridge. Of course, anadditional guidelines would be offered to use the product correctly.



Components

- three rings with vegetable icons and one ring with alternative ingredient icons
- transparent vegetable containers
- a guide booklet

Advantages

- a random stimulus for a user who cannot come up with a single recipe
- easy to generate a vegetable combination
- no need to buy a recipe book

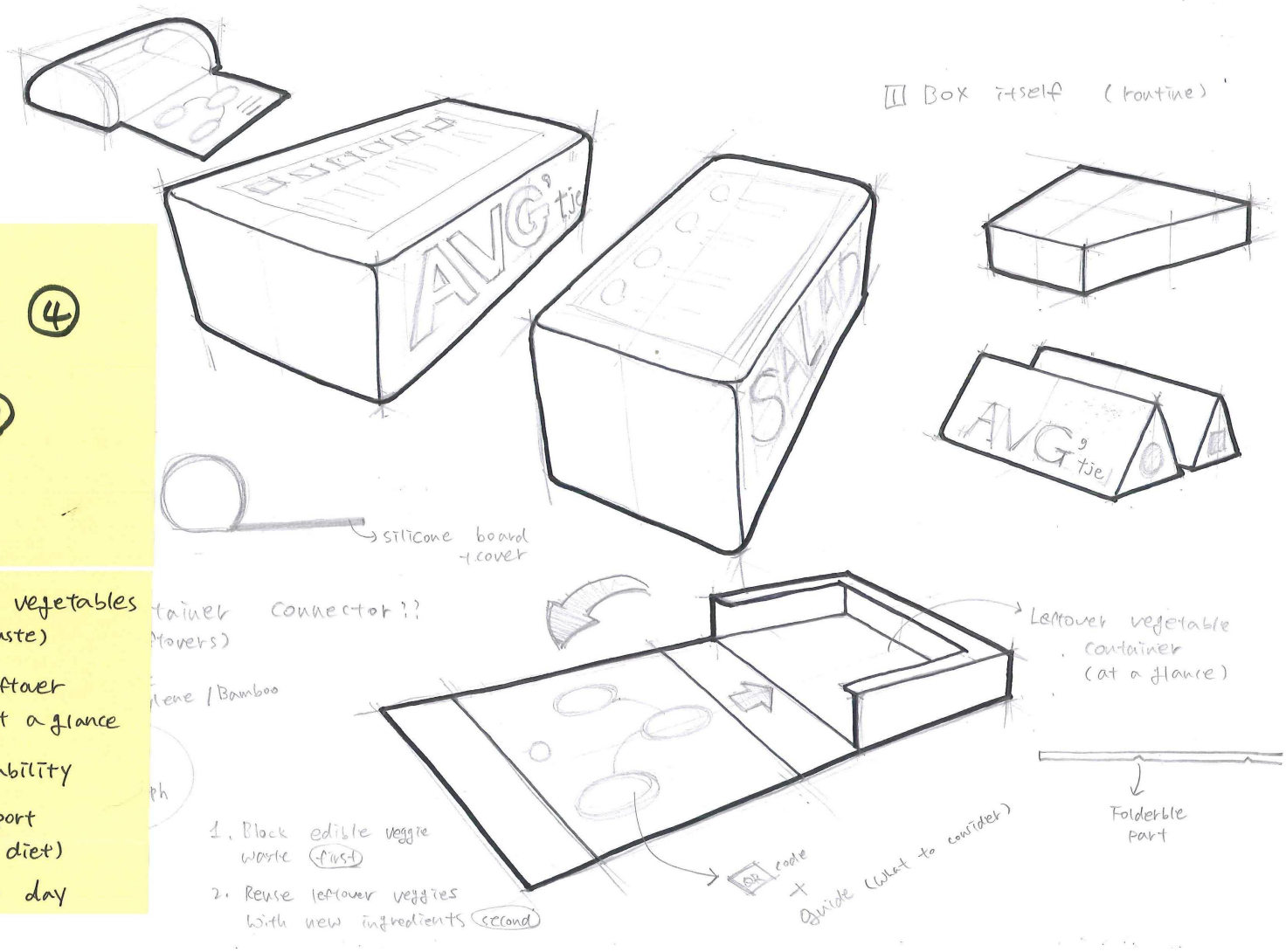
Disadvantages

- an unexpected taste dish
- less extensibility to cooking experience

Estimation

- Feasibility ★★
- Aesthetics ★★★
- Usability ★★★
- Effectiveness ★

CONCEPT 4. VEGGIE-TABLE



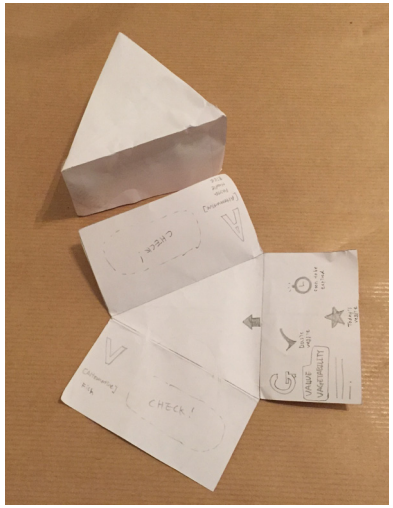
② ③ ④

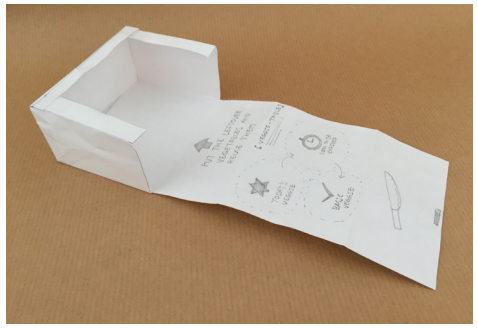
⑦ ⑨

- save edible vegetables (avoidable waste)
- see every leftover vegetables at a glance
- Check vegetability
- AVG'tje support (typical Dutch diet)
- For leftover day

Description

Most vegetables are gradually spoiled after cutting or unpacking. They are remaining vegetables, and need a special aid to be useful as long as possible. Thus, an integrated vegetable storage and preparation system would be efficient like Veggie-Table. This concept has the similar idea of Concept 2, but relatively it requires less effort of users. This is because it encompasses the three functions such as storage, cutting board, and guidance. The three aspects are naturally continued since the product would guide users step by step. The primary goal of the concept is to save leftover vegetables in the same place and use them first so that the edible vegetable waste can be decreased.





Components

- a sturdy container with transparent part
- a cutting board from the container
- a guide booklet

Advantages

- no need to keep half cut/eaten vegetables somewhere in the fridge
- easy to generate vegetable combination
- education about how to manage vegetables
- no more a lot of plastic bags and containers

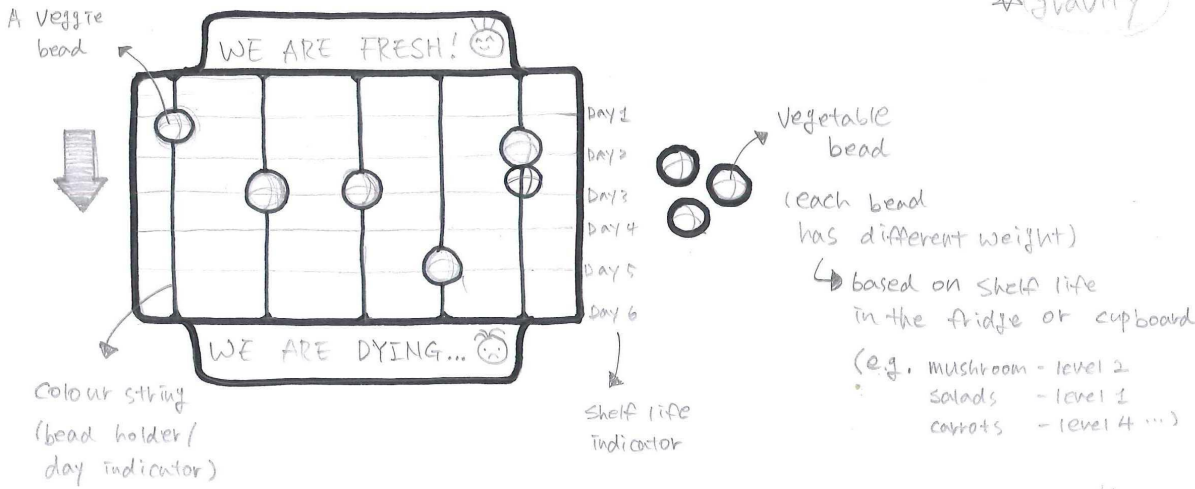
Disadvantages

- the hygiene issue of an inseparable cutting board from the container
- a possibility to be messy the inside of the container

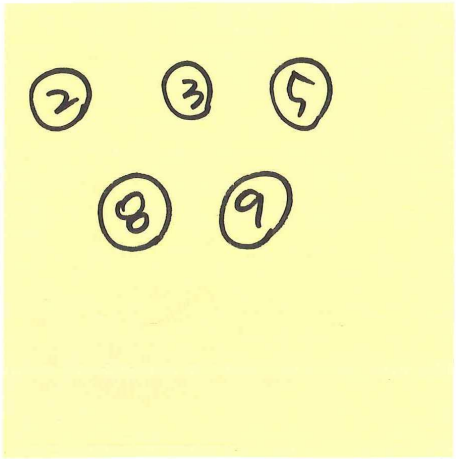
Estimation

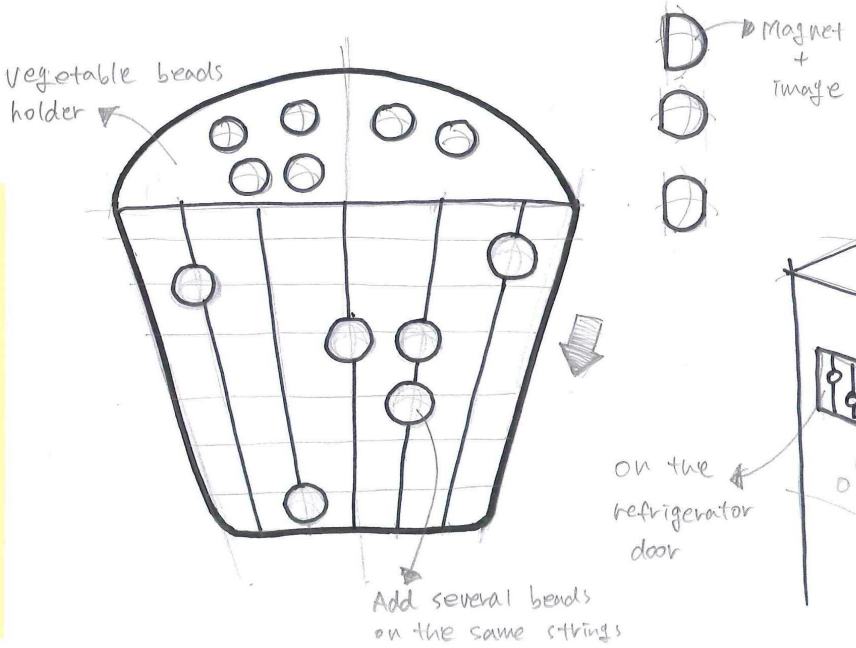
- Feasibility ★★★
- Aesthetics ★★
- Usability ★★★
- Effectiveness ★★★

CONCEPT 5. THE TIME OF VEGETABLES



- Check fastly what I have vegetables
- Expiry date indicator
- Deliver the vegetability by different colors, icons and weight of beads
- No need to check crisper drawer every time





Description

Do you know what expiry date means? And do you sometimes throw away foods based on the information? There are several types of date labels on the food package such as ‘best by’ or ‘sell by’, and the information is used to distribute food products to the supermarkets and supply chains. It is difficult to understand especially for vegetables, so the shelf life of vegetables need to be managed by user-centered design.

