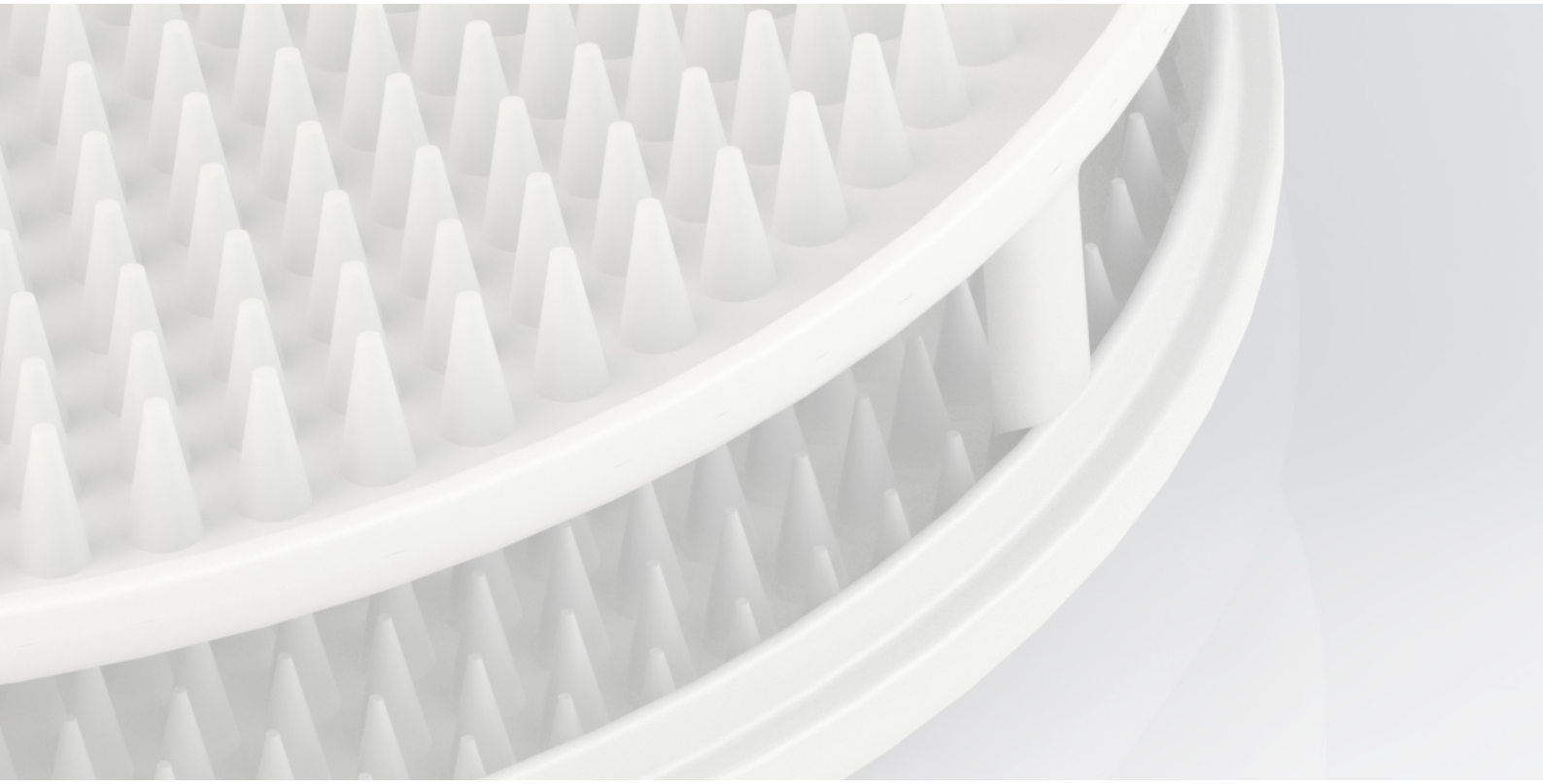
Master thesis

Attila van Dijk



Supervising team

Dr. ir. Rick Schifferstein (Chair)

Dr ir. Sacha Silvester (Mentor)

Design for Interaction
TU Delft
December 2018

INDEX

PREFACE

This research project was conducted as part of the Food & Eating Design Lab of the TU Delft, contributing to novel food-focussed innovations aimed at improving people's health and general well-being. In particular, this report addresses the important topic of food waste and and aims to advance this active area of research.

My passion for food and cooking is something many of my acquaintances can readily attest to. It thus came to no surprise that I would use my passion for food as an inspiration to design as part of the Master Design for Interaction. I felt that so much still stood to gain in this area of innovation, where much is drawn from traditions, emotions, and, sometimes, even prejudice. I wanted to combine design and food to improve our culinary experiences and to further explore the intersection of these domains. Additionally, during this master track, I have worked in several (fine dining) restaurants, from which I gained experience and inspiration that I used to advance my studies. By working with different top-level chefs, I obtained new insights in all aspects of dining, such as cooking techniques in meal preparation, dish presentations, and balancing of flavours. I was especially intrigued to discover that in a professional kitchen almost every bit of produce can be used, the application of which in recipes is only limited by imagination. In the professional kitchen, much of this practice is actually fuelled by economic considerations, where costs need to be cut, but to me it meant much more. Apart from a financial incentive, we humans do not like to waste. Could we encourage and inspire home chefs and consumers by design to pick up these professional practices and reduce waste streams from food? Using food more efficiently will provide enhanced peace in mind, can improve the food, and can reduce our carbon footprint, as we shall see later in this work. My personal wish has been to transfer some of the knowledge I obtained in professional kitchen settings into the domestic domain through clever design: for better food and reduced disposal to the benefit of all.

ACKNOWLEDGEMENTS

This project could not have been completed without the help of many others. Here, I would like to give special thanks to the people that I am particularly indebted to and without whom this project would not have been possible. First and foremost, I would like to thank my chair Dr. ir. Rick Schifferstein and my mentor Dr. ir. Sacha Silvester for their valuable input and supervision during this graduation thesis work. Second, I would like to thank all participants that provided precious input to this study and were prepared to share personal insights into their daily lives. My gratitude also goes to the gentlemen at the PMB, who assisted me in the production of the prototypes, the chefs I have had the pleasure to work with in the years and that have lead me onto this culinary path. Last but not least, I want to express my deepest thanks to Dr. Daniel Verschueren and Casper Jonker for their support and feedback during this project.

ABSTRACT

This graduation report describes the motivation and processing that resulted in the Zesturn. The product is designed to make vegetable trimmings and leftovers, which are otherwise discarded, directly available for cooking in Dutch family households. The Zesturn facilitates this through converting vegetable scraps into powders that can be repurposed as natural flavourings.

By analysing the context factors within family households, key aspects regarding habits, cooking knowledge, and attitudes towards food were identified. These insights were used to generate concepts and that ultimately resulted in the Zesturn.

The final design is a device that enables vegetable scraps to be dried in a common household oven and can subsequently be ground into powdery flakes. Due to this transformation the vegetable trimmings and leftovers become more acceptable for future consumption, have extended shelf life, and can be efficiently fed back into the cooking process, reducing food waste as a welcoming consequence.

ANALYSIS

INTRODUCTION

"We are living in a world today where lemonade is made from artificial flavors and furniture polish is made from real lemons."
- Alfred E. Neuman

Until food became abundant and readily available, Food Waste (FW) was negligible in the Netherlands. Any digestible leftovers had inherent value, as it could be used to maintain livestock, the living recycling bins of pre contemporary times. With increasing wealth food became more plentiful and changes in the demographic landscape saw the advent of large towns and cities. Whereas in rural areas sustenance waste was administered to self-owned livestock, jobs like the 'schillenboer', who collected the scraps to be used as stock feed elsewhere, emerged in more urban settings. Currently, with commercialization of livestock the viability of such practices declined, but the rapid increase in consumption and overproduction of food lead to an ever larger pool of food scraps whose only faith is compostation or incineration. Nowadays, perfectly edible leftovers are squandered and wasting food has become commonplace.

Fortunately, awareness about wasteful practices is currently rising and lavish use of resources is more and more denounced. Not only are we now more attentive about cautiously using energy and water, we are more carefully recycling disposable materials and employing reusable energy sources, ultimately aimed at creating a sustainable society to preserve our planet for future generations. Equally, food waste in our current economy pressures environmental sustainability. And even though food waste is combatted, it has not yet earned the attention it deserves.

Besides the obvious downside of wasting produce, more efficient food processing aids economic production and competitiveness by making better use of expensive resources (food). Moreover, consumers themselves suffer from guilt and anxiety when trashing food, recent research shows (Evans, 2012; Quested, Marsh, Stunell, & Parry, 2013; Stefan, van Herpen, Tudoran, & Lähteenmäki, 2013), and helping consumers avoid these wasteful practices will alleviate them from these negative emotions.

Whereas current efforts to restrain the waste of eatables have mostly focused at the processing stage, little support is available for the consumer whose mere option is to throw away her unwanted food excess. Novel and innovative tools are required to increase awareness about food waste and to equip the consumer with a new channel of disposal that serves the recycling nature our society is moving towards.

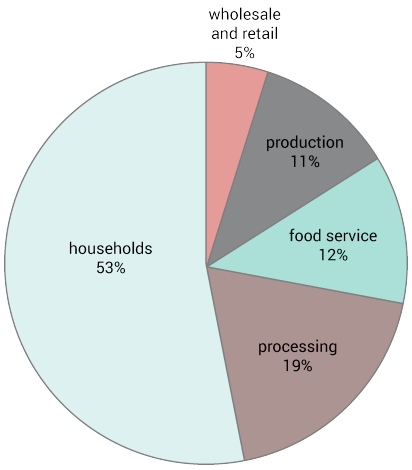


Figure 1 Weight distribution of wasted food per sector (Stenmark et al., 2016).

AN INSIGHT TO FOOD WASTE

This section provides an overview of the current status of food waste in the European Union (EU). Through a careful evaluation of available statistics on food consumption at the consumer end in the region, a compelling argument is presented why food waste at the end stage of the supply chain has been the focus of this study.

A VAST WASTING

On many fronts we stride towards a CO2 neutral society: through developing circular production schemes, adopting renewable or green energy sources, using sustainable transportation, such as trains and electric cars, and even through developing more conscientious, i.e. vegan, eating habits. However, one major mark that weighs heavy on the carbon footprint has not be targeted: food waste. As a product class at the end of a production line that has to meet stringent conditions to qualify for human consumption, production uses large amounts of water, energy, and landmass, and thus has a strongly negative environmental impact. Wasting food is directly converting that effort into carbon dioxide, counteracting the efforts to create a better world future generations.

And worst of all: food is waste on a vast scale. According to Stenmark et al. (2016), the total (cradle-to-grave) amount of food wasted in the EU during the year 2012 accumulated to around 88 million tonnes. The production of this wasted food accounts for 8% of emitted CO2 (Timmermans, 2018) in the respective year. In comparison, passenger aviation, often loathed as an inefficient mode of transportation, only accounted for 3% (Erbach, 2018). While this reflects in one way the abundance of food in our developed society (total food consumption in the EU is 430M tonnes in 2012 (Stenmark, Jensen, Quested, & Moates, 2016)), it creates a grim contrast with the pressing problem of hunger and malnourishment in less developed parts of the world. Wasting food does not only affect these parts of the world through worsing climate conditions instigated by global warming in these regions, it also feels greatly morally unjust (Evans, 2012). Moreover, wasting such a valuable resource as also large direct financial consequences. where the food waste in the EU in 2012 was been estimated at 143 billion euros (Stenmark et al., 2016).