This concept would be an intuitive indicator of the vegetable shelf life using gravity since each magnetic bead has a different weight based on the official consumption period. For example, leafy vegetables need to be consumed within three days, but potatoes can be eaten for more than a week. Therefore, a bead of leafy vegetable has much heavier weight than tuber vegetable one. Several beads go down in different speed for seven days on the strings so that users are able to manage the quantity and quality of vegetables. Furthermore, users can attach the product on the refrigerator door and quickly understand what I have and what I need.

Components

- vegetable icons on magnetic beads that have different weight
- a magnetic plate with strings

Advantages

- no need to consider the date labels on the vegetable products
- understanding of vegetability through the color and weight of the beads
- a useful tool to plan meals

Disadvantages

- hard to think about recipes
- a possibility of forgetting to hang the beads on the strings

Estimation

- Feasibility ★★★
- Aesthetics ★★★
- Usability ★★
- Effectiveness ★

Conclusion

The creative session brought out many inspiring ideas, and they were classified and polished during the individual ideation. Five concepts were created in this phase, and they are summarized by four aspects: feasibility, aesthetics, usability and effectiveness.

Concept 1 is a new approach to preserving fresh vegetables to consume them often and make them visible. This approach is simple, but many variables such as temperature, vegetability and frequency of use make it unstable.

Concept 2 is a guide to vegetable combination to inspire users before cooking. However, this idea may not fulfil the goal of reducing vegetable waste since it requires an effort of pre-preparation such as chopping, trimming and blanching vegetables that are not familiar to Dutch householders.

Concept 3 can be defined as an unusual recipe-maker that generates random vegetable combinations. It could make the experience of vegetable preparation fun, but it is not certain that the concept would reduce vegetable waste.

Concept 5 would resolve the difficulty of understanding expiry date labels on current food packages. It shows the shelf life of vegetables on the refrigerator door to remind householders of purchased vegetables.

Concept 4 was chosen for further development since it involves two vital functions simultaneously, storage and preparation, which have not much improved in recent times. In addition, this idea has relatively high feasibility, usibility and effectiveness compared to other ideas. Finally, the concept is still unclear, so it will be improved in various aspects in the next chapter.

Photography by AMBAliving.

TEXT BOX 1. STUDY OF EXISTING PRODUCTS

An extra research of current products that try to enhance the experience of vegetable management and preparation was conducted. The significant trend of vegetable management seems to switch the ordinary ways of storage to making vegetables visible. Thereby, the products remind users of the edible and fresh vegetables in the kitchen.
On the other hand, there are rarely particular products for only vegetable management. This is probably because people are likely to
perceive that preparation and cooking are the almost same process. For example, preparation means to wash, trim and chop vegetables, but methods are close to cooking. Thus, it is required that the two activities have to be approached
differently regarding producing vegetable waste.

As a good example of the vegetable management, the *Food Huggers* made by food safe silicone cover the cut surface of vegetables and fruits. The product keeps half used ingredients fresh and prevent the contamination by germs.

Figure 33. Food Huggers by Michelle & Adrienne.

OLTU is an integrated food conservation system for fruits and vegetables. The product consists of a refrigerator and clay containers, and keep the vegetables in the containers fresh in a sustainable way. It uses the heat from the refrigerator, which is wasted energy from cooling down inside of the refrigerators, to maintain the humidity in the terracotta storages on the top of the refrigerator. For the refrigeration system, the storages have a double layer on the wall (water tank) to contain the water, and the heat from the fridge evaporates the water to lower the temperature in the containers.
Thereby, some vegetables that do not need to be stored in the fridge can ripen and hydrated outside of the refrigerator and even stay longer.

Figure 34. OLTU by Fabio Molinas.

Figure 35. GRÖNT by Agnes Sjöberg.

GRÖNT concept suggests storing vegetables outside of the fridge. We all may have a typical preservation behavior regarding food which keeps everything in the refrigerator. This is probably not the best way to store vegetables because the inner temperature of the refrigerator cannot be optimised for all ingredients. This is why the design product utilises water to keep some vegetable's freshness even though they are on the kitchen counter. The methods of the concept are three; submerged under the water, contained in an air-tight container, or standing in the water. The other advantages of this product are to put vegetables on the eye level. Therefore, the product consistently reminds people to use vegetables on the kitchen counter more.

Figure 36. Cook This Page by IKEA.

Cook This Page is an easy cooking concept that was presented at the IKEA Canada Kitchen event in 2017. The idea seems to change a paradigm of the ordinary cooking ways. Moreover, the concept argues that numerous usual recipe books will not be attractive in the future. This is because users can see the overview of the ingredients intuitively in the pages without text-based instructions. Users need some prepared ingredients and a big paper that contains simple illustrations of a recipe. The next step is just to fill in the blank on the paper using real food ingredients. The drawings are printed on a parchment paper with food-safe ink. When everything is in the right place, the paper can be rolled up and put in the oven. On the other hand, it has a disadvantage that it cannot satisfy every recipe such as fresh salads, soup or stir fry menus. Nevertheless, Cook This Page is definitely an efficient and fun cooking concept.

8 | CONCEPT DEVELOPMENT

In this chapter, the decisions involved in materialising the project idea and the prototyping process are explained.
Concept 4 (Veggie-Table) was chosen due to its design directions, interactive qualities and the estimation of each concept based on the four aspects, feaibility, aesthetics, usability and effectiveness.
The fundamental concept was retained, but the structure of the concept was changed from the original design to enhance its usability and feasibility.

THE FINAL CHOSEN CONCEPT

The Veggie-Table, briefly, has three integrated functions, which are storage, a cutting board and guidance. These factors need to be addressed in present times, since they have not been developed in the culinary field, and each function cannot be separated to reduce vegetable waste. Here are the main concerns in developing the chosen concept.

First, current food storage systems are mostly (airtight) plastic bags or containers. They are convenient for storing food, but they are not sustainable methods of helping people consume sufficient vegetables or good for the environment.

Second, a cookbook is sometimes needed when cooking a meal. Recipe books recommend using a strict order and ingredients. However, people tend to cook a meal based on what they have tasted before and what they have already.

Last, partly used vegetables often remain after cooking. They may be hidden somewhere in the refrigerator. Eventually, when they are not used, they may be discarded. Thus, this concept attempts to resolve the three practical issues simultaneously:

1) *Too much separate storage such as plastic bags and containers in the refrigerator*

2) *Lack of guidance on good vegetable combinations*

3) *Abandoned leftover vegetables*

THE FINAL CHOSEN CONCEPT

To improve Concept 4 at this phase, different types of research were conducted, such as shape, size and material studies, classifying of vegetables, lists of requirements, product structures and user scenarios.

Concept definition

Figure 37 illustrates a virtuous Veggie-Table cycle. This product is mainly for vegetables that partly remain after cooking. Also, the goal of the product is to remind users of leftover vegetables that they have already used. As a result, the leftover vegetables become a priority while preparing ingredients.

The partly used vegetables can be naturally grouped following the information on the lid. This skill can be enhanced by some additional information, such as from a mobile application, at the beginning of product use. After practising vegetable grouping, users would form their own vegetable management habit.

Three characteristic patterns are engraved on the surface of the lid, which inspire users to combine vegetables. The basic concept of the patterns is to imply the three classes of vegetables, respectively Stem & Leaf (SL), Flower & Seed & Fruit (FSF), and Root & Tuber (RT), since most vegetables can be classified into these three categories.
Furthermore, users can immediately prepare the selected vegetables on the lid. If they are not sure about how to store and prepare vegetables with the product, a mobile application will offer proper answers.

In summary, the container helps users to organise vegetables in a certain order, shown by the lid patterns. The lid leads users to cook several vegetables by encouraging them to consider three types of vegetables at a glance.

Therefore, the users can consume all partly used vegetables, and it ultimately results in the reduction of vegetable waste at home.

The detail product description is explained in the Design proposal section at page 104.

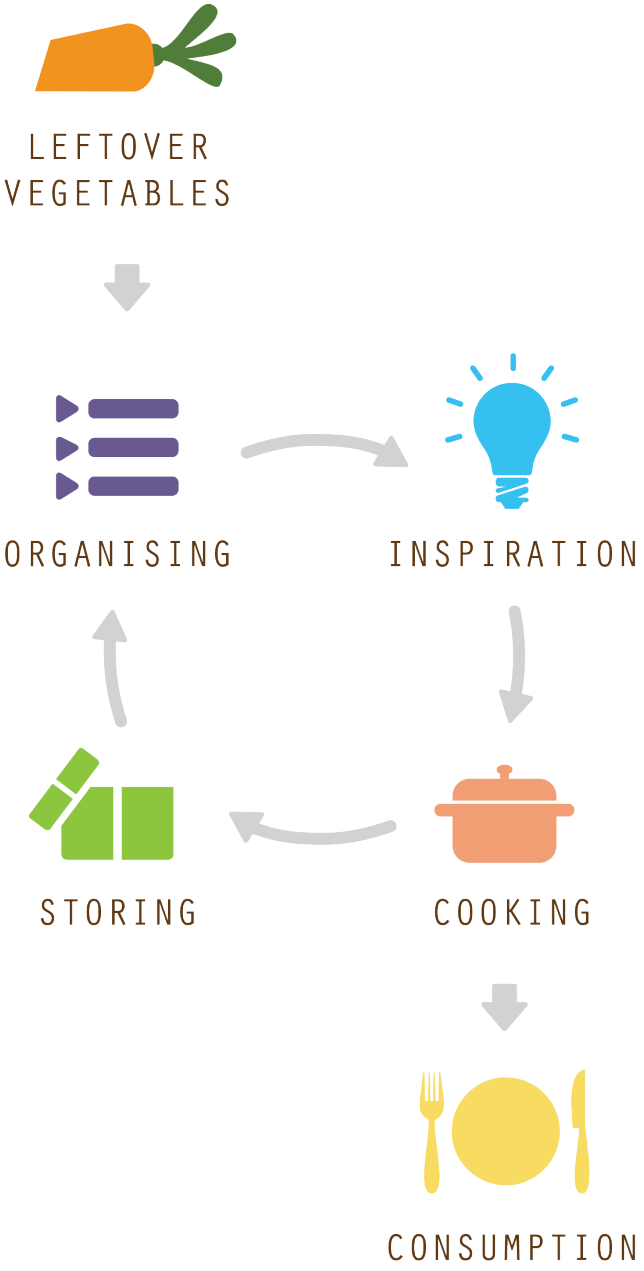


Figure 37. Process of the product usage.

Creative thinking through three classes of vegetables

Most vegetables can be categorised into three classes based on vegetability: Stem & Leaf, Flower & Fruit & Seed, and Root & Tuber (see Figure 38). The three groups of vegetables are interpreted by three figurative patterns on the product lid as guidance.

Through the pattern information, users can produce various vegetable-centred recipes. For instance, a user may be in the mood for a specific vegetable and then considers which meals can be made with this vegetable. Naturally, he or she needs to consider other vegetables that are already in the fridge to complete the meal.

The most interesting technique for this situation is what chefs call mise-en-place. The term means putting everything in its place, which means seeing all ingredients at a glance. This is an important aspect of the concept of reducing avoidable vegetable waste since the better people can see the vegetables, the more likely the vegetables will be used.

The Veggie-Table concept provides users with a feeling of autonomy by facilitating random vegetable combinations. Thus, the patterns that represent the groups of vegetables are a new approach to preparing vegetables and encourage people to consider the leftover vegetables before using new ones.

Furthermore, considering several of the methods of famous chefs, interestingly, it is apparent that their recipes have a broad variety of vegetables that belong to the three groups. For examples of the vegetable-centred recipes, see Appendix I. Thus, any partly remaining vegetables can be useful and valuable again when three groups of vegetables are cooked together.