But at which stage of the production process is most of the food wasted? Every product that reaches a consumer will have gone through production, processing, wholesale, retail, food service, before it finally ends at the households (consumer stage). Figure 1 demonstrates to contribution to the total food waste at each stage of the production process. As is immediately obvious from the chart, a huge disproportionate amount of food is wasted at the EU households (Parfitt, Barthel, & Macnaughton, 2010; Stefan et al., 2013; Stenmark et al., 2016). To make matters worse, contrary to food wasted elsewhere in the supply chain, the impact of food waste at this stage of the production process is compounded: food that has reached the consumer in the EU has typically been carefully transported, packed, stored, refrigerated, and displayed. The valuable resources that are invested in the food will be squandered alongside the wasting of perfectly fine produce (Stenmark et al., 2016). If we want to make the most significant decrease in environmental impact possible, we need to provide consumers with an opportunity and an incentive to reduce their waste streams at the end of the supply chain.

HOUSEHOLD LEVEL DATA

FOOD TYPES

Fortunately, opportunities for improvement might be readily identified. Afterall, food wasted at the end stage of the supply chain is directly available for consumption. By categorizing the types of food wasted at the household, different strategies can be developed to the reduce the amounts wasted. Naturally, not all food waste can be necessarily be avoided. For example, kiwi skin or orange peel cannot be used for consumption and will require more inventive repurposing. Hence it is worthwhile to distinguish between waste that can strictly be avoided and refuse that cannot. Here, we adopt the approach used by Quested et al. (2011), where food waste is split into waste that is possibly avoidable: "food and drink that some people eat and others do not (e.g. bread crusts), or that can be eaten when a food is prepared in one way but not in another (e.g. potato skins)" and waste that is unavoidable: "waste arising from food or drink preparation that is not, and has not been, edible under normal circumstances (e.g. meat bones, eggshells, pineapple skin, tea bags)"

A careful analysis of the distribution of categories of foods ('drink', 'fresh fruit', 'fresh vegetables and salads', 'bakery', 'meat and fish', 'dairy and eggs', and 'other') that are wasted at the household stage, split into possibly avoidable and unavoidable, is shown in figure 2. According to the data, by far the largest (in mass) food category for which waste can be avoided is 'fresh vegetables and salads' and amounts to about 800,000 tonnes per year in the EU. This is corroborated in other studies (Jörissen, Priefer, & Bräutigam, 2015; Langley et al., 2010; Quested et al., 2013), suggesting that a significant reduction in carbon footprint can be achieved. Thus we should present users with practical alternatives to wasting of food of this category.

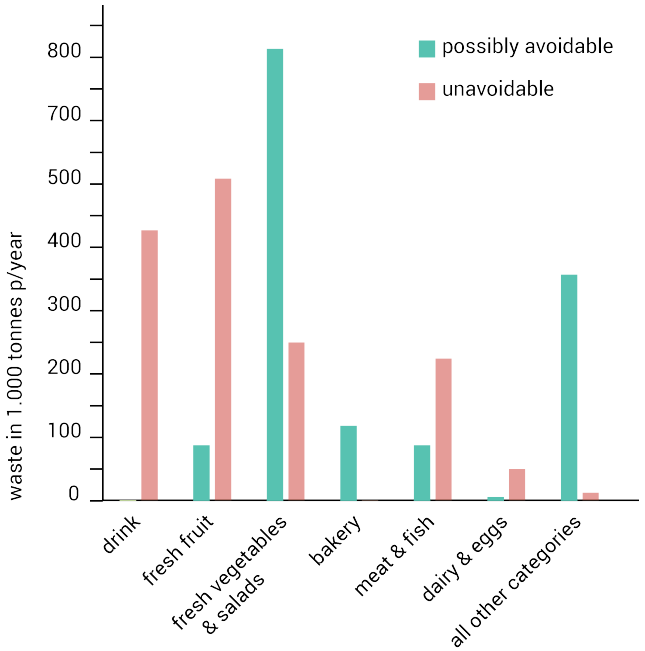


Figure 2 Distribution of wasted food per food type (Quested & Parry, 2011).

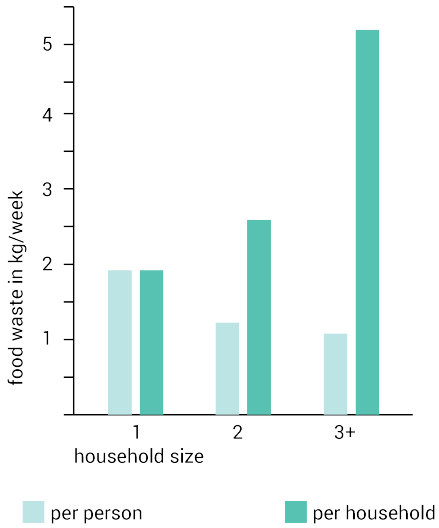


Figure 3 Amount of food wasted per household size (Ventour, 2008).

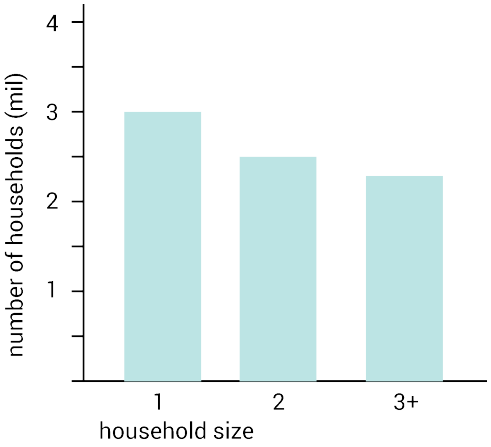
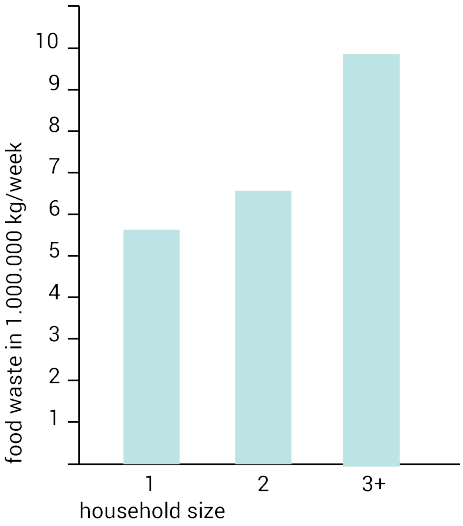


Figure 4 Amount of households in the Netherlands in 2017 (CBS, 2018).



Calculated combined numbers of wasted food per household type in the Netherlands (CBS, 2018; Ventour, 2008).

TYPES OF CONSUMERS

To be able to develop a practical solution for fruit & vegetable food waste at the household level, we need to home in on this category and set a more specific focus. Figure 3 shows the amount of food waste per household size (number of residents per household). For larger households (3 and more members), even though the waste per person decreases in this household size compare to others, the absolute amount of food waste per household still increases. Which group will we then target? Recalling that our aim is to be able to improve the carbon footprint of the society as a whole, we need to determine which household size contributes most this.

Using the Netherlands as a representative sample of the EU, we can generalize the conclusions drawn from this sample to the whole EU. Since there are roughly equal number of households for each size group in Holland, the largest contributor to food waste, on an absolute scale, are the largest household group. This trend is shown in figure 4. Decreasing spillage in these larger households should therefore have the largest impact. Furthermore, these larger households are likely to contain children. Effective reduction of food waste could generate a beneficial side effect, where children in these household will be more aware and will learn to reduce food waste. When they in turn become independent, they can take these lessons with them creating an impact that extends beyond the original target group the impact (Jörissen et al., 2015). Moreover, solutions found for this group can potentially be implemented in households of other configurations, in particular if small adjustment to the proposed solution are made.

CONCLUDING

Our analysis reveals that the largest reduction in carbon footprint in the EU society can be achieved by reducing food waste streams at the household (consumer) level. To be more specific, the largest impact can be expected if the largest waste category and most wasteful household type can be targeted, which is vegetables and fruits in households with 3 members or over. Further research and solution design will be tailored towards this group to reduce the fruit and vegetables waste stream.

FOOD WASTE IN HOUSEHOLDS

After establishing that food waste in households presents a large negative environmental impact, what can we do about it? By dissecting the various stages our food is subject to in our households, we establish a framework based on existing literature, that helps us analysing the problem in greater detail. We perform context mapping and interviews that are summarized into habit maps and allow us to focus on a particular solution.

FRAMEWORK

Although food waste is generally considered adverse, the food waste in household levels is still the result of consumer's decisions. Two main elements can be resolved that influence these: behaviour and marketing techniques (HLPE, 2014). The consumer's behaviour such as time planning, purchasing habits, preparation, consumption, and coordination of the whole process are areas that should be addressed and focussed on when it comes to food waste prevention(HLPE, 2014; Jevšnik, Hlebec, & Raspor, 2008; Quested et al., 2013; Stefan et al., 2013). Although an important factor in influencing consumer's decisions, marketing strategies, in particular those that persuade consumers to buy more than they need, will not be discussed here. Marketing is part of the retail section of the food supply chain and as such we consider it outside the scope of this project. Furthermore, according to Quested and Parry (2011), a decrease in food wasted at the household level results in a decline of the amount of food purchased. This interesting effect, although perhaps obvious, suggests that changing food consumption and processing practices at home surpasses marketing influences and can indirectly affect consumer's purchasing.

Within households, food typically transitions through some, if not all of the following phases: purchase, transportation, storage, preparation, consumption, and disposal as illustrated in figure 6 At each phase behaviour can be influenced and suitable solutions that aim to reduce waste can be developed.

METHODOLOGY

To identify areas where research and mainly practical solutions to food waste (in particular those of fruits and vegetables) at the household level are lacking, we conducted a small literature review that will be presented below. The focus concerns food waste at the household level and we will particularly look into previously conducted student projects at the TU Delft, so that a potential solution can be most naturally integrated in other established strategies that aim to reduce food waste.

For qualitative in-depth data on Dutch households of three or more individuals, we perform context mapping.

To understand and clarify behavioural patterns in regard to food waste, we diagrammatically visualize the complex connections between the aspects of knowledge, attitude, and behaviour that control these patterns.

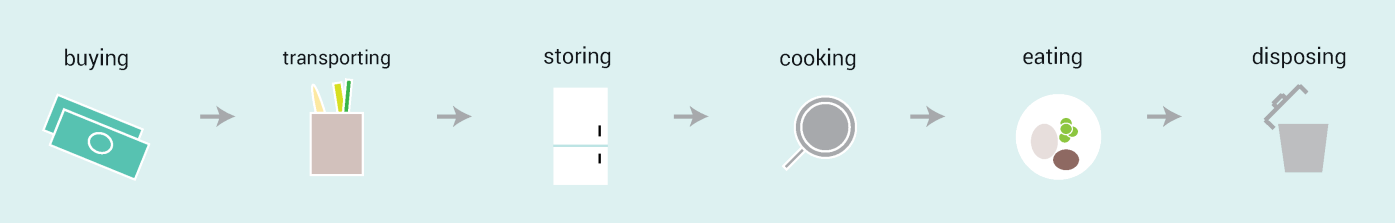


Figure 6 Food transition phases as described by Quested et al. (2013)

LITERATURE REVIEW

Most available literature that discusses food waste focuses on the upstream section of the food chain, namely the production, processing and retailing of food. Valuable in its own right to the prevention of food waste, as company level processing is arguably more straightforwardly adapted than consumer behaviour, their content and advice cannot necessarily be related households, as discussed here. Despite this, there is still, albeit less extensive, literature available on food waste at the household level. Insights where gathered from two particularly relevant papers. First, Wahlen and Winkel (2017) stress that even though many initiatives have been set in place to prevent food waste in households, there is a knowledge gap when it comes to how and why food is wasted. To reduce this knowledge gap is essential on bringing consumer's good intentions to reduce waste to practice. The procedural aspect of food in households might play an important role in closing this gap as planning, shopping, storing, cooking, and eating are in some way comparable between households (Wahlen & Winkel, 2017) and advice can be easily generalized.