	Classes	Types of vegetables
	Stem Leaf	Asparagus, Basil, Brussels Sprouts, Cabbage, Celery, Chard, Chicory, Collard Greens, Endive, Fennel, Kale, Kohlrabi, Leek, Lettuces, Pak Choi, Radicchio, Rhubarb, Rocket, Savoy Cabbage, Spinach, Spring Greens, Water Cress...
	Flower Seed Fruit	Artichoke, Aubergine, Avocado, Broccoli, Broad Beans, Capsicum, Cauliflower, Cumin, Corn, Courgette, Cucumber, French Beans, Lentils, Marrow, Paprika, Peas, Pepper, Pumpkin, Runner Beans, Soya Beans ,Squashes, Sweet Chestnut, Tomato...
	Root Tuber	Beetroot, Carrot, Cassava, Celeriac, Garlic, Ginger, Jerusalem artichoke, Kumara, Light Root, Onion, Parsnip, Potato, Radish, Salsify, Shallot, Spring onion, Swede, Sweet Potato, Taro, Turnip, Yam...

Figure 38. The three class of vegetables.

The primary design

The prototyping tests were briefly conducted several times. In so doing, the feasibility of the prototypes was judged quickly, and several ideas were then developed in detail (see Figure 40).

The Veggie-Table is kept in the refrigerator so that the leftover vegetables can survive longer. For the efficient organisation of space inside the refrigerator, a rectangular shape was chosen for the concept's exterior.

The product dimensions are 200 mm wide, 120 mm high, and 350 mm deep. The height and depth of the product correspond to the average depth of the shelves and the door of refrigerators. On the other hand, the width was determined to occupy half the width of a shelf for efficient space management in the refrigerator. In addition, the container is for only partially remaining vegetables so it does not need to be as large as a standard crisper drawer.

The product is opened like a gift box, and the lid is completely flat so that users can see every component of the product at a glance. At the same time, the guide of how to use the product is immediately shown inside of the lid when it is opened.

The interior of the product should embody the guide of how to organize the leftover vegetables in an informative way. There is the requisite information, such as Today's Veggie, Soon-to-be-Expired Veggies and Essential Veggies. It first asks users which vegetable they would like to use and that leads to the next two questions. By doing so, users can see the leftover vegetables in the container spontaneously as well as think about the vegetable combinations. Furthermore, the flat part of the product plays a role as a cutting board so that users can immediately prepare the chosen vegetables. An additional transparent cutting board is attachable and separable from the product so that it can be washed after use.

Quick evaluation test

Additionally, the information display of the concept appears to be important since this aspect requires a high level of interaction with users. Therefore, the information display was tested before making prototypes. The purpose of the test was to find an appropriate way to guide users. 10 master students in IDE participated in the quick evaluation tests, and they were asked to rate three different styles of the infographic on a score from 1 to 5. Before the test, the researcher prepared some vegetables and gave participants a hypothetic situation: Now, you are about to use the vegetables to create a new vegetable combination.

The three types of the infographic were named 'step', 'icon', and 'pattern'. The graphics were judged by two major categories: Understanding and Aesthetics.
The test results can be found in Appendix J.

As a result, 'pattern' was rated the highest, accounting for the highest average score in Understanding and Aesthetics, 3.9 and 4.1 respectively.

Participants preferred the pattern concept since it evokes their curiosity of the meaning of the patterns and looks better than other options. Also, they often mentioned that 'icon' is the easiest to understand when it comes to the symbols. However, they pointed out that the vegetable icons limit their thoughts of other vegetables and combinations.

On the other hand, 'step' showed the lowest score in Aesthetics (1.5) because it has many texts and the graphics do not look clear enough.

Figure 40. The first shape study of Veggie-Table concept.

The modified design

After several quick prototyping tests, the structure of the product was improved regarding the method of opening and showing the guide on the product.

STRUCTURE

Veggie-Table consists primarily of two components, a container and a lid. When the lid is joined to the container, the inside of the product becomes airtight to protect partly used vegetables from spoilage.

The partitions in the container are installed based on the graphics on the lid to manage the leftover vegetables in a large container hygienically. The sections in the container and the graphics on the cover have the same concept, vegetability.

After a user understands the patterns on the lid, he or she perceives which vegetables need to be stored in which section. Furthermore, the lid has a reverse L-shape and the container has two open surfaces to enhance usability. Users can open the lid inside the refrigerator by pulling the lid and taking out leftover vegetables. It is also possible to lift the cover on another surface, such as a kitchen counter.

SIZE

The product is placed on any shelf in the refrigerator because it should be visible at the user's eye level. Therefore, the previous dimensions were retained to make the final prototype, but it was proved that the depth should be less than 350 mm according to the first prototyping test (see Figure 42).

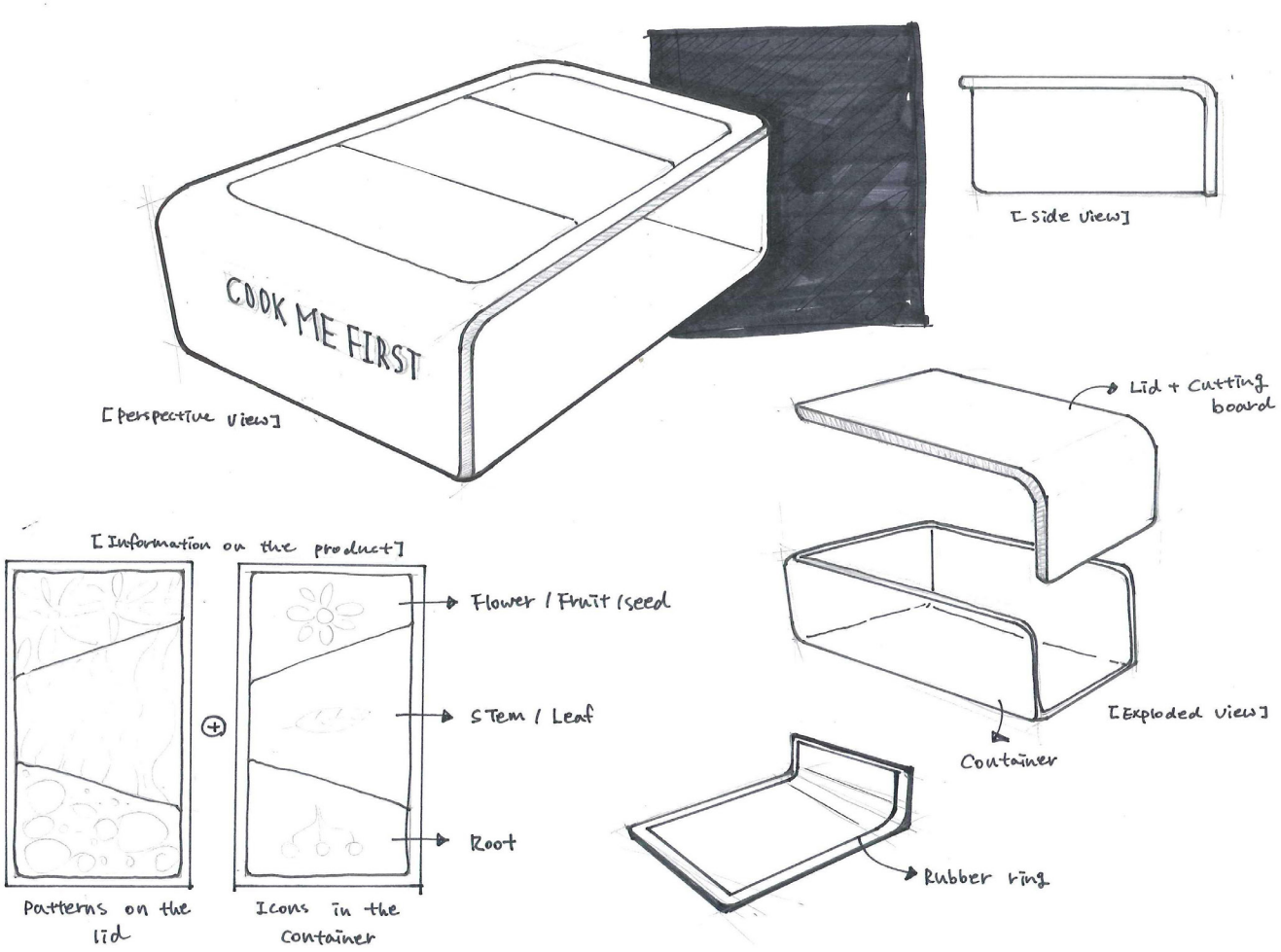


Figure 41. The final sketch of the concept

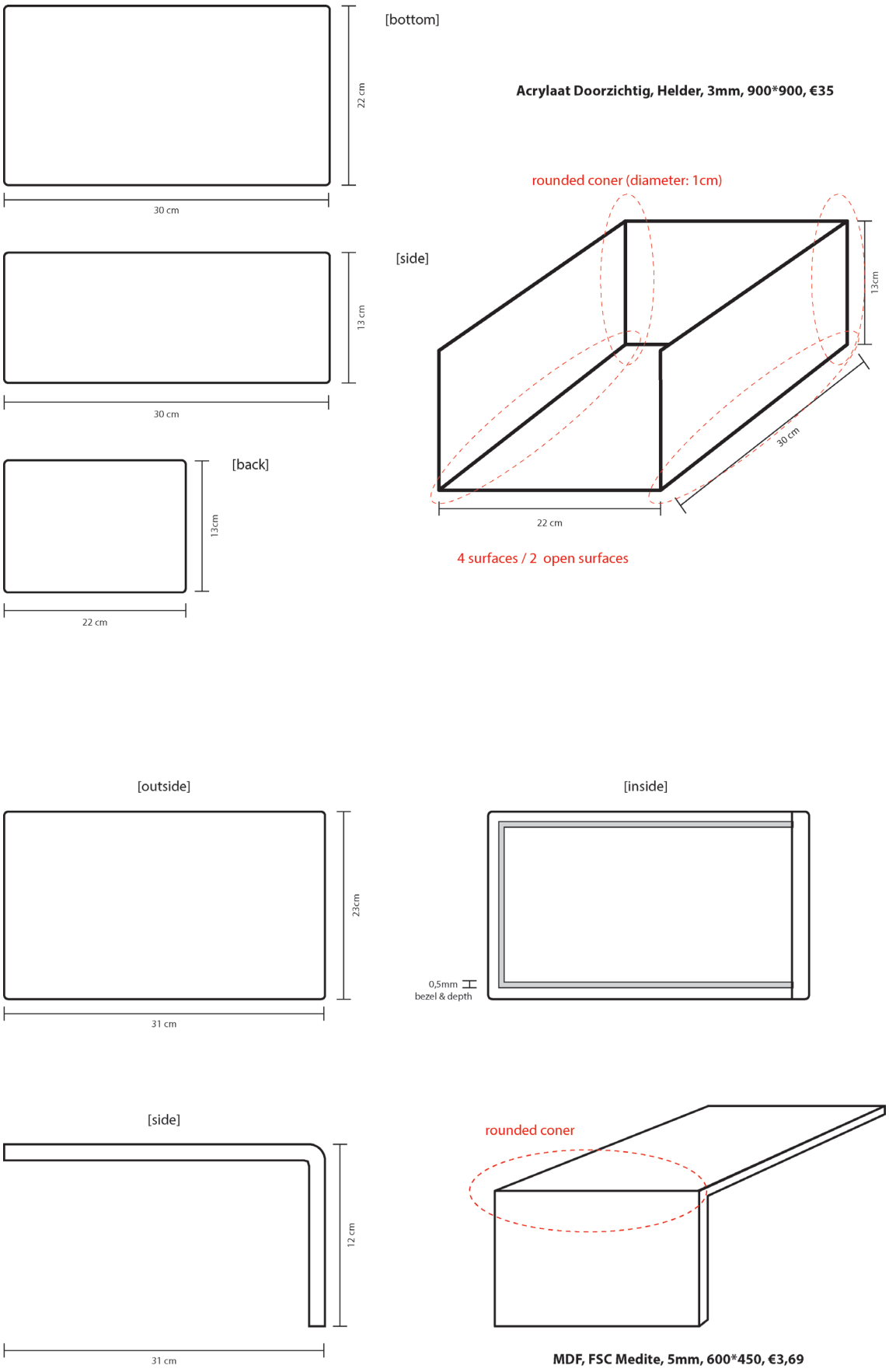


Figure 42. Dimensions of the container (top) and lid (bottom).

Embodiment

Materials

As for the container, it needs to be transparent for the inside of the product to be visible, so 100% transparent Polypropylene and glass were considered for their durability.

Bamboo and beech, which are hard woods, are recommended materials for the lid since preparing vegetables on wood is acceptable. Wood is better than plastic for cutting vegetables on, according to Ben Chapman, who is a food-safety researcher at North Carolina State.

Also, the wooden lid should be washable in the dishwasher for sanitary reasons. Material references can be found in Figure 43. Note that a plywood plate was used at the prototyping phase instead of bamboo or beech because of budget and delivery issues.

Figurative patterns

The figurative graphics on the lid represent the three groups of vegetables. The patterns enhance the aesthetics of the product and play a leading role as inspirational support to users. They each occupy a separate space so that users can place vegetables on them.

Doing so allows users to get to know a vegetable's character over time and accumulate knowledge of its vegetability to broaden their cooking horizon.

To create these patterns on the wooden board, laser engraving was chosen because it lasts longer than paint.

Application

In addition, a mobile application containing detailed information on the Veggie-Table was considered in this phase. This is positive, because a website or application is an informative source of support as well as easy to access via mobile phone.

In addition, numerous recipe videos on the Internet can be linked with the application to enhance the vegetable-cooking experiences of the users.

Moreover, a QR code is imprinted on the lid to allow access to the application at any time. The application concept and design are described on page 101.

Figure 43. Inspiring images of the product's materials and character.

Prototyping process

Two different methods, thermoforming and laser cutting, were applied to the model making since the concept has two components that are supposed to be made of plastic and wood.

As for the container making, a big shape of wood had to be formed first based on the measurement. The tricky part of executing the method was the sharp edges of a wooden mold. After sanding the edges by 20mm diameter, it was ready to be done by vacuum forming.

A transparent acrylic plate was heated to a pliable forming temperature, and then rapidly formed to the container shape in a mold. The edges were still rough, so it was conducted three times more.

The partitions inside of the container were made of the same material to the container and glued to it, see Figure 44. Besides, a silicone mat was attached on the bottom to prevent the slip of vegetables in the container.

Figure 45 shows how the lid was created by plywood. The reason why a plywood was selected is that the material has enough strength and durability since its many layers are intentionally glued together. Therefore, living hinge could be applied to the plate to make one part bendable.

Lastly, a laser cutting machine engraved the patterns and text on the plywood.

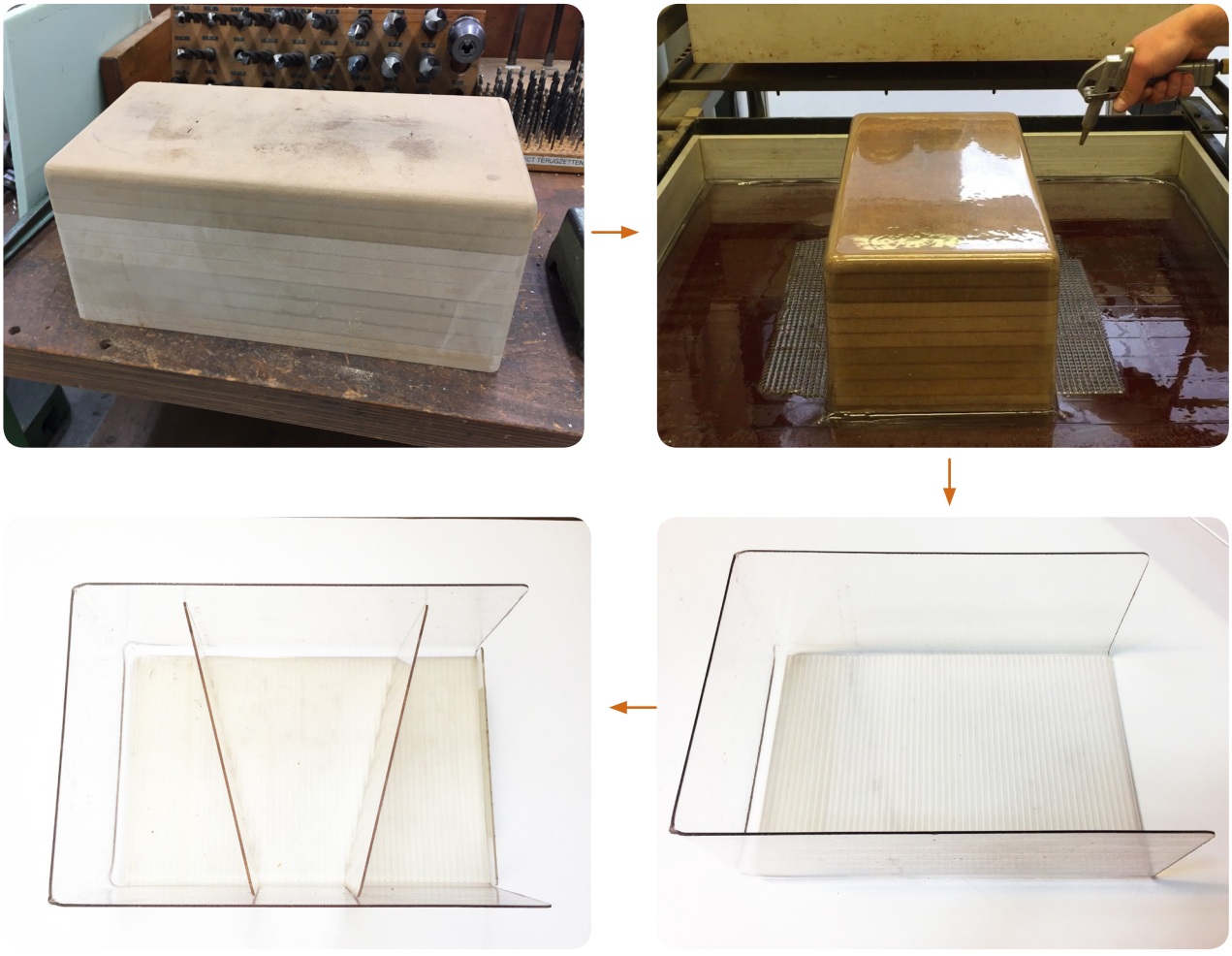


Figure 44. Embodiment process of the container.

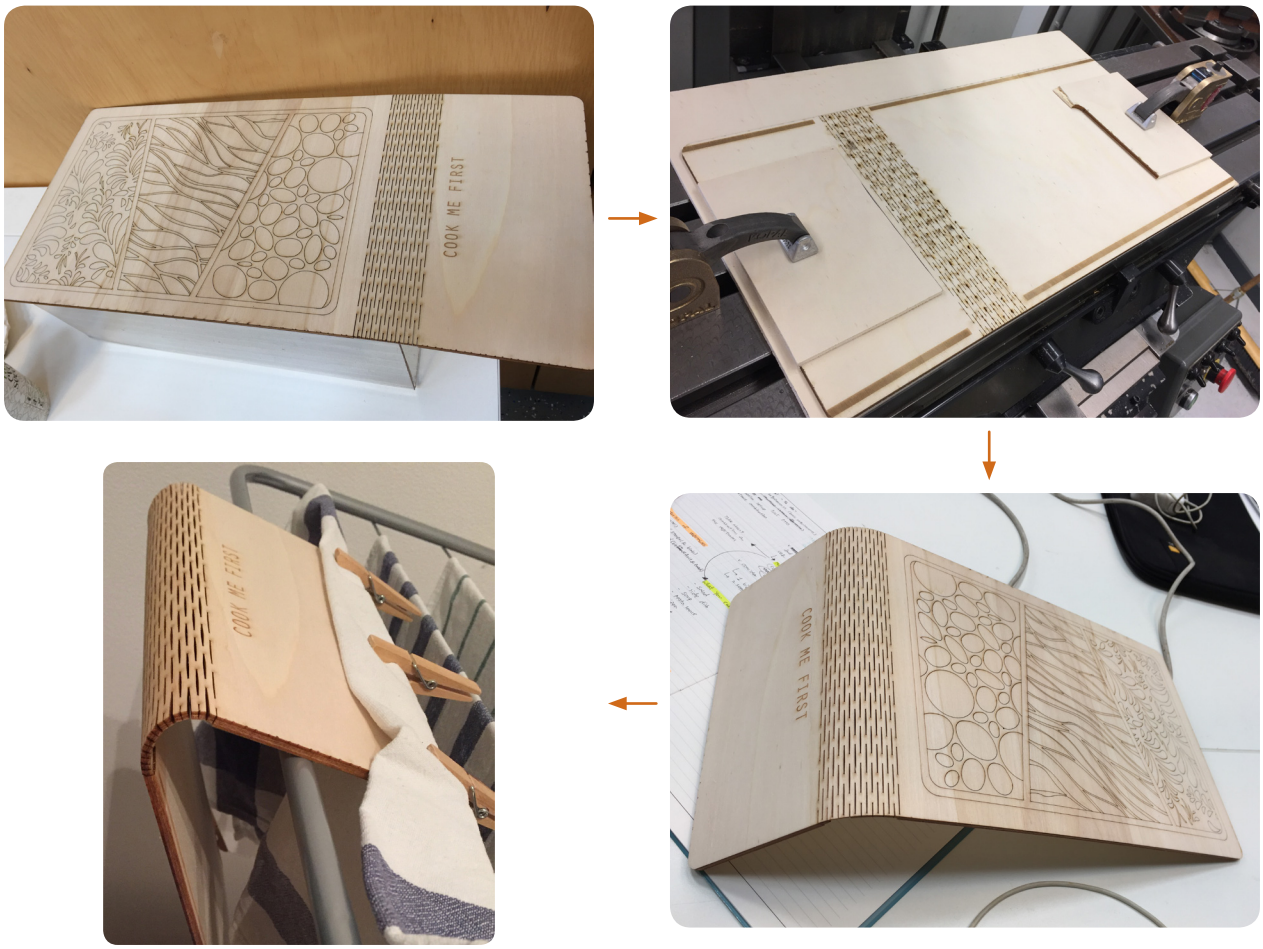


Figure 45. Embodiment process of the lid.

Figure 46. Tests of the living hinges, size and pattern modification of the lid. The right output was chosen as the final prototype.

Figure 47. Pictures of the final design.

Application design

As informative support for the tangible product, a mobile application was considered. The purpose of the app is to enhance the interactions between users and the product as a subsidiary function. To easily access the application, a QR code is engraved on the front side of the lid.

The information architecture outlined at Figure 49 explains how users can follow the application menus and what content they will see. When the QR code is activated on a smart phone, users see three main menus on the default page [A]: 'How to use Veggie-Table', 'Vegetability' and 'Veggie-centred recipes'. To make it more useful, an archiving system comprising numerous videos or recipes should be designed to provide an efficient service.