Second, Janssen, Nijenhuis-de Vries, Boer, & Kremer (2017) suggests that even though much is known about the quantity of food that is being wasted, the causality thereof is not well documented and researched. Concluding, there is a necessity in researching the context and underlying causes to food wasted (Janssen, Nijenhuis-de Vries, Boer, & Kremer, 2017; Wahlen & Winkel, 2017).

LEFTOVER CUISINE

As wasting food is a reasonably new phenomenon, originating at large scale only in the past few decades, it might be useful to investigate how food used to be repurposed in earlier times. Furthermore, observing how this is done across different cultures could provide a good starting point that can inspire a myriad of possible solutions.

Broadly speaking, practices that counter wasting of food can be sorted in two different categories. On one side, there are dishes where flavours are mellowed to accommodate different ingredient proportions such as soups and stews. On the other are dishes that utilize strong herbs and spices to overrule all flavours such as nasi goreng, curries, stir-fries and salads (Rodgers, 2017). Both techniques allow for a larger proportion of produce to be used in cooking. These groups of dishes are on themselves not necessarily complicated to make but require some level of knowledge, technique, and maybe even just some courage to make.

Despite the popularity of these dishes, in practice there is a decline in purposeful usage of these dishes to use leftover vegetables (Rudin, 2017). This decline in purposeful use of leftovers in these dishes is attributed to the loss of the knowledge about the original purpose of the dishes amongst millennials (Mitchell, 2016). Although this might certainly be the case, many chefs argue that the more dominant factor might be the way recipes are presented nowadays. In contemporary recipes, the focus is mainly on the end result [dish], perhaps dashed with a few related fun facts about the origin of the recipe. Considering the abundance of food around us, this focus is completely understandable. However, since the recipes fail to provide a good reason to why these dishes have come into existence, the instructions do not reduce the waste generated during preparation and might even encourage wasting unintendedly. Additionally, this lack of background information on the dish limits the chef to strictly adhere to it. This can hamper dish improvisation, whether the meal is made from scratch of through including leftover elements, something older generations are quite accustomed to (Quested et al., 2013).

Furthermore, in other, mainly Asian cultures, leftovers are used as side dishes for other meals. This requires proper storing (and reheating) of leftovers to ensure food safety comes into play (Jevšnik et al., 2008).

Concluding, in facilitating the prevention of food waste, this waning knowledge could inspire possible strategies that aim to reduce waste and the skill should not be forlorn. The solution should ideally also contribute to and encourage skill learning in meal preparation, such that in fighting food waste, the usage of poor parts of the vegetables can result in a richer kitchen.

OTHER GRADUATION ASSIGNMENTS

Combating food waste is an important line of research at the TU Delft. Nine reports of former students that focussed on diminishing household food waste were found in TU Delft repository (in June 2018).

Interestingly, none of these research projects directly focused on the cooking or consumption phase of food. Five other projects focused on other phases in the supply chain process of food: governmental policy(de Vrijer, 2016), retail sector (Bektes, 2010; Boll, 2016; Meulendijks, 2016) and a pickup and recycling system for bread (Wybenga, 2016). Three projects focussed on reducing food spoilage at the household stage through the implementation of a fridge box that can better preserve vegetables and educate the end user about vegetable storage. None of these projects managed to focus on the final phase of food in households. Pesquera, 2017 on the usage of Internet of Things to make consumers more aware of leftovers in their fridges. Here, decisions of food preparation would have been aided with smart scales in the cooler, but unfortunately the idea did not find implementation because due to technical difficulties (Pesquera, 2017). Another report by Carletto, 2016, also focused on the Internet of Things, did not manage to focus on the end stage due to a mismatch in interest from a collaborative company (Carletto, 2016), and a project by Go, 2017 failed to be implemented because the concept proved too complicated to use in Dutch households (Go, 2017). Finally, a project by Spengemann, 2011, took an interesting new angle to food waste reduction by stimulating households to waste less through the establishment of a community that supplies information about food waste prevention and challenges (Spengemann, 2011). Though this last example aims to address the food preparation phase, it relies on the building of the community to take effect.

While some reports tapped into the complexity of the food waste context, none of the projected sought to solve this problem by directly targeting the 'cooking' and 'eating' phase (see figure 1.5). As such, this direction to reduce food waste remains largely unexplored and it seems that much can be gained by developing strategies to reduce waste during these phases. By encouraging consumers to treat food differently during those two phases, novel ways to prevent food waste can be developed. Furthermore, by changing the behavior of food handling, changes in attitude regarding food can be achieved (Ajzen, 1991). These in turn, can usher new behavior to diminish food waste, resulting in compounded gains (Ajzen, 1991).

CONTEXT MAPPING

To further corroborate the findings from literature and determine the best approach to start tackling vegetable food waste at the household stage and cooking phase, context mapping is used. This is an approach where designers use the people's expertise over their own lives to facilitate in ideation and to find context factors. The choice for this particular method is twofold. Firstly, it is suitable for contexts where sensitizing is needed to explain routines (Sanders & Stappers, 2012). As food management in households is a daily task, people can be unaware of the reasons behind their actions in food management. Since these habit are often engrained routines, the execution of these actions themselves might even go unnoticed. Secondly, context mapping can clarify a complex many variable system by simply attempting to map out these variables.

METHOD

The context mapping performed here contains a sensitizing booklet (figure 7) and a subsequent interview, where the booklet is used to ask more relevant and detailed question that allow us to delve deeper into the problem of habitual food waste. The generated qualitative data is used to identify:

1. Moments in the participants' routine where (new) rituals can be inserted;
    a Planning behaviour of main meals;
    b When is cooking not enjoyed;
    c Difference between weekday and weekend cooking;
2. Desire of participants to change their eating habits;
3. When and what kind of vegetables are discarded;
4. Ways food is prevented from being wasted;

The booklet contains an introduction and various questions for five days. The questions for each day are designed such that they comprise a theme. During the five day the sensitizing booklet is to be filled, the participants are asked to note down every food item that is discarded.

- The first day covers the kitchen and the tools that are especially liked or often used by the participants. This is to find out how the kitchen is organised and if there is an opportunity or need for new kitchen utensils to be developed. Participants are requested to take pictures of the kitchen to support their answers.

- Day two delves into the planning of meals and what moments during planning are experienced positively or negatively. Together with the questions in the interview such as 'how does cooking differs between weekdays and weekend?', this serves to find routines and how these are influenced by external factors (busy days at work, etc.).

- On the third day, practices regarding leftovers are covered. Questions like 'how do you use leftover vegetables?', 'do you fully finish food that you have through improvisation?' shed light on if and how participants adjust their cooking to use spare ingredients. Alongside, photographs of the fridge and other caches of food are taken to assess how the food is stored. Moreover, participants are asked how to deal with partially used items such as open food containers and parts of vegetables.

- The fourth day is about grocery habits and how the participants want to change their eating habits. During the interview, the connection between meal planning and grocery timing is made. By asking 'what would you like to eat more/less?' and 'what prevents you from doing so?' underlying motives and problems in dietary

wishes and vices are addressed. The answers serve to inspire different solution directions to what consumers desire.

• The final questions delve into the way food is thrown out. When and why is food seen as waste, how are measures taken to prevent food waste, how is the act of discarding experienced, and how has filling in the booklet influenced the aforementioned practices.

The full list of questions can be found in appendix 1.

Since the context mapping is performed in Dutch households exclusively the booklets were written in Dutch, to facilitate participation. Allowing the interviews to flow more naturally, the interviews too were conducted in Dutch and audio-recorded. The transcripts can be found alongside the respective pictures in appendix 2.

PARTICIPANTS

Since most of the waste is produced by households of 3 residents or over, the research presented here focuses on these households. Out of ten households contacted to contribute to the study, seven followed through and contributing for the research. All of these were families with two adults and one to three children living at home. In one household the children were already adults and in one other they were in their early teens. The other five households contained children under six. The cultural background in four households was native Dutch. The remaining house were either, Indonesian-Dutch, Mexican-Dutch or Portuguese-Dutch. Socio-economically, all adults in the households were working four to five days a week. The education levels varied from intermediate vocational to academic education.

RESULTS

Below a representative selection of the context mapping results can be found, the comprehensive list of all answers of all participants can be found in appendix 2.

1. *[Moments in the participants' routine where (new) rituals can be inserted.]* Routines vary greatly among different people, yet there are similarities that are universal to all answers:

a. *[Planning behaviour of main meals]* Overall,

Figure 7 Context mapping booklet.

main meals are planned once or twice a week, prior to the main shopping, which also occurs once or twice a week. This is done by whoever is in charge of cooking. When this planning is done, activities of family members are consulted so meals are adjusted according to accommodate dinner table presence. Both amounts and dish types are adjusted accordingly. *"When my husband is not eating at home, I usually try to buy some fish. […] I really like fish but I'm not cooking two meals."*

The family consisting of older children finds it difficult to assess the total amount people they have to cook for (absent family members or some additional people dining along).

b. *[When is cooking not enjoyed.]* Participants often mentioned that fatigue or tiredness has drained the person cooking, causing the chef to not enjoy the act of cooking. Long workdays are often identified as culprits, yet busy weekends are also mentioned as a cause by two families. Three interviewees admitted to get take-out in such situations or make pizza (store-bought).

c. *[Difference between weekday and weekend cooking]* During weekdays, there is generally less time for cooking so time-efficient meals are usually prepared: "during weekdays we try out something quick and easy", "weekdays are tight, timewise, so everything has to be in house and it has to be quick". The weekend is a more complicated matter. While it is often mentioned that there is more time to spent on cooking, it is also stated by the participants that they want to relax more in the weekend and have little desire to cook then: "In the weekends it [cooking] can take longer, but usually we don't feel like going all out".

2. *[Desire of participants to change their eating habits]* Following the overall trends of natural food and healthy food, participants want to decrease the amount of processed food they consume, in particular the use of ready-prepared flavouring sachets. Eating less meat is also mentioned as a desire. Nonetheless, implementation of these desires remains limited, due to the ease of preparing that these practices offer. Flavouring packs give signature flavours to dishes, allowing for instant recognition and guaranteed success "[I] would like to cook without packs, but sometimes [I use them because] it is easy". Meat alternatives still offer challenges to the interviewees: "I need knowledge for that [vegetarian alternatives, sic.] and for that I need time, so it doesn't end up happening".

Figure 8 Slightly cluttered counter of a participant.

Figure 9 Well stocked fridge from the participant that throws out to make room for new groceries.

Moreover, the participants would like to eat salads more often. The reason for preventing them in doing so, is time restriction: "I'd have to wake up half an hour earlier".

(Seasonal) vegetables are also mentioned when asked what the interviewed would like to include more in their diet.

3. *[When and what kind of vegetables are discarded]* As mentioned by some participants, filling the booklet made them more aware of their food wasting habits: "…then you don't want to write stuff down that often". Thusly a more active stance against it was taken, leading to less waste: "we talked about it: if we don't eat it we need to write it down and throw it away". As such, the survey influenced cooking habits and this is taken into account when considering the 'food waste diary'.

The main recurring vegetables that are thrown out are potatoes (due to sprouting), halves of onions (recipe requirements) and cucumbers (gone bad). Besides vegetables, fruit and bread are also often mentioned as being wasted.

4. [Ways food is prevented from being wasted] Here one participant had an especially inspiring solution: leftover vegetables are [after being blanched] put into the freezer to be held there until soup-day [Saturday]. This way almost no vegetables are wasted in this particular household.

As to when food is thrown out, the respondents mentioned "being mouldy", "sometimes I just do not trust a certain kind [of food], or meat, and then I dare not eat it and then I throw it away". Visual and olfactory cues, together with a certain 'carefulness' are used to (re) asses their quality of the food.

Surprisingly, multiple households mentioned that if only they would have had a pig, they would waste less: "So if I would have had a pig, I would have given it to the pig [laughs] but I don't have one".