The 'How to use Veggie-Table' menu provides an overview of the three figurative patterns on the lid as well as what the vegetable groups are. There are the keywords of the groups, Root & Tuber (RT), Flower & Seed & Fruit (FSF) and Stem & Leaf (SL) on a mini map of the Veggie-Table. Tapping any of the vegetable groups connects to the 'Vegetability' page, which is also the second menu on the default page.

The 'Vegetability' menu [B] categorises a variety of vegetables into the three classes mentioned above. Users can explore and educate themselves on the characteristics of vegetables to properly store and prepare various leftover vegetables. By selecting vegetable icons, detailed information is shown such as how to prepare and store a specific vegetable in the Veggie-Table [D]. Moreover, there are several recommended recipes on the same page, so it inspires users to cook a meal using the vegetables.

The advantage of the recommended recipes is that it can be an iterative activity whenever users are handling or preparing vegetables in person. Therefore, the more users apply the information from the app, the more knowledge and skills they can accumulate in the long term.

Screen [C] displays the three vegetable categories with text boxes into which users can type vegetable names. The titles SL, FSF and RT steer users to consider three different types of vegetables, but it is also possible to search recipes using only one vegetable name if users would like to browse only the vegetable combinations or other ingredients to cook a meal.

Figure 48. Default screen of the Veggie-Table application.

Embodiment

Depending on the vegetables a user selects, proposed recipes with pictures and the names of the dishes appear on the screen [C-1]. By simply tapping a picture of a menu, an ingredient list and cooking methods are displayed, and even a relevant cooking video can be included on the page [C-2].

As mentioned in the first paragraph, this mobile application is a supportive method to help users with the real product. In case users need to understand the product the first time or want to know about vegetability, the application can be used on its own.

However, it should be used alongside the Veggie -Table to impact the reduction of vegetable waste. This is because recipe videos and books tell how to make a meal using certain ingredients and following certain methods. If a user does not have the vegetables required by a recipe or the recipe calls for vegetables the user does not have, the recipe in the application does not affect the user's vegetable experience or the use of leftover vegetables.

In these cases, the recipe in the application does not affect the user's vegetable experience or the use of leftover vegetables.

Thus, it is strongly recommended that the product and vegetables be used together in the preparation phase.

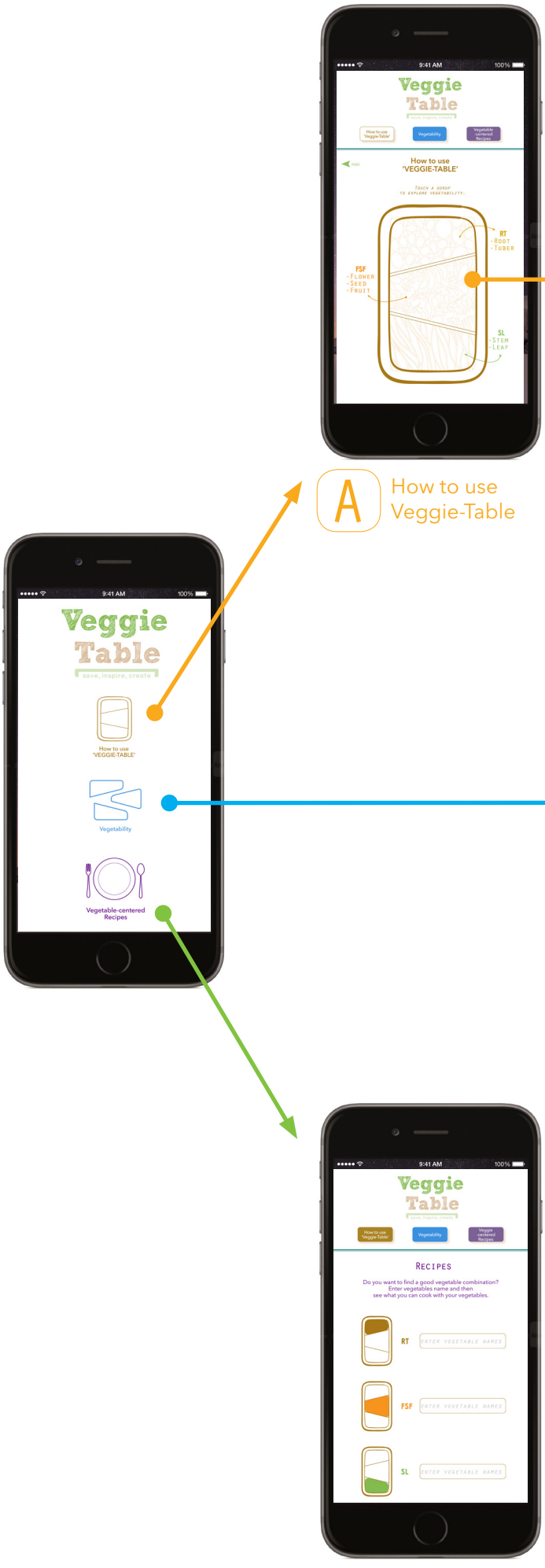
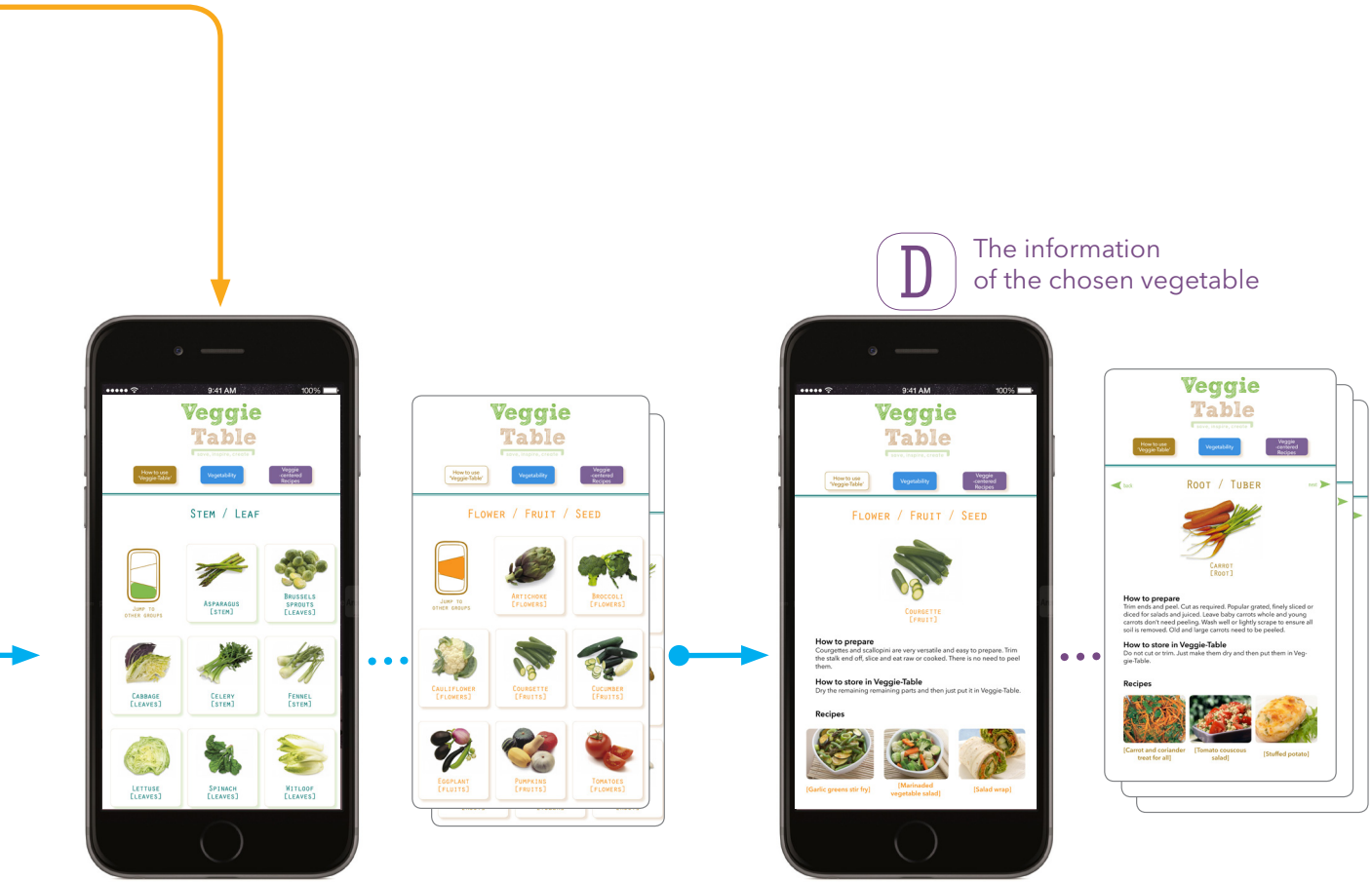
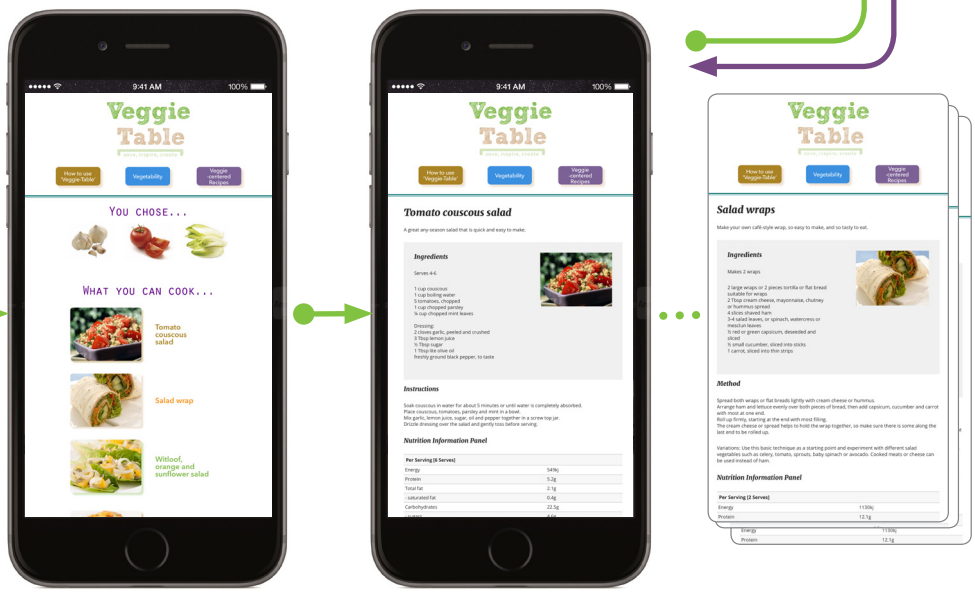


Figure 49. Flow chart of the Veggie-Table application.



D The information of the chosen vegetable

B Vegetability



C-1 Recipe list with the chosen vegetables

C-2 Methods of the chosen recipe

Design proposal

This section introduces the product's features.

When a vegetable package opens, its special treatment characteristics are no longer effective. A half-cut vegetable rapidly deteriorates unless it stays in an adequate place or is consumed in time. Moreover, people sometimes neglect half-used vegetables in the corners of their refrigerator until they become spoiled and are thrown into the garbage bin.

In order to resolve these issues, the Veggie-Table encourages people to consider using leftover vegetables first in the moment of ingredient preparation. Additionally, this product guides people through how to save their vegetables and even how to combine vegetables properly.

Veggie-Table

The product not only inspires users to cook a meal using vegetables, but also helps them to not neglect any leftover vegetables in the refrigerator. This is due to the fact that the Veggie-Table is an integrated system for vegetable storage and preparation.

The container can store used vegetables. It has an airtight wooden lid, which keeps vegetables fresh and prevents contamination from other types of food such as meat or fish.

The most intriguing feature of the lid regards the three figurative patterns, which represent Stem & Leaf; Flower, Fruit & Seed; and Root & Tuber. They lead users to place a few vegetables from each group on the patterns and encourage them to be creative cooks, as they can come up with their own recipes by seeing the overview of vegetables.

In addition, the finding that most recipes contain more than two vegetables, which belong to the three groups (SL, FSF and RT) is the fundamental feature (Appendix I). The idea is that users need to be creative when thinking about recipes by using their ingredients first. Through a simple action with the product, users can feel fulfilled and in control due to the fact that they saved vegetables and created a delicious meal.
By delivering this inspiring concept to users, the product presents them with a mission to prepare a healthy meal and consume vegetables in time.

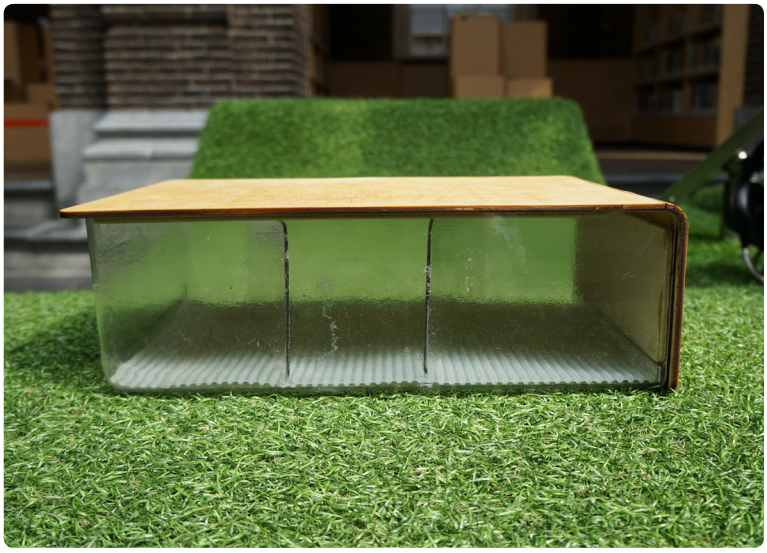
How to use

After preparing vegetables, some remaining vegetables can be stored again in the container for later use. Users can categorize the vegetables by three partitions in the container and then keep it in the refrigerator. Next day, users can place some leftover vegetables from yesterday on the lid to think about what they can cook with them (see Figure 50). When they come up with a vegetable combination, they can start preparing the vegetables with other types of ingredients such as meat, fish, pasta, etc. Lastly, they store some half-used vegetables again in the container and put it back in the refrigerator. The user scenario at page 104-107 will explain about the product use in detail.

In addition, users are able to access the Veggie-Table application through a QR code. Its purpose is to educate users on the product's functions and to provide vegetable combinations as a supportive method. The application's usage is described in Figure 49.

[BACK]

[FRONT]



[SIDE]

Veggie Table

save, inspire, create

[TOP]

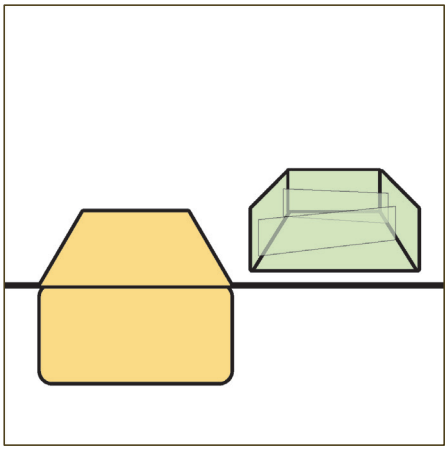
Figure 50. Photos of the Veggie-Table (left), and description of the lid of the Veggie-Table (right).

USER SCENARIOS

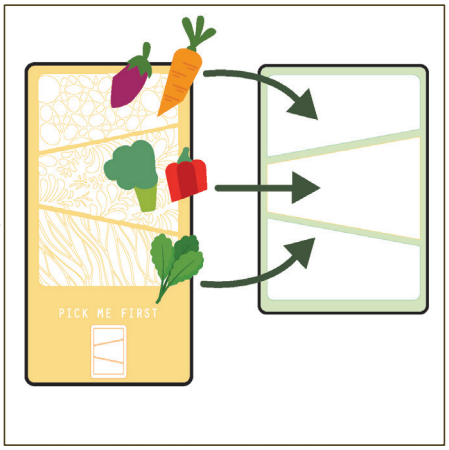
The two story boards illustrate the different usages of Veggie-Table.

Scenario 1. "I need an inspiration for our family's leftover day."

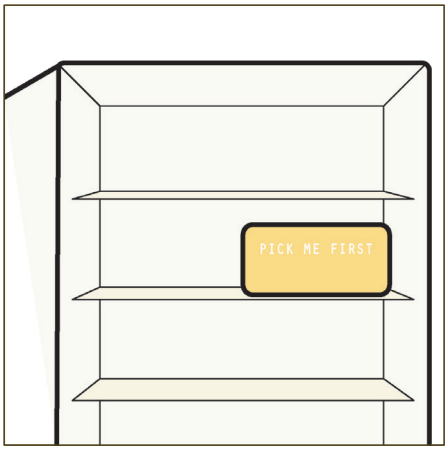
At the beginning of the product use



1. Open Veggie-Table on the kitchen counter after cooking.

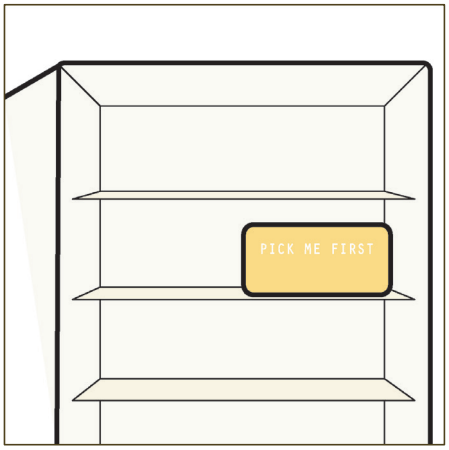


2. Put some half cut vegetables in the product following the patterns and images.

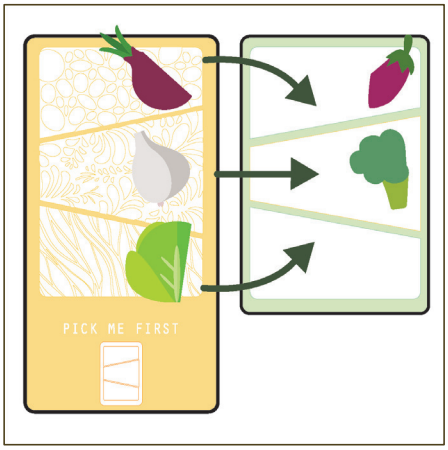


3. Place the product in the middle shelf of the refrigerator.

At the end of the product use

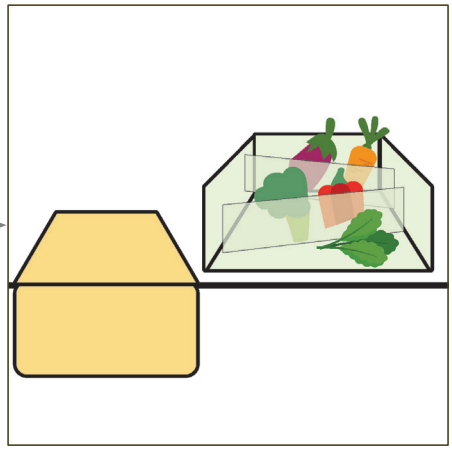


9. Close the lid and put the product back in the fridge.



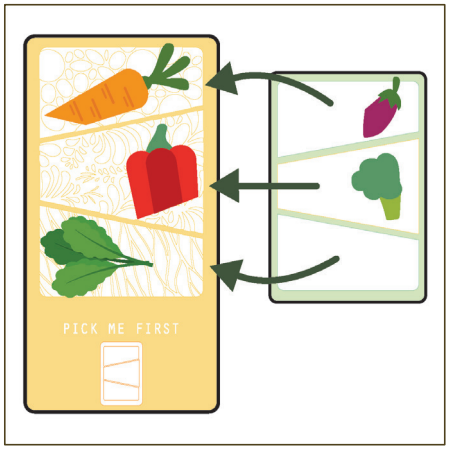
8. Put back the half cut vegetables in the product again considering the patterns on the lid.

Being inspired by the Veggie-Table

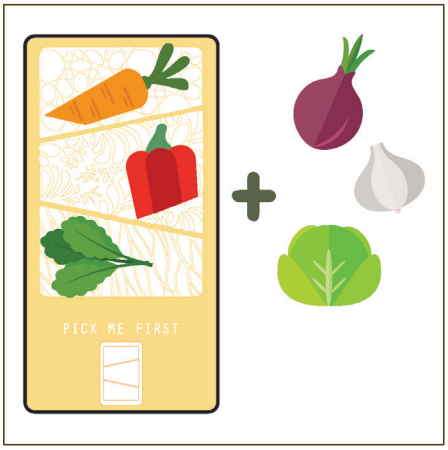


4. (next day) Take out the product on the kitchen counter and open the lid.

5. See all half used vegetables in the product (you already organized them yesterday).



6. Put some vegetables on the lid first follwing the information of patterns.

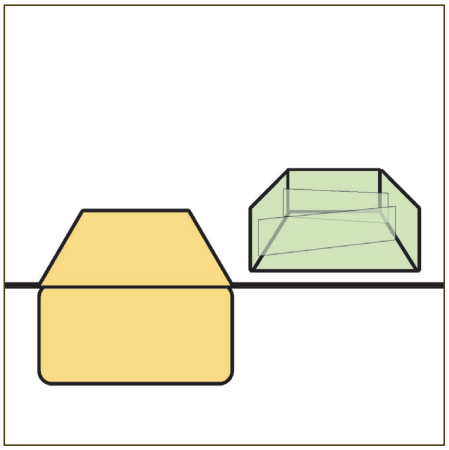


7. After placing leftover vegetables, Cook the vegetables with other ingredients such as meat, rice or pasta by searching the recipes on Veggie-Table app.

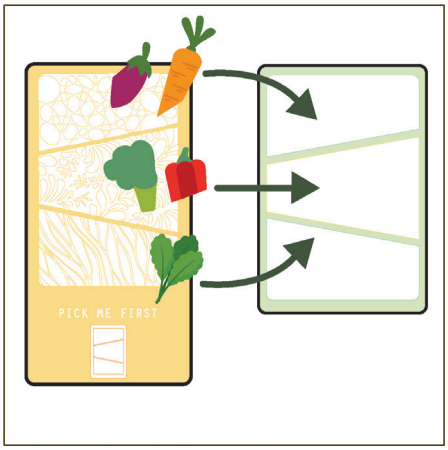
USER SCENARIOS

Scenario 2. "I am in the mood for a specific vegetable to cook dinner"