FOOD WASTE JOURNAL

Figure 10 demonstrates the amount and types of vegetables and fruits wasted, as reported in the diary. Other food categories (e.g. dairy, bread) have been omitted from the table, as these are beyond the scope of this project. Note that due to the participants being actively monitoring their waste, less waste is created as previously mentioned. See also 3. in Results (this page).

OTHER INSIGHTS

- Remains of vegetables which are partially used in only one dish or novel to the chef, are often thrown out after cooking as the person in question does not know what to do with them: "then I really don't know what to do with the rest of the endives", "I just used that fennel for the fish dish, [after that] I don't use it". Indicating a lack of culinary knowledge and/or inability to acquire it.
- Vegetables that are only partly consumed are stored, but often end up as waste anyway: "…half an onion I leave it [in the fridge for some time], and then it goes in the bin", suggesting there is a difficulty translating the desire to use the articles into actions.
- Those who did not enjoying cooking were the ones that threw out most.
- All of the participants disliked throwing out food: "And then I do feel ashamed about it

User/Day	1	2	3	4	5
1	Part of a green cabbage; ½ avocado	1/8 bunch of alfalfa; ½ bunch of parsley		Sprigs of fresh herbs; 2 chicories; ½ avocado	2 bananas
2	½ box of coriander; ½ box of parsley; ¾ box of dill	Trimmings of: 2 carrots, 3 onions, 2 apples	Trimmings of: 2 apples, 1 banana	½ banana Trimmings of: Pineapple, 1 pear	Potato, orange and cucumber peels
3	200g endives	¼ onion; ¾ lemon; 1 lettuce		3½ celery stalk ½ lettuce; 2 boxes of rosemary	½ tomato; Box of pineapple (unripe)
4		Bits of pineapple		½ can of corn	
5	2 apples		½ onion		
6	¼ cucumber				
7	Fruit peels (apple, banana, pear)	Fruit peels (apple, banana)	Apple peels	Fruit peels (apple, kiwi, pear)	Apple peels

Figure 10 Foodwaste journal results from all participants.

[throwing out food]. Quite a bit actually."

- After doing (bi)weekly shopping, food is thrown out of the fridge to make room for new food: "usually my husband throws out a lot of things after he has done the shopping, then I'm like 'Noooooo! We can still eat that!' which sometimes leads to arguments".
- Potatoes are frequently thrown away because of sprouting. Potatoes should be stored at 5-10 degrees in a dark and dry environment. In many households such an environment is not readily available. Furthermore, in five of the households, potatoes were stored together with onions, which reduces the shelf life of the potatoes. This is due to the ethylene released by the onions (Quirk, 2004).
- Similarly, bananas are often kept [on pictures taken at the households] in the same bowl as other items of fruit, see figure 11. Bananas also release ethylene that encourages ripening and ultimately rotting of other fruit in the near vicinity (Quirk, 2004).
- Households where less food is wasted have a more systematic approach to food management. This means having fixed days for planning the week's meals, recurring dishes that use leftover food and (arguably most important) the habit of adapting dishes to the food that has been bought.

LIMITATIONS

Even though a useful tool, the context mapping sessions are subject to several limitations. First and foremost, the sample size used is small. Only a small number of households participated in the research. Hence the results cannot be generalized to all different types of households, in particular considering the unique nature of every home. Second, keeping a waste journal may affect and bias the amount of food that is wasted. As some participants even admitted, describing experiences in the sensitising booklet influenced the behaviour and sometimes even the attitude of the interviewees. Third, within each household only one person was interviewed. In some cases other inhabitants were also involved with the cooking activities, so not all practices are covered per household per se. The interviews have been designed to circumvent this problem, using questions as 'how does your wife/husband do this?', but an interpretation step still remains.

Figure 11 Fruit bowls of two of the households

ROUTINES

For a household there are many moments where food can be discarded. By understanding this process it becomes clear that much of the food wasting or spoilage can be avoided. In the process the following moments were identified:

- Planning: weekly or daily plans are often transcribed into grocery lists to aid shopping. Information on quantities is derived from recipes or experience. To reduce waste, this step can be skipped altogether or used as a reminder of missing essentials (Thomas & Garland, 2004).
- Buying: The pruchasing of goods depends on the grocery list, availability, visual quality of the products, promotions, advice, packaging size, and price. The level of influence of these factors are in turn dependent on the user and its state of mind (e.g. hungry, in a hurry) (Dijksterhuis, Smith, Van Baaren, & Wigboldus, 2005). Nowadays pruchases can also be made on the digital realm. Food boxes as 'HelloFresh' and the 'AllerhandeBox' are becoming more popular as it allows consumers to more easily try out novel meals. Using such boxes could create food waste when ingredients are not liked or when amounts are exceeding necessity although research on this topic is yet to be done.
- Transporting: As consumers not always consume food immediately after purchase and often it is destined for home. Transportation is an essential component in the household phase of food and its influence of food quality (Jevšnik et al., 2008) is often overlooked. Duration, temperature, and bruising can affect food and possibly degrade product quality.
- (Un)Storing: even though food deteriorates over

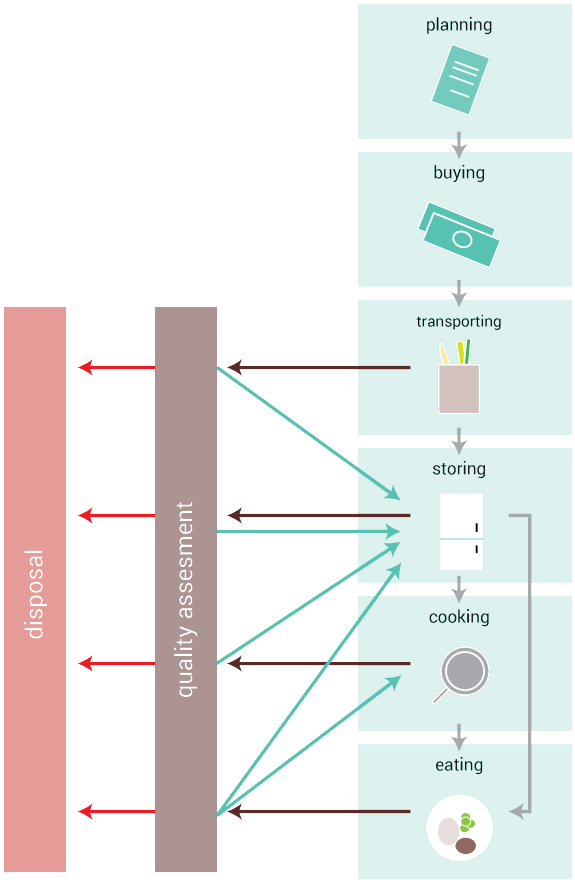


Figure 12 Stages of food handling on household level.

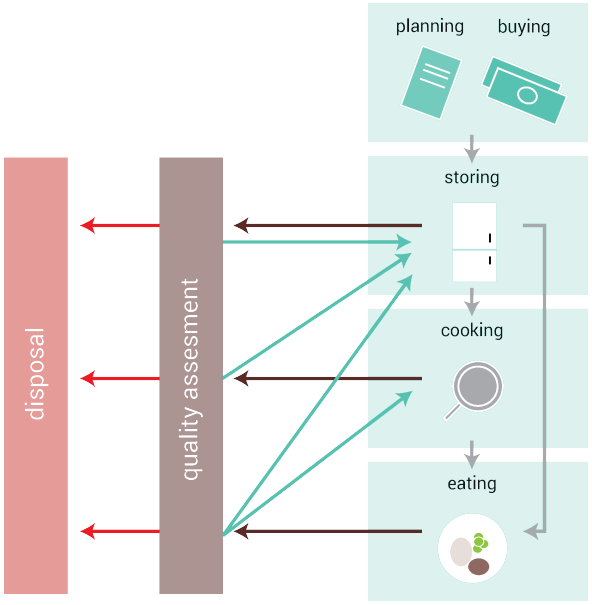


Figure 13 Handling system when using food boxes.

time, proper storing can have a big influence in shelf life at home. Knowledge, tending, defrosting methods, and proper storage conditions are key when storing (Jevšnik et al., 2008).

- Cooking: When preparing food, portioning and timely use of produce is influenced by time, knowledge, care, and kitchen conditions (Jevšnik et al., 2008).
- Consuming: Sharing and eating food.

At every stage, actions can be taken by the consumers that can lead to food waste. In figure 12 and 13, an overview is presented of the described stages, how they are connected, and where waste creating habits most often develop.

From figures 12 and 13 it becomes clear that many actions revolve around storing and assessing the quality. According to Evans (2012), a peculiar practice takes place here: whilst examining food on its quality, consumers do place produce back into storage knowing that it will go off soon. The products are not used as they might not be suitable for the intended meal or might have been consumed recently (Evans, 2012). When the items in question are re-examined and now determined to be unsuitable for consumption, the user disposes of them with still some feeling of anxiety. This 'two stage holding process' is a sociological phenomenon that manifests itself when guilt and anxiety influence decision making (Gregson, Metcalfe, & Crewe, 2007; Hetherington, 2004). It comes down to consumers not wanting to throw away food in an edible state as it would feel bad (Quested et al., 2013; Stefan et al., 2013), despite the suspicion that it will not be consumed anyway (Evans, 2012). In time the food will perish creating thusly less anxiety when throw it out (Evans, 2012), easing the consumers mind. This cycle is illustrated in figure 14.

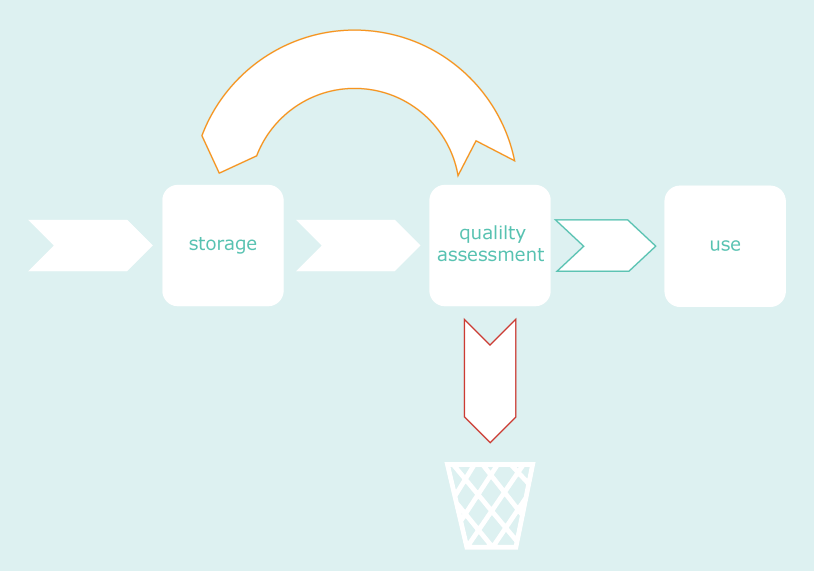


Figure 14 Two stage system which delays disposing of food.

PERSONA

With the insights gathered with the context mapping a persona is created together with a diagram of the person's cooking routines. In this diagram, key actions can be found that should give a clearer overview of the complex task of food preparation in this given context. The displayed actions are categorised by behaviour, attitude, and knowledge. This allows for a deeper understanding of how the actions come to be and how to possibly prevent or stimulate them.