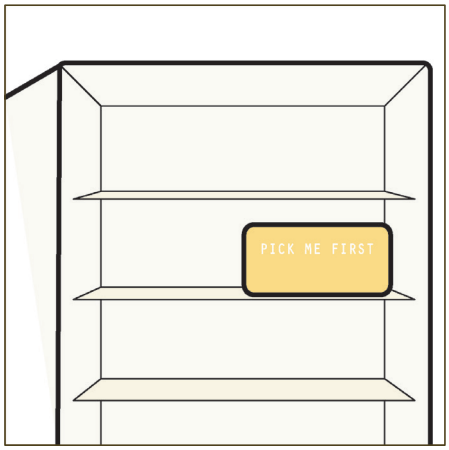
At the beginning of the product use



1. Open Veggie-Table on the kitchen counter after cooking.

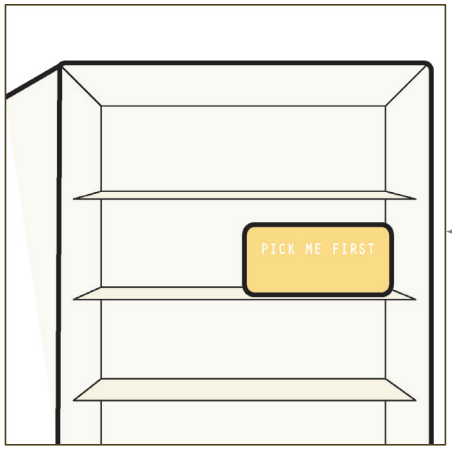


2. Put some half cut vegetables in the product following the patterns and images.

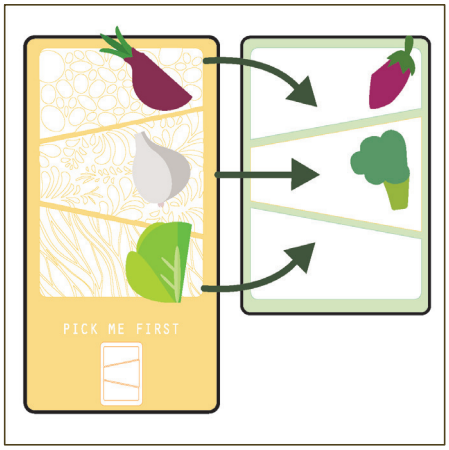


3. Place the product in the middle shelf of the refrigerator.

At the end of the product use

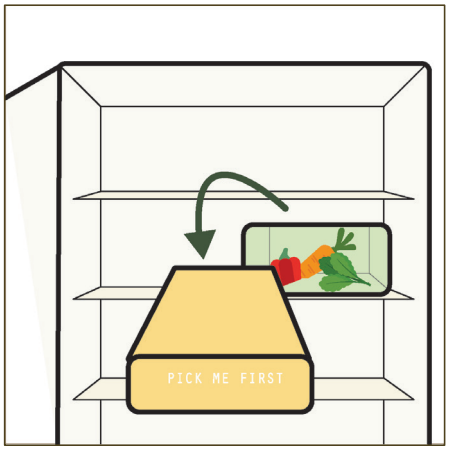


9. Put the lid back in the refridgerator to close the container.

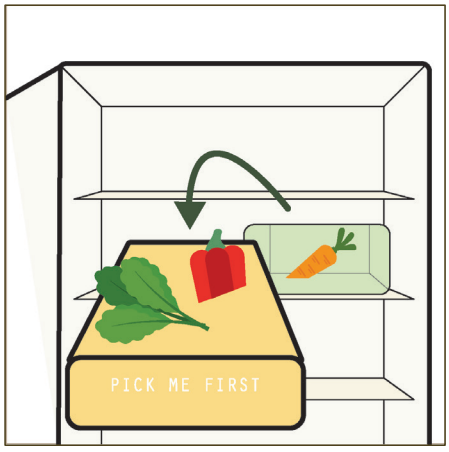


8. Put back the half cut vegetables in the product again considering the patterns on the lid.

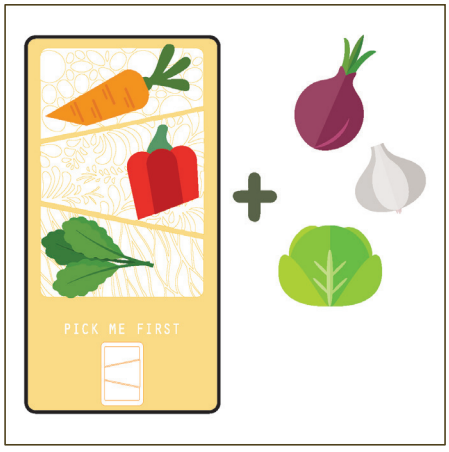
Quick use of the Veggie-Table



4. (next day) Take out only the lid in the refrigerator.



5. Take out a vegetable you want to cook today and place it on the lid.



6. Put the lid on the kitchen counter and add some vegetables on the lid imagining the result of the vegeta-ble combintion.

7. Prepare the vegetables on the lid immediately and cook them with other ingredients.

9 | EVALUATION

This chapter presents the evaluation tests, which were held in three households to test the usability and level of understanding of the prototype and the application. Additionally, participants were asked to answer questions after completing some of the tasks. The evaluation results were analysed based on the sessions' three major sections.
Some of the critical issues that arose from the tests are interpreted in the recommendation section of the project's concluding chapter in order to improve the product in the future.

METHODS

Evaluation questions

The purpose of the evaluation test is to examine the usability and credibility of the prototype in demonstrating the final concept. This study helps to cover the range of issues in order to enhance the product's effectiveness and verify the concept's intended use. Furthermore, the evaluation results in a series of recommendations from which to further develop the design.

Note that the questions are mainly aimed at determining the short-term rather than long term impact. It would be interesting to evaluate each participant's use of the prototype for seven days in order to test the consequences of use, but the tests were conducted for only one day in consideration of the participants.

Key evaluation questions were drawn up for the interviews on the basis of the user scenario. The evaluation questions are as follows:

1. *What is users' first impression of the product?*
2. *Do the product and application evoke users to think about vegetable combinations?*
3. *Is the product efficient to store the half used vegetables?*
4. *Was the information in the application helpful to use leftover vegetables?*
5. *What did users think of the interface of the application and product? (size, graphic, structure…)*
6. *What were users' ambiguities?*

7. To what extent will users' be more aware of this product?

8. Does this product inspire users to think differently in terms of a new recipe?

9. Do you have any comments, suggestions, questions?

Setup

The participants of the design evaluations were three households which correspond to the focus group of this project. To test the prototype properly, it is required to visit participants' apartments because the product context is the inside of refrigerators and every household has an entirely different kitchen- and food-management system. Therefore, implementing the appraisals of a prototype within a real-life context is a crucial factor in this phase.

Each of the three evaluation sessions took about one hour to complete. On the participants' request, no facial photos or personal information were collected.

Before starting the sessions, some vegetables from the three vegetable groups (SL, FSF and RT), the prototype and the mobile application were set up on the kitchen counter. Subsequently, a brief of the design project and concept was given to each participant in order to quickly make them involved in the tests.

Each session was composed of four parts. The first step was to check the extent of the users' understanding of the product. Secondly, it was observed how participants interact with the product while using vegetables. PrEmo tool was used during the tests (Figure 51). In the last experiment, it was judged how informative the application is in terms of supporting the product. Subsequently, the participants were asked for their comments, questions and opinions regarding the general design concept and the prototype.

Limitations

In order to achieve a high quality of usability results and to collect users' deeper insights into the prototype, the evaluation tests needed to be executed by each participant for one week. However, the evaluation sessions were conducted with a limited number of users for one day due to the participants' preferences and project schedule.

In addition, the application's layout, colours and visual effects were not tested as the aesthetic aspect lies outside of this project's scope.

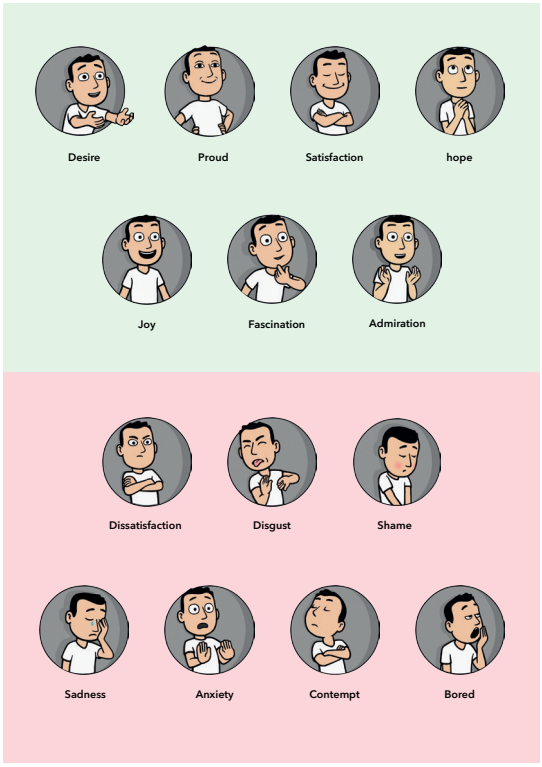


Figure 51. PrEmo (Desmet, P.M.A., 2003). The participants chose emotion icons after completing each task to express their feelings about the experiments.

The extent of understanding the prototype

In general, the three participants seemed immediately understanding the prototype because of its shape. Also, they thought that the three patterns might imply the three groups of vegetables even though that did not look at the minimap on the lid. Additionally, the "COOK ME FIRST" text is supposed to be placed forward in the fridge, and it proved through the tests that the participants put it correctly without hesitation.

"This looks a nice box for vegetables. I like the patterns and... I guess they mean root, flowers and leaves? Maybe I need to put the vegetables in the container following the patterns."
- participant B -

The inside of the container is divided into three sections that look exactly like the graphic image on the lid, as a result of which all participants matched the patterns and partitions to organise vegetables. During the interview, they often mentioned that they liked the patterns very much.

Most notably, two participants mentioned that the graphics hinted at something that they needed to do with the vegetables, but that they were not certain about this as they could not find clear guidance about the product. Nevertheless, the uncertainty of the prototype was resolved through the application, as is explained on Figure 49.

Unfortunately, the participants did not recognize the cutting-board function of the lid as the other purpose of the cover was entirely new to them and there was no clue regarding this function. Two participants found the plate to be a bit small for cutting vegetables, though another participant presumed that one or two vegetables that do not need to be trimmed very much could be prepared on it.

"I would like to use the other cutting board that I like. Otherwise, I think I can use it when I need to prepare only few vegetables, slide them into a pot and boil them.
- participant A -

"It is too beautiful to cut it."
- participant C -

Figure 52. Setup the sources for evaluation sessions.

Figure 53. Test of how to place the prototype in the fridge.

Figure 54. Observation of three participant's product usage in terms of organising vegetables.

The wooden lid is intended to be placed on the kitchen counter, as illustrated in Figure 55. It can be clearly verified that the participants placed it correctly due to the bendable part of the lid.

Interaction with the prototype

All participants were asked to imagine that they are about to cook dinner using the vegetables in the container. They perceived that the filtered vegetables should lead to certain directions such as recipes or ingredient management. Of course, they had not previously seen the prototype, so guidance was offered to them in order to make the tasks clear. They received a hint on combining the half-used vegetables in the container.

Two participants felt "joy" and "hope" when moving the vegetables to the patterns on the wooden cover (see Figure 55). According to their answers, they somewhat anticipated a new type of meal that they had not experienced before.

"I like the fact that I can see all leftover ingredients at a glance."
- participant A -

"The container and cover give me an overview of the vegetables"
- participant B -

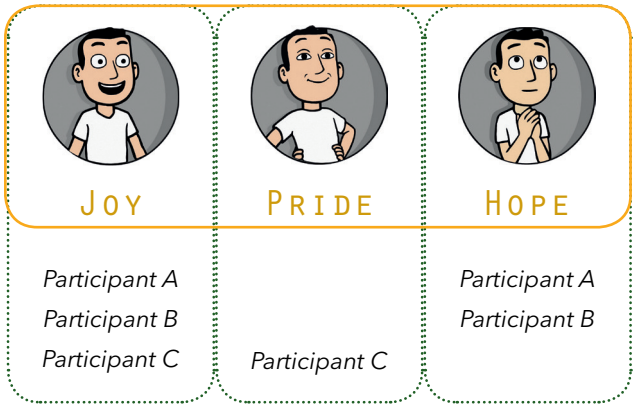


Figure 55. Answers on the PrEmo by each participant.

On the other hand, the other participant mentioned that the visuals on the lid seemed unpredictable until she opened the mobile application with the QR code. After checking what the patterns on the app mean, she felt confident and proud of herself for performing the activities correctly.