Willem 33, shopkeeper
Lives with:
Wife 32, primary school teacher
Son 5
Daughter 3

"...would like to eat less meat, not meaning more fish but just more vegetarian"

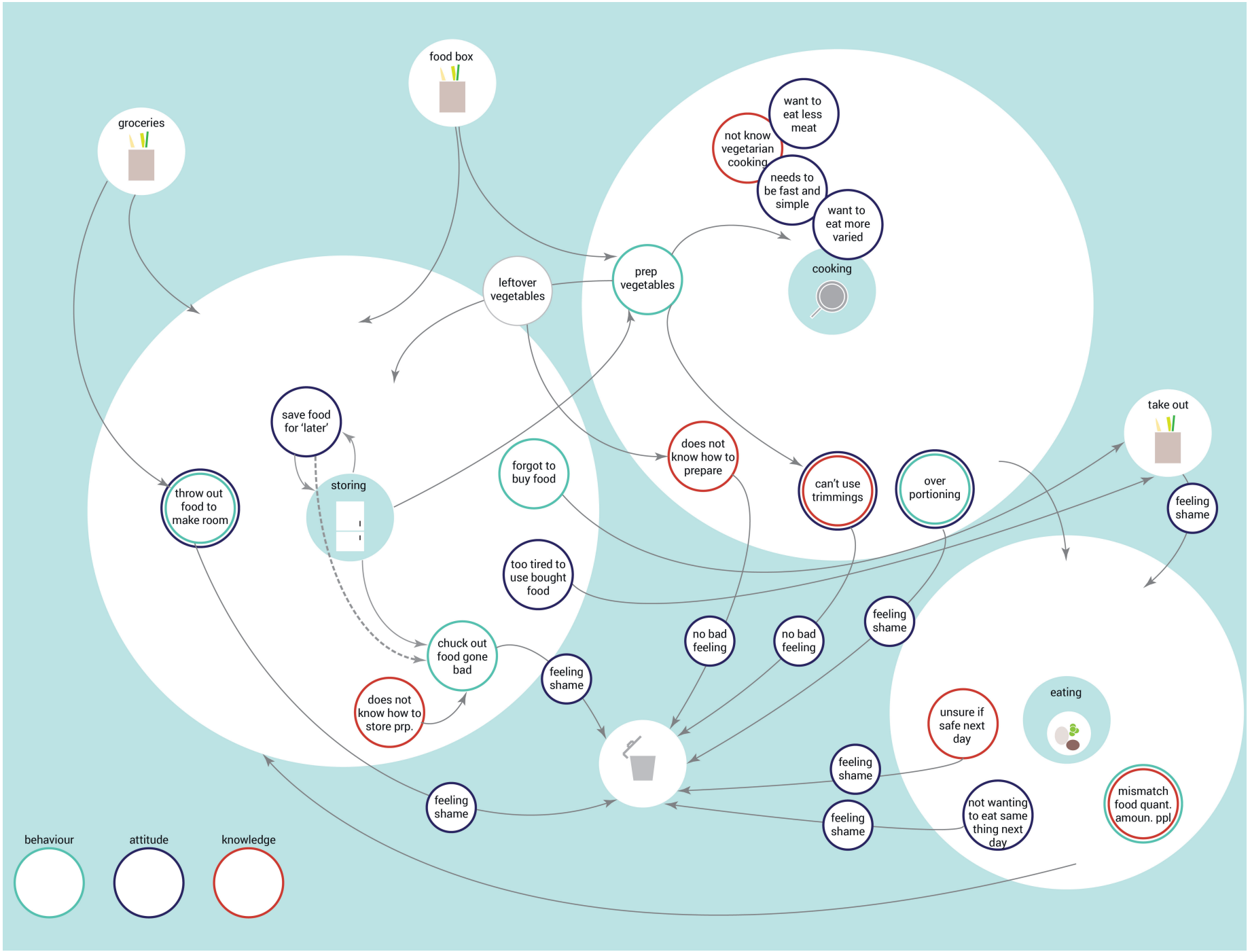
Activities
Shops three times a week
Cooks six times a week

Daily routines
After work Willem commutes from Rotterdam to Haarlem by train or motorcycle.
His wife picks up the kids and does some of the shopping. While traveling he thinks of what to make for dinner.

"I would like to cook without packs, but sometimes it is easy"

Goals
Consume less processed food
Make healthy food for his family
Eat more vegetarian food

Frustrations
Does not like using flavoring sachets yet uses them often
Time management, weekdays can be so busy with the kids
Does not always feel like cooking, but has to do so


food box
groceries
want to eat less meat
not know vegetarian cooking
needs to be fast and simple
want to eat more varied
cooking
prep vegetables
leftover vegetables
save food for 'later'
storing
throw out food to make room
forgot to buy food
does not know how to prepare
can't use trimmings
over portioning
take out
feeling shame
too tired to use bought food
chuck out food gone bad
does not know how to store prp.
feeling shame
no bad feeling
no bad feeling
feeling shame
eating
unsure if safe next day
feeling shame
feeling shame
not wanting to eat same thing next day
mismatch food quant. amoun. ppl
feeling shame
behaviour
attitude
knowledge

CONSUMER LEVEL FOOD TRENDS

Food is so much more than just feeding. To some, it is even a lifestyle. The following assesses culinary trends that serve reveal food types that have gained some popularity and help illuminate the context into which food is consumed. Simultaneously, these trends serve as both an inspiration and direction into which to develop potentially fruitful solutions. The trends are a relevant selection of those found in food blogs, magazines and gastronomic conferences.

POKE BOWL

Originally a Hawaiian dish, the poke, or poké, bowl has quickly spread across the globe. Made mainly of fresh uncooked ingredients and rice, it is quickly prepared and thus it fits well in the trends of health-food and fast-casual dining. Recently, stores that offer poke bowls are now to be found in western Europe or are integrated into the assortment of different established stores (Cheng, 2017). The poke bowl is basically a cold bowl of rice or noodles topped with (pickled) vegetables, some form of uncooked protein (traditionally raw diced tuna or salmon), and a dressing typically consisting of sesame oil, lime juice, and soy. It is conceivable that Hawaiians regularly eat poke bowl and empty their fridge of leftover carbs and vegetables.

FERMENTED FOODS

The practice of fermentation of foods is currently, after being rekindled by higher gastronomy, being reintegrated in household everyday cooking. In line of the current health-food trend, more attention is drawn to the health benefits of cultured., or fermented, foods. Fermented foods, such as the Korean kimchi, and beverages, like kombucha, are becoming increasingly more mainstream. And with them so does the use of fermentation in restaurants and households.

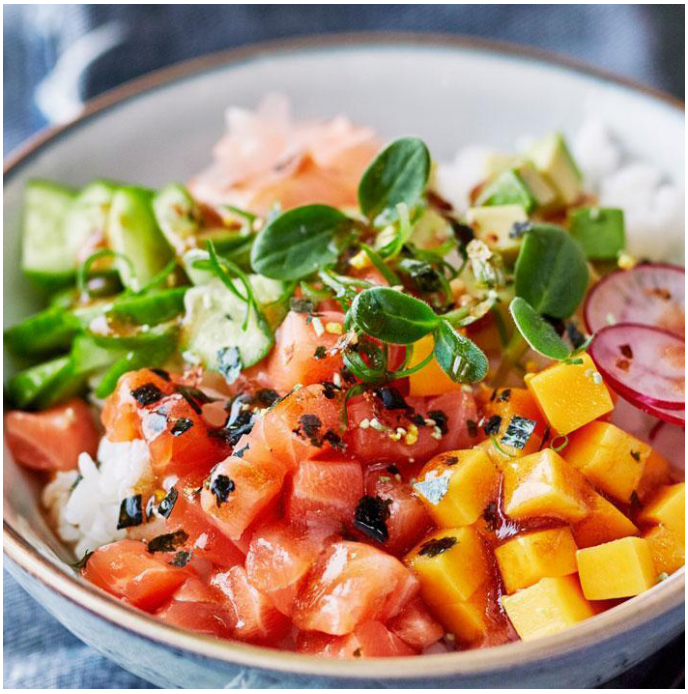


Figure 15 A Poke bowl filled with salmon and vegetables.

Figure 16 Pots of fermenting kimchi.

PLANT BASED MEATS

A relatively new invention is heme cooking. 'Heme' indicates the use of vegetable extracts to form the bases of imitations of meats. Examples include products such as the 'impossible burger' are becoming available at restaurants in the US. Heme, derived from haemoglobin, the oxygen binding agent in blood, is responsible for some of the taste and appearance of red meats. Used in veggie burgers, the experience of a medium-rare burger can be simulated (Sharp, 2018)(see figure 17).

SOUTH AMERICAN CUISINE

As some of the world's highest ranking chefs come from Brazil, Peru, and Chile, dishes and indigenous ingredients are trending. Many of these dishes are stews that combine savoury seafood with sweet tropical fruits.

SOUP STARTER

A start-up from Rotterdam that developed a way to facilitate the making of soup. As the founders found out that making soup on a daily basis can be strenuous and time consuming, they sought to make it simpler. The product consists of a dry mixture of vegetables, herbs, spices and salt. These are simply to be mixed with vegetables of the consumer's own liking and some water.

Figure 17 Advertisement of the hi-tech vegetarian hamburger.

Figure 18 Jar of Soup Starter, filled with dried vegetables and spices.

ANALYSIS CONCLUSIONS

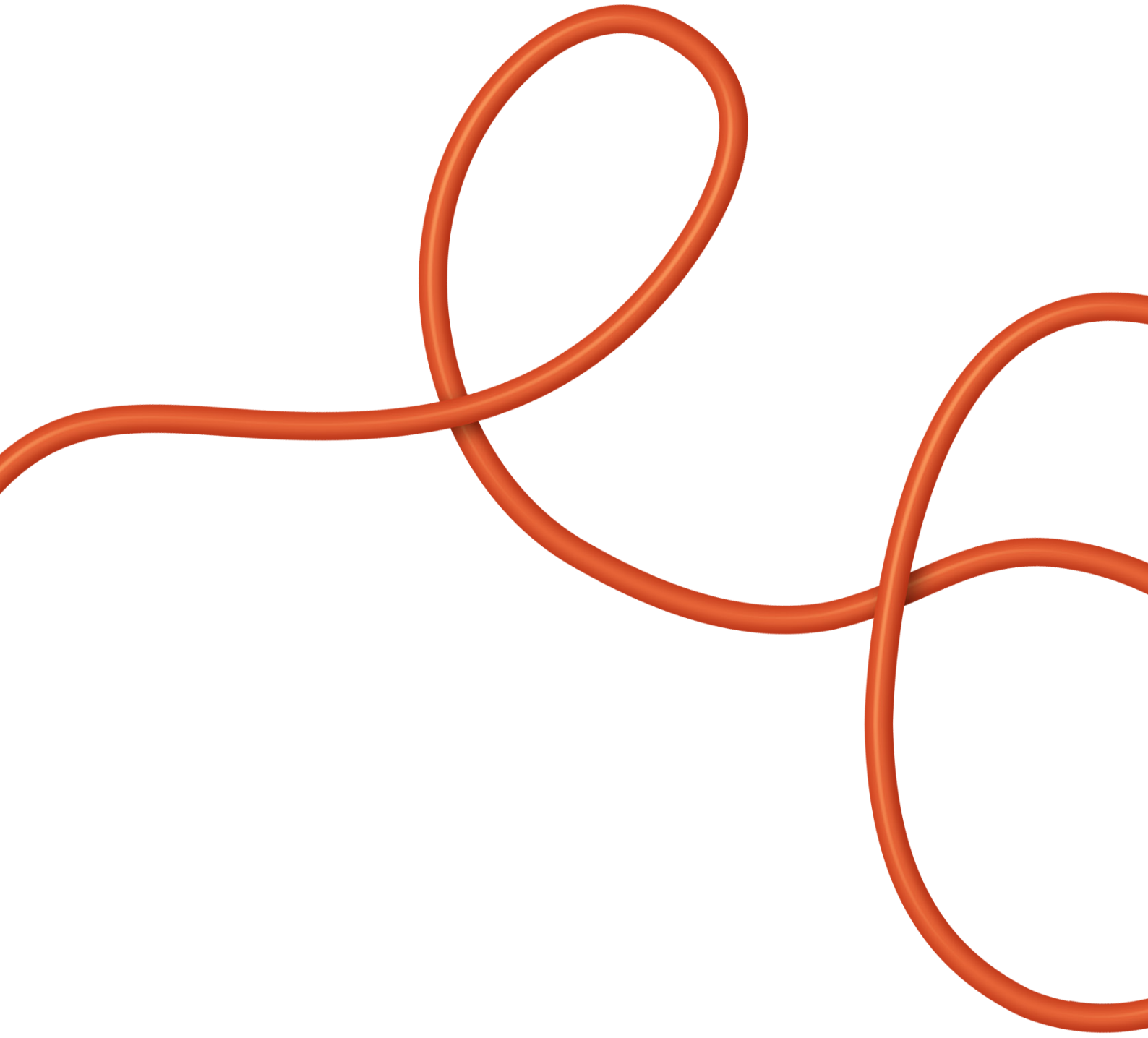
Although food waste is a complex subject, a systematic approach made it possible to identify some key causes on why people waste food. To create a optimal reduction in the amount of food wasted amount on an absolute scale, while still preserving a specific enough target group, households of three or more people have been chosen as an appropriate user group for initial product design.

Food traverses a path through the household that can be separated into various phases: purchase, transportation, storage, preparation, consumption and disposal. Most current research has focused on food waste that is generated even before food reaches the households, and when research covers households, it mainly addresses problems with purchase and storage. Surprisingly, the 'preparation stage', where a significant portion of food is discarded, has been largely left unremarked. As a result from the lack of research into this stage, no other projects at the TU Delft regarding food waste have embarked on solving the food waste problem at this perspective. Through context mapping interviews conducted in this report, it became obvious that limits in knowledge, rushed attitudes, and ill-conditioned behaviour in the preparation phase are actually major causes of wasting food.

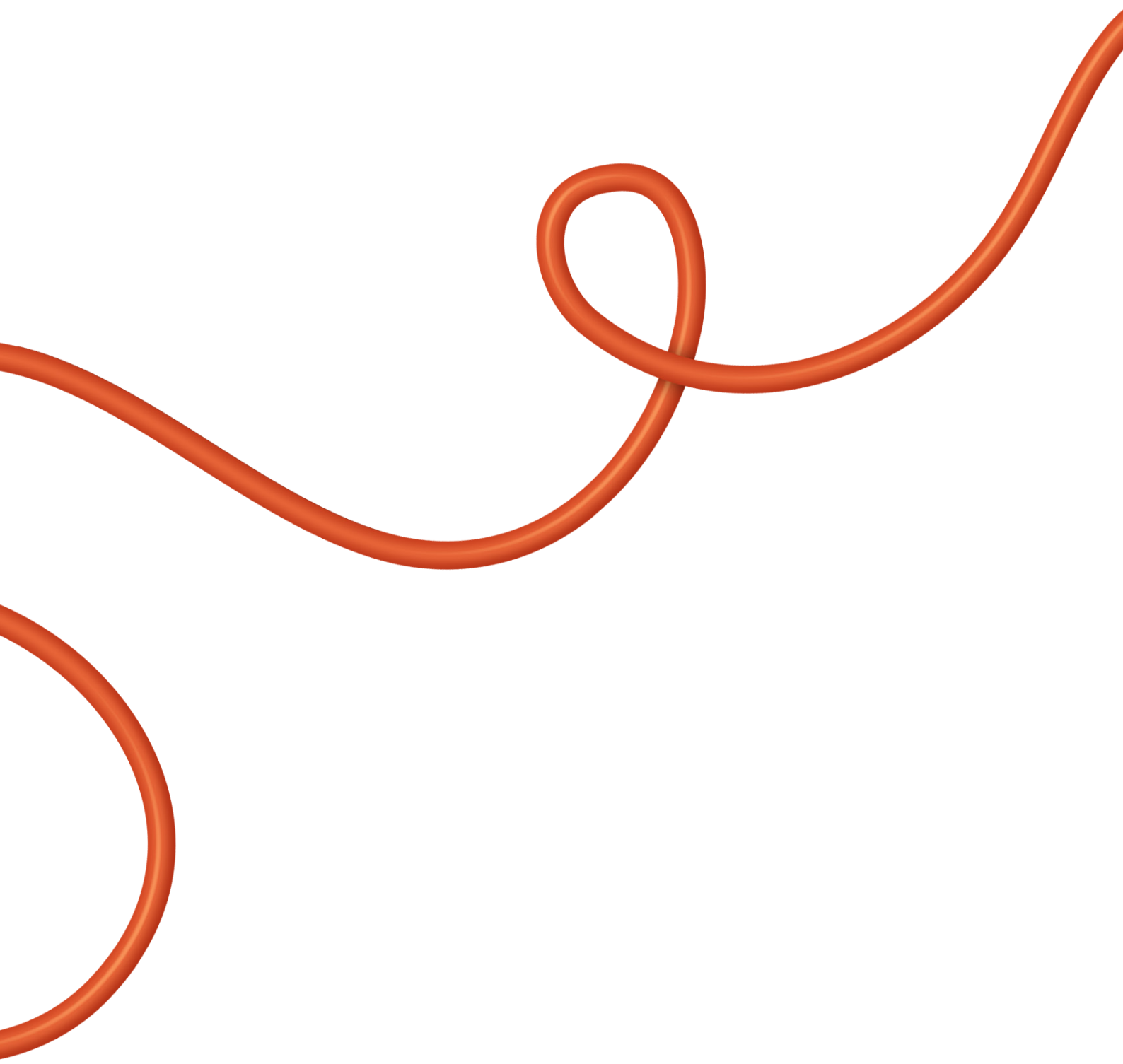
More specifically, the lack of knowledge of how to adapt dishes and the inability to prepare meals from the food that is already present in the house fuel excessive food waste. This wasteful habit is reinforced by the limited time people allow themselves to cook and sometime their general dislike of preparing regular meals altogether. Strikingly, when inventory is made of leftover vegetables, the vegetables are not used for meal preparation, but left deliberately in storage until they are fully spoiled and inedible such that they can be thrown out with little guilt.

Those interviewed who waste little do also feel time pressure around dinner time, but overcome the need to leave vegetables to rot by habitually adapting dishes. They see recipes as guidelines and customarily deal with leftovers.

To overcome this problem of vegetable food waste at preparation phase, a solution needs to be found which facilitates and encourages people to use what food they already have directly available. Key aspects will be enabling improvisation, time efficient use, the promotion of culinary knowledge, and ease of implementation.



CONCEPTING



INTRODUCTION

Vegetable food in households is wasted in large amounts during the preparation phase, as argued in the previous chapters. Fortunately, this presents an excellent starting point for the development of a solution. The section below covers the concepts derived from the gathered data in the previous section. First, the problem of leftover vegetable waste is more narrowly defined and a design vision is presented. Then, several concepts and their implications are discussed, followed by the justification of the concept selection. Finally, this chapter is concluded with a user test, to debug the concept and identify potential shortcomings that can be resolved during the detailing stage.

REDEFINING THE PROBLEM

By sorting out the information gathered in the analysis, a structured problem definition is presented that is used as a guide during the concepting phase.

What is the problem?

- Lack of knowledge and material to use vegetable peels and trimmings;

Who has the problem?

- Most home chefs, from the experienced to the novices, from those that waste much to those that take care to waste little;

What are relevant context factors?

- Peels/trimmings are not really seen as food waste by some users;
- During dinner preparation, there tends to be little time;
- None of the interviewed used peels/trimmings;
- If peels are seen as edible valuable sources of food, the 'main' parts of the vegetables might be regarded as even more valuable;
- Peels and trimmings have a high flavour content and are very nourishing;
- (high-end) restaurants use peels;

What are the goals?

- Users would like their families to eat more (organic) vegetables;
- Users would like to waste less;
- Demonstrate the end-users the value of vegetable (waste);
- Show the possibilities of vegetables (and leftovers thereof) in cooking;

- The solution should be (particularly) suitable for leftover vegetables;

What are the side effects to be avoided?

- The solution should not:
- Compromise food safety;
- Increase food waste;
- Deter people from cooking by it more complicated ;
- Clutter the kitchen space;
- Using more resources to save food;

Which actions are admissible?

- During cooking, the solution should take as little time needed as possible;
- More time can be devoted to the solution after dinner or during the weekends;

What is meant by vegetable peels and trimmings?

- Peels of root vegetables: beetroot, parsnip, celeriac, carrots…
- Outer layers of cabbages & leeks
- Stems and leaf's of herbs

PROBLEM STATEMENT:

Home chefs do not use vegetable skins and trimmings as they do not regard it as edible food and/or do not know how to use it. Yet this portion of the vegetables is considered highly nutritious and flavoursome, creates excess waste, and generates a sense of guilt upon disposal.

DESIGN GOAL

A design goal serves to focus and clarify what is being strived towards explicitly. This section covers the why and what as a setup for the rest of this chapter.

As defined in the problem statement, the trimmings and peels are not regarded as edible. So to make it 'acceptable' to eat these parts, either these trimmings or their consumers/wasters will have to go through a transformation. The intention of this project is to transform this perfectly nutritious food from 'inedible' to 'edible' in some way and consequently change the consumers' perspective on what is regarded as inedible. Furthermore, the interviews confirmed that users are willing to use scrap vegetables in some way, but, as multiple respondents to the interview questions pointed out (see section Context Mapping), a lack the knowledge on how to use scrap vegetables leaves them not choice but wasting them.

By providing an easy tool to use veg scraps, users can be enabled to take out more of what they buy. As the chosen user group, families with children can have hectic lifestyles, the tool should be well fitted to their needs and limitations. Hence the following design goal is proposed:

"To provide a practical tool for families with children to change vegetable scraps and peels into appealing food in order to decrease food waste and change how food (waste) is perceived".

CONCEPTING

H2 SESSION

With the design vision in mind, concept directions were sought using 'How To' (H2's) (see appendix 3a). The starting points were 'how to use vegetable trimmings' and 'how to preserve vegetable trimmings', leading to three concepts: a soup maker, powder maker and a grinder (see appendix 3b).

CONCEPT DESCRIPTIONS

Trimmings soup: building on earlier identified culinary trends, soups can easily be made with scrap parts of vegetables. Once blended or otherwise pulverized, peels and other tough parts become edible just like any other part of the vegetable.

The concept consists of a device (see figure 19) that heats up a mixture of trimmings and water, with the additional ability to blend the mix. To support this system, a bag is used to store the vegetable scraps in the freezer to prevent freezer burn. This bag would be used to accumulate enough scraps to make an amount of soup suitable for the whole family.