In the next step of the product's use, the users were of course requested to think of some vegetable combinations from the categories on the lid. All participants began to move the half-cut vegetables onto the wooden cover and replaced some vegetables.
As they generally had preferences, they placed their favourite vegetables first and subsequently considered other vegetables according to particular recipes that they knew. In one case, a participant could not find a recipe with the chosen vegetables and seemed to hesitate about starting to cook.

On the other hand, two participants thought that combining random vegetables was fun and they were stimulated to consider the three types of vegetables because of the patterns and detailed instructions on the app.

"When I looked into the container, I could imagine directly what I can cook somehow. So… this product may not only for the half used vegetables, but also other vegetables that I cook often."
- participant A -

"Flowers, leaves and roots... It gives me an idea of how it comes to a meal and keep it balanced"
- participant B -

Regarding the product's efficiency of vegetable management, two users observed that it has three divided sections on which to place leftover vegetables and therefore thought that they do not need to have other plastic containers in the fridge. Notwithstanding the large size of the container and its partitions, one user considered using a few small containers as she is accustomed to preserve food in a conventional way.

"As you can see, my crisper drawer is messy and full. I think this product would solve this situation somewhat."
- participant B -

Figure 56. Participants behavior towards storing and preparing vegetables with the prototype.

All participants indicated that collecting all leftover vegetables in one place is a good way to manage food and even reduce weekly vegetable waste. However, they recommended making the container a bit smaller. They recognised that the product is intended for preserving half-used vegetables.

Usability of the mobile application

It seems that the mobile application played a supportive role during the evaluation process. One of the three participants felt insecure and uncomfortable while using the mobile application. He stated that he dislikes most applications and would rather read a paper-based instruction than access instructions online through an electronic device.

However, the other two users acknowledged the importance of the application. They directly activated the QR code via mobile phones and freely browsed the information. One participant was interested in exploring the vegetables' characteristics in the "Vegetability" menu and the another was quite enthusiastic about searching recipes in the "Veggie-centred recipes" menu.

"I didn't know about the vegetability of a courgette. It may be the useful information to teach my children about vegetables. I would like to try it with my kids."
- participant C -

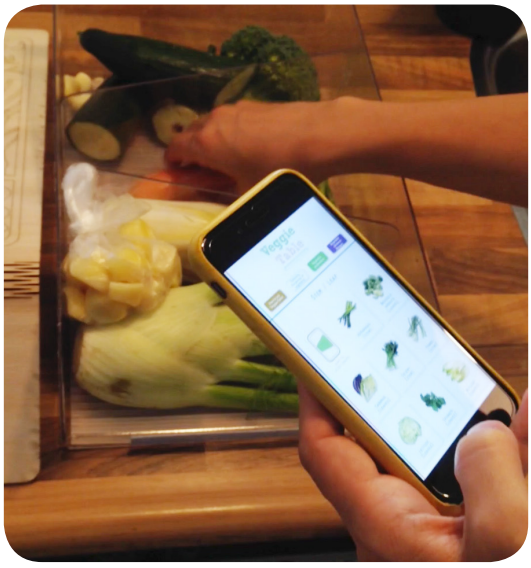


Figure 57. Observation of how users utilise the mobile application.

With the exception of the participant who did not like mobile applications, the two other users made many general comments about the "Veggie-Table application". No remarks were made regarding the "How to use Veggie-Table" menu, the goal of which was to help users clearly understand the patterns on the lid.

The users showed a positive response to the "Vegetability" menu, possibly due to the educative information that they had not previously learned. They also frequently mentioned the method of searching vegetables that they already had in the container. As the application had a few images and touch functions that needed to be tested for the quick prototype, they could not browse other vegetables. Therefore, the tests were guided by questions 4 and 5, which are listed on page 110. In their answers, all participants indicated that the application's interface is clear and well structured, but needs to contain many larger images instead of texts.

"I think this is something new. Because people buy a container and recipe book separately, but they are come together now."
- participant A -

"The application has a nice feature. It really helps me combine as much vegetables as I can. If I go to this page (Veggie-centered recipes), there might be a search engine to filter and find all the recipes for the three ingredients in this app."
- participant C -

The two participants who were interested in the app had strong opinions on the contents of the "Veggie-centred recipes". They appeared to be eager to find as many recipes as possible in order to be motivated to cook. Additionally, they were accustomed to using web-based methods such as YouTube and online articles, so it was recommended to apply universal ways by which to show numerous vegetable recipes.

Overall, the users to some extent understood the recipe menu's function, which is to encourage people to consider the different classes of vegetables and find a solution for a recipe. As this new approach of searching cooking methods with an application was not yet familiar to them, it was assessed based on the participants' previous experiences with recipes. In order to make the function useful, it therefore appeared that the reasons for why the three groups of vegetables should be prepared together needs to be clearly explained in the application.

Figure 58. Prototype in the participant's refrigerators.

Additional comments and quetions from the participants

"Do you also have a smaller or bigger size of it?"
- participant B & C-

"My crisper drawer is full. Instead of having a plactic bag for half used lemon, I have this. Then it would be definitely helpful.
- participant B-

"Why don't you make the lid transparent? ... I wonder how the wooden lid works in the fridge and in the dishwasher. Maybe you need to cover something on the lid."
- participant A -

"The advantages of this product, I think, I can reflect on the next dinner menu while putting leftover vegetables in this container. For example, no beginners, if someone used this product and application several times, and got used to this experience, he sees the overall vegetables left in the container and recognise an empty or full section. So it is possible to set up a meal plan as well "
- participant A -

"After cutting them on it, I have to wash it and dry it. Then I put it back into the fridge because I am not gonna use everything in it. I am afraid of warm or too humid condition in the box without a lid."
- participant C-

Conclusion

In general, all participants understood the primary goal of the prototype, which is captured in the phrase "everything in its place". The term stems from the French "mise en place": quite a fundamental skill for chefs. The evaluation tests were intended to verify whether the participants understood the implied concept of the prototype. They indicate that the physical prototype, container and lid satisfied the product's purpose, which is to identify he three groups of vegetables and to inspire users to come up with random vegetable combinations.

Even though the users understood the three figurative patterns on the lid and the partitions in the container, they could not easily find a hint as to what the next step was. This is probably due to the lack of guidance in the form of a process, which can be resolved by applying a digital prototype. Thus, how to inform users about the product's explicit use needs to be further investigated.

Furthermore, the participants were unaware of the additional function of the lid as a cutting board. This is due to the fact that the prototype's material seemed non-washable and because the plate size was a bit smaller than that of normal cutting boards. As this is not a primary purpose of the lid, it may be excluded from the product's future development.

However, a better material and product finishing technique should be implemented.
Most importantly, it is reasonable to focus on the original idea of this part of the product, which is to induce users to take into account the three classes of vegetables.

Finally, it can be said that the participants operated the mobile application properly and in agreement with the prototype. The intended use of the application is to discipline users repeatedly by offering information about the vegetables' characteristics as well as a number of recipes based on the chosen vegetables.

During the evaluation sessions, these two major factors of the application were largely achieved. Regarding the further development, the application needs to maintain its secondary role as in the original design concept, because of the ultimate goal of this project is to "reduce household vegetable waste".

In summary, this product emphasizes that users should control vegetables with a physical product in order to have an impact on vegetable waste, without directly accessing the Internet, which presents tons of arbitrary information.

Figure 59. Picture of the prototype.

Photo of the Veggie-Table.

10 | PROJECT CONCLUSION

CONCLUSION

This project began with the goal of designing a product by which to reduce household food waste. Through the three research questions (p. 58), the users' food-consumption related concerns, the most-wasted food and the current interaction between users and food were investigated in depth. The design statement was therefore formulated as follows:

"I WANT TO MAKE CONSUMERS FEEL IN CONTROL BY PROVIDING THEM AN INSPIRING AND SUPPORTIVE TOOL FOR PREPARING VEGETABLES TO REDUCE VEGETABLE WASTE."

The design direction was embodied in a particular design concept called the Veggie-Table, which is composed of a box for leftover vegetables with an inspiring guide for vegetable combinations and a mobile application that supports the use of Veggie-Table.

After making a prototype of the concept in an iterative process, three participants evaluated the design. During the evaluation sessions, it was verified that the design concept fulfilled the primary goal of this project by showing the positive emotions of users: joy, pride and hope.

Moreover, all participants recognised that the prototype provides an overview of leftover vegetables and new perspectives on vegetable preparation. These advantages of the design concept stimulate consumers to use half-used vegetables first and have an impact on households' reduction of avoidable vegetable waste in the long term.

In conclusion, the project was aimed at reducing vegetable waste at the consumer level and found a solution in the consumers' consumption behaviours. Through the Veggie-Table concept, it is expected that users are stimulated to use half-used vegetables first and that this has an impact on households' reduction of avoidable vegetable waste in the long term.

Discussion

The process and results of this graduation project were mostly positive and successful, but it is essential to consider some critical aspects for the future development of the design concept.

Firstly, the Dutch family was chosen as a focus group at the beginning of the project due to the differences in food culture and diet between Dutch and international people. It seemed reasonable to choose large household types as a family of more than three people produces far more food waste than a single person, couple or elderly household. Due to the research consistency, the evaluation sessions were conducted with Dutch families only.

However, this management system for leftover vegetables would be interesting for the single-person household. Most supermarkets sell vegetables such as courgette or paprika without packaging. Although consumers are able to buy pre-trimmed vegetables as well, the portion of packed foods is normally too large to consume at once for a single person. Thus, it can be recommended to single-person households to adopt this product in managing leftover vegetables at home.

Regarding the evaluation, the user tests were executed with three Dutch families on one day. Even though the predetermined period of the assessment was seven days for each participant, it was only possible to spend a very short time on the assessment due to one participant's vacation period and personal matters, which may influence the evaluation's results. A longer period of time may therefore be needed for an in-depth investigation into the level of usability and feasibility of the prototype.

During the evaluation sessions, the aesthetic aspects of the mobile application, such as colours, layout or text size was not investigated.
The test goal of the application was to determine whether it is supportive and informative in dealing with the tasks of the Veggie-Table prototype.

In summary, the designed prototype should be further developed in an iterative process between user tests and embodiment phases. This is because the prototype did not embrace every feature from the user research and final design concept. Lastly, the product's impact on the reduction of vegetable waste is not yet clearly proven and needs to be examined in order to obtain more practical results, and to confirm the design quality.

RECOMMENDATIONS

This project has discovered many design insights and opportunities, but some aspects need to be considered for the future prototype development.

For the Veggie-Table prototype

- The lid material could be 100% transparent glass or plastic to see the inside of the container.

- The size of the container could be different from the original dimensions. Smaller and bigger sizes of products should be taken into account to accomodate for various refrigerators.

- The three patterns on the lid could be tested in different styles such as typography, colours or icons.

For the mobile application

- The form of the additional instruction could be a small booklet since some people prefer not to use electronic devices.

- In the application, the 'My veggie-centered recipes' menu can be added as a quick search function. Through this, users are able to save their favorite vegetables or recipes on a separate page.

- A data server should be built for managing and storing the recipe contents. If it is not possible, the URLs of Youtube and Tasty videos or online recipe articles could be set up in each vegetable page.

In general

- Before in-depth user interviews and evaluation sessions, a pilot test needs to be conducted.

- To acquire the understandable and in-depth data from the users, the interview needs to be performed in Dutch.

- The information in the application and lid could be in Dutch since the target group was 'Dutch households'.


PICK ME FIRST
- ROOT
- TUBER
- FLOWER
- FRUIT
- SEED
- STEM
- LEAF
SCAN ME

Photo of the Veggie-Table.


PICK ME
· ROOT
· TUBER
· STEM
· LEAF

Photo of the Veggie-Table.

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MASTER THESIS

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