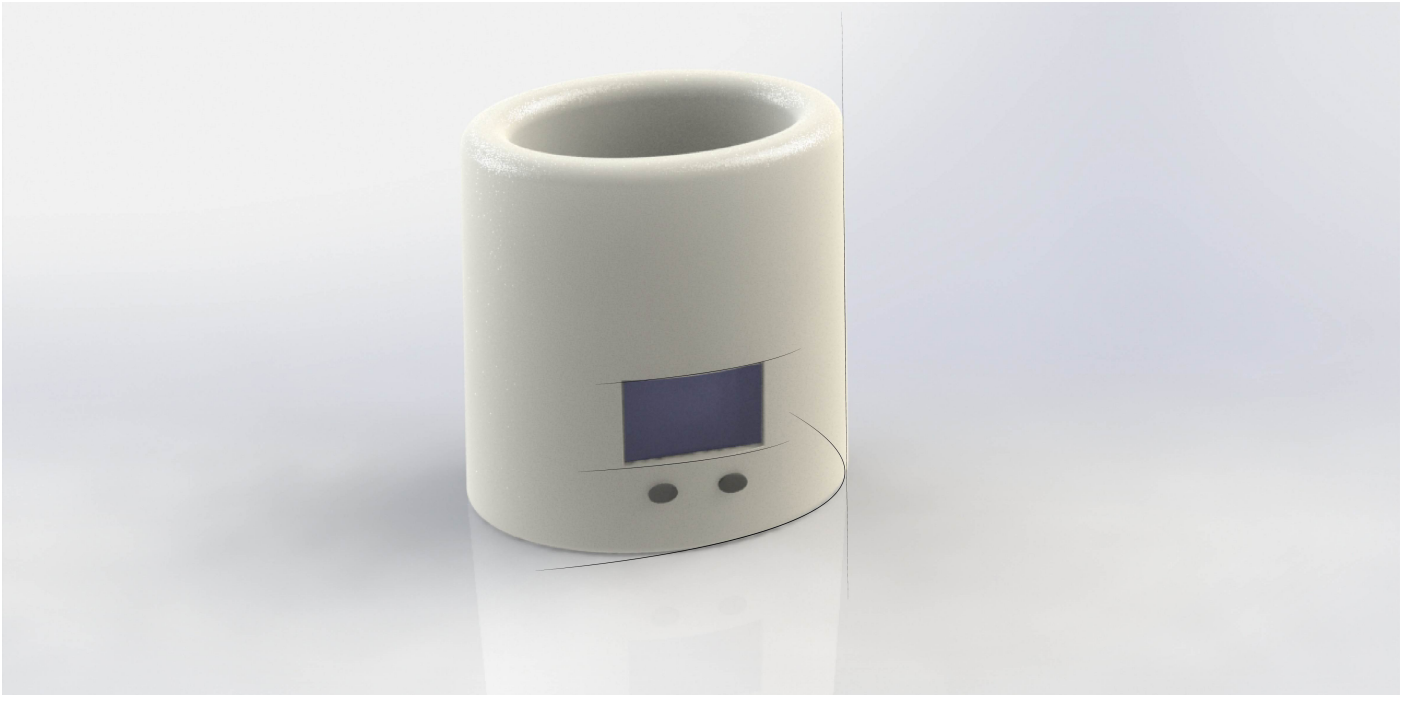


Figure 19 Impression of the Soup making concept.

Vegetable powder machine: another way to transform tough and unappealing looking vegetable peels and trimmings is by turning them into powder. Users can gather the trimmings of a cooking session and place them in a container. First it is placed in the microwave for a short heat treatment and then it is placed in a device that dries the vegetables completely using hot air. Finally, the dried materials are placed in a closed container and are ground to a fine powder using the device. This last closed container can be used for proper storage, functioning as a barrier to oxygen, moisture, and UV light. See figure below.

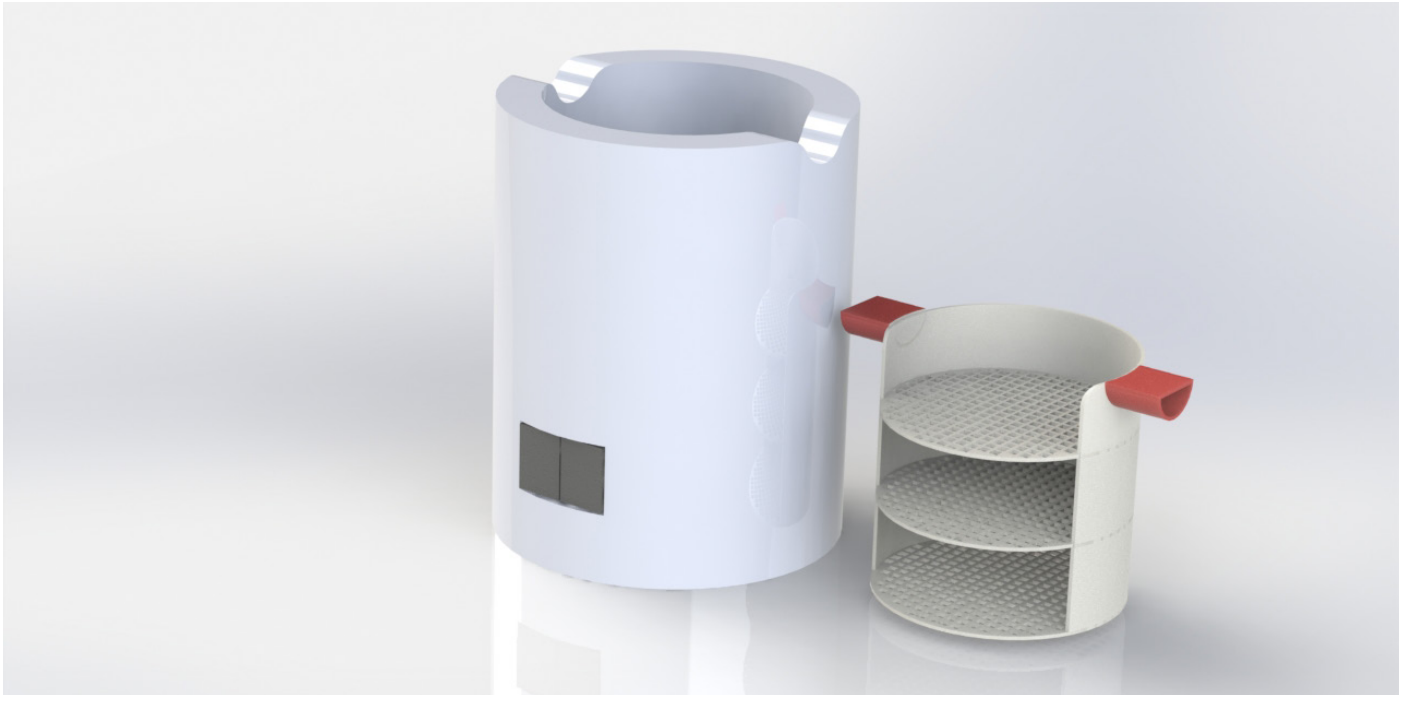


Figure 20 Impression of the Powder making concept.

CONCEPT EVALUATION

Powder grinder: the third concept is a low tech vegetable grinder. This should be used in combination with a (convection) oven, where peels can be dried. The device consists of a two interlocking parts (a top and bottom rack) with grinding teeth that double up as aeration racks (see figure 21).

To dry, the vegetable strips are placed on the teeth of both parts. The top rack is placed on the bottom one and they are put in an oven set to 50°-60° and left for 45-90 minutes depending on the thickness and type of vegetable. Note that the top part is perforated to allow air to flow from the lower level.

Once dried and cooled off, the top part is flipped over onto the bottom part and the dried vegetables are ground between the teeth. The vegetable powder can be stored for future use.

The advantage of this concept is the relative low cost of production as it has no electrical components and is comprised solely of two injection mouldable shapes.

FLAVOUR

For scraps to be considered edible, their flavour should be pleasant in order for consumer to consider using the product. The scrap soup will require the user to add water and, to make it more palatable, seasonings. The most important would be salt, yet the user can further enhance the soup by adding herbs and spices as they see fit or as suggested by recipes. When using vegetable powders no additional seasoning is requires, since the vegetables themselves are the seasoning: they are used to enhance other dishes. As most of the flavour of the vegetables is preserved during drying, applying the vegetable powder can strengthen the vegetable flavour or give a subtle accent when, for instance, mixed with condiments such as mayonnaise. The flavouring strength of the powder varies greatly between the different vegetables. Where beetroot gives a strong sweet and earthy note, tomato powder is tangy and mushrooms provide earthy and umami flavours when added. If different powders are mixed, it can function as stock by resulting as a flavour enhancer, while providing additional nutrients. The versatility of the powders can allow users to experiment and try out new combinations, making the process of cooking and food altogether more enjoyable.

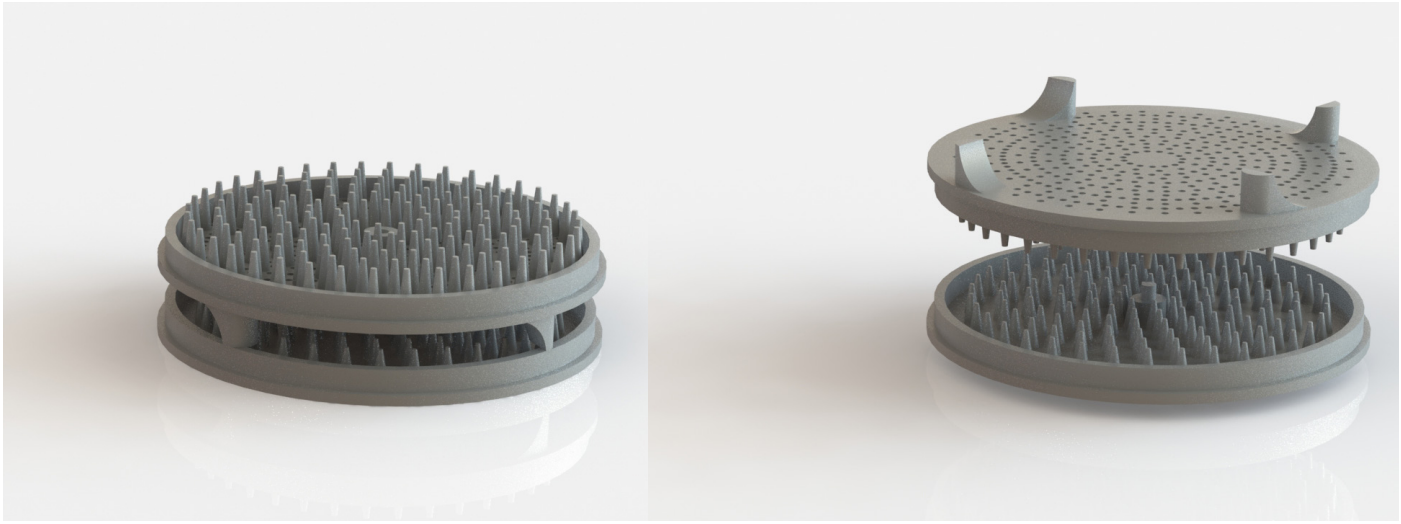


Figure 21 Render of the vegetable grinding concept.

CHANGE IN NUTRIENT CONTENT AND PRESERVATION

One of the main reasons why food is consumed, is simply for its nutritional value. Therefore it is important to evaluate the effects of making soup and drying to the nutritional value of result. Evidently, the resulting food should remain edible. This section covers the possible effects that the concepts would have on the nutritional value of vegetable peels and how to further preserve nutrients and prevent their decomposition.

For vegetables, the amount of nutrients, in particular vitamins, are strongly affected by the time spent after picking, the temperature (changes) vegetable have been exposed to, and their handling (bruising) (Barrett, 2007). When dried, vegetables keep their fibre and mineral content (Bell et al., 2006). So while this is outside of the scope of this project it is important to keep in mind that the nutritional value of vegetables varies.

Making soup: While a short heat treatment (like blanching or microwaving) is beneficial to the absorption of nutrients by the human body, prolonged heat affects the vitamin content of food (Barrett, 2007). Especially prolonged exposure to heat, which is associated with soups making, reduces vitamin content up to 64% (Barrett, 2007; Nutrient Data Laboratory, 2002).

Making powder: when drying vegetables using a initial preheating in the microwave oven followed by convection drying can maintain most vitamins with the exception of vitamin C (Kendall, DiPersio, & Sofos, 2012).

Minerals and nutritional fibre is preserved in both methods (Barrett, 2007; Kendall et al., 2012; Nutrient Data Laboratory, 2002).

Nutrient decrease and decay in vegetables can occur due to microbial activity, enzymes in the vegetables, air and light oxidation. Temperature and moisture levels act as catalysts that can accelerate decay. To reduce or eliminate microbial activity, moisture levels can be lowered (drying), vegetable can be subject to heat treatments (pasteurisation, sterilisation), or additives can be applied (nitrite) (Sebranek & Bacus, 2007). Oxidation is prevented, by packing food in oxygen free containers, or minimised, by use of airtight containers (Jiang, Zhang, & Adhikari, 2013). Enzymes natural to the vegetables can be inactivated by short heat treatments (blanching, steaming, microwaving) (Jiang et al., 2013).

Conclusion

While minerals and fibre is maintained with all three concepts, powdering vegetables has a slight advantage in terms of vitamin retention. During the processing it is beneficial to use low temperatures and reduce processing time to a minimum. To maintain the nutritional content after processing, prevention of (UV) oxidation and microbial growth is key.

TOXICOLOGY

Any product that is somehow involved in the preparation phase of a meal can by no means comprise the digestibility of the food. Since we here develop a product that directly connects produce to a meal, special attention should be devoted to the food safety of the product. Any handling of food can introduce or enable bacterial growth and spoilage, and this section discusses the potential toxicological dangers that come with each product design and how each of these dangers can be avoided.

Even though vegetables are widely consumed, they can, in some case contain low levels of compounds that are toxic to humans (solanine). Examples include: the skins and piths of potatoes, th unripe tomatoes and the crowns thereof (Barceloux, 2009). The amount of these toxins contained in each item of vegetable are small in these particular parts of the plants as compared to the levels of the same toxin in the leaves and stems (Barceloux, 2009). These toxin are harmless when these vegetables are consumed in quantities of a typical meal. For example, even the potato tops, which contain far higher levels of solanine than the peels (Phillips et al., 1996), can safely be consumed 2-5g/Kg bodyweight per day (Phillips et al., 1996), without any effect to the human body. When making powders however, the toxins are up concentrated, possibly leading to the ingestion of harmful amounts of solanine when used in large quantities. Especially small children are vulnerable to this, since their body mass is low. Therefore future users (families with children) should be warned against powdering potato peels and tomato piths, preventing possible adverse effects.

Besides toxins that are naturally occurring in vegetables, pesticides used in agriculture could compromise food safety and are often considered a threat. As a means to fend off parasitic bacterial or fungal growth or attack from insects, vegetables and fruits are often coated with a thin layer of pesticides before being harvested. Most of these pesticides are degradable or can be readily washed off, but residual quantities can remain nonetheless. Moreover, these compounds, in contrary to popular belief, are not only found in the peels of vegetables but can also penetrate beyond the outer layer (Voedingscentrum, 2018). Worrying about the levels of pesticides in peels, participants in the context mapping session have raised concerns about this. In accordance with Dutch law however, vegetables are routinely checked and the food safety is strictly monitored to prevent harm to consumers. Amounts of permitted pesticides are no threat to the consumer and food safety is warranted, even if large quantities of vegetables are consumed (Voedingscentrum, 2018). In case users remain concerned, the use of produces that has been treated with pesticide can be omitted altogether by the use of organic vegetables. Organic vegetable contain no pesticides (Voedingscentrum, 2018) and the use of organic produce would fulfil consumers' desire to consume more organic vegetables (see Context Mapping).

Making soup: When the submerged vegetables are heated up to the boiling point of water, most microbes are eliminated (Jevšnik et al., 2008). However, the soup must either be used right away, kept above 60° until use or cooled to below 20° within two hours to prevent the proliferation of microbes in the food. For long term storage (few days) the soup must be cool to below 6° within four hours (Haraminac, 2017).

Making powders: Even though drying vegetables would concentrate possible traces of pesticides and small quantities of natural toxin, the powders remain safe for consumption, even in large quantities. The dehydration would further protect the vegetables from microbial spoilage, as the lack of water creates an inhospitable medium for microbes to grow and stops microbial activity. Ensuring this protection persists, by keeping them dry, the powders can be stored for months.

CONCEPT CHOICE

To determine the concept that bears the highest potential for kitchen use, key aspects derived from the context mapping sessions will be used as criteria. After evaluating these criteria for each of the concepts, a Harris profile is used to condense the results and arrive at a final decision, where one concept is selected for further detailing.

CRITERIA

Ease of use: Soupmaking involves the following few steps to create a consumable soup and prepare the machine for the next use: collecting the vegetable scraps while preparing dinner; storing them in the freezer until a suitable quantity is accumulated; setting up the machine by filling it with the scraps, water, and spices; consumption of the food; cleaning the machine. Storing of the scraps can pose a problem as users are often unaware of the content of the their freeze and what gets put inside is often forgotten about. This was also raised during the context mapping sessions. Overall there are six major steps in using this concept, of which one might be problematic.

Usage of the powder machine involves the following steps: collecting the vegetable scraps; cutting the scraps into thin pieces; microwaving the scraps; setting up the machine and drying the scraps; transferring the scraps into the blending vessel and blend the dried scraps into powder; storing the powder until use; using the powder; cleaning the parts of the machine. This concept requires a total of seven major steps. As the drying and grinding uses different components, switching between these steps might be cumbersome and additional components will require additional cleaning, which might deter the user.

For the powder grinder the steps are the following: collecting the vegetable scraps; clickling the scraps into thin pieces; placing the scraps in the grinder and drying the scraps in the oven; grinding the scraps into powder; transferring the powder into a vessel until use; using the powder; cleaning the parts of the grinder. As this method utilises the existing ovens, part of the process should be more intuitive for the end users. Furthermore, switching from drying to grinding involves merely closing the grinder.

Applicability: to make the outcome of this project successful, the product system should be useful. The vegetable powders can be used in a wide variety of dishes and can be applied to enhance pretty much every meal. The soup is in a dish on its own, limiting its applicability and would have a larger impact on cooking routines. However, context mapping revealed that there is a general desire to eat soups more often, which indicates that there might be a demand for a soup maker.

Kitchen space: Kitchen space is limited, as became apparent from the context mapping sessions. The participants stressed that adding more appliances to their kitchens was not desirable. As the soup and powder makers take around the same space as a toaster, future users might not welcome them in their kitchens. Here the grinder has an advantage as it uses an oven, which is a standard integrated kitchen appliance in most kitchens. The grinders shape (flat) makes it easy to be stowed into cupboards without taking up much space.

Energy efficiency: Energy usage is an important aspect of each design. Since the intended product should not only reduce food waste, but ideally reduce the carbon footprint of household cooking altogether, we pay special attention to each design in terms of energy performance. In these terms the soup maker concept has a slight advantage over powder making, assuming that one weeks' worth of vegetable scraps would yield a litre of soup, whereas vegetable powder are made about three times a week. Heating a litre of soup would consume around 0.1 kWh (costing about 2ct) while making powders three times would use 0.2 kWh (costing around 4ct). The energy consumption of the powder grinder is mainly determined by the efficiency and size of the oven that is used. As the temperature that is used with this concept is relatively low, one could even make use of the heat generated during cooking to dry the scraps. Using the oven at 60°C for an hour would amount to 0.75 kWh (costing about 15ct). These amounts are substantial when the total process of cooking consumes around 1.3 kWh of energy per day on average (Wood & Newborough, 2003).

Yet it is arguable that the grinder would use an excessive amount of energy when regarding the total energy usage of cooking. For full calculation see appendix 4.

Shelf life: Vegetable powders can if stored properly remain usable for 6-12 months. After this flavour decreases and caking will inevitably occur, making the powders less appealing (Jiang et al., 2013; Kendall et al., 2012). As the powders can be used with almost every meal, this period should be more than sufficient. Vegetable soups can be kept in the fridge for up to three days or frozen for up to three months (USDA, 2018).

Innovation: making (vegetable) powders at home is not commonplace in Dutch households and even though there are products on the market to do so, these are not well suited for household use due to their bulky nature. This means that the powder maker and the grinder do present something new for the Dutch households. As the grinder utilises the heating capabilities of the oven, it makes this novel procedure more accessible to the end user. On the other hand, most households are generally already equipped with utensils to make vegetable soups (stove and a mixer), reducing the attractiveness of the soupmaker.

HARRIS PROFILE

Translating the aforementioned advantages and disadvantages of each concept into a Harris profile (see figure 22) helps to visualise the overall anticipated performance of the three concepts in the households (Roozenburg & Eekels, 1998). Since the grinder concept is small, easy to use, novel, and widely applicable, the concept seems clearly to most promising candidate and this concept will thus be developed further.

CONCLUSION

After evaluation the grinder concept seems most promising and is further pursued. One major drawback in the product is the substantial energy consumption required to dry the vegetable leftovers in the oven. This aspect will have to be considered in the detailing phase as it should be possible to decrease this negative effect.

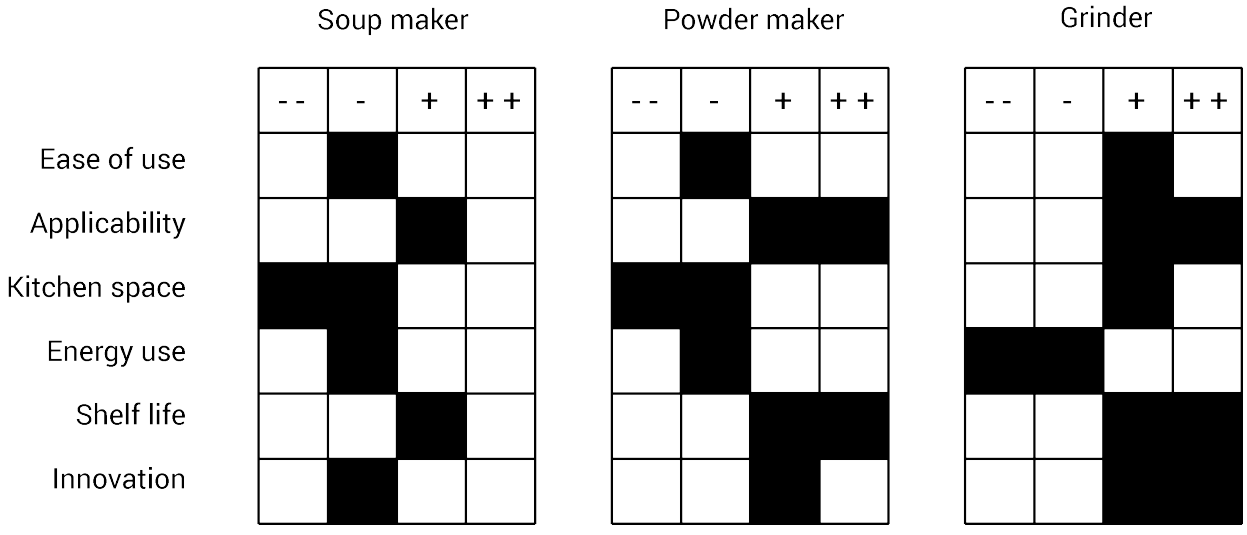


Figure 22 Harris profile visualising advantages and drawbacks of each concept.

SECOND USER TEST: THE POWDER EXPERIMENT

To evaluate the users' understanding of the vegetable powders and their propensity to use them, a second user test was conducted. Vegetable powders are widely used in processed food, especially in flavouring sachets (see figure 23). Many families are unaware they consume vegetable powders on a regular basis through such spice mixes. Using pure veggie powders might thus be experienced as an novel and hence an unfamiliar item to be used in cooking.

PARTICIPANTS

Three families were approached to participate. The families in question were all multimember households (3+) and had Dutch, Ukrainian, and Dutch-Portuguese backgrounds respectively.

PROCEDURE

The families were each given tree powders in jars (see figure 24). Two of the powders were made of common vegetables (carrot, onion, etc.) and one of less commonly used vegetables (parsnip, celery root etc.). The powders were made by me using a professional dehydrator and a coffee grinder (see figure 25 and 26) The test consisted of two parts, each executed during preparation and/or consumption of the dinner meal. The first part was an open test where users were asked to use one or more of the powders during cooking or at the dinner table to their own discretion. In doing so users were encouraged to be inventfull and creative in applying the powders and new modes of usage could be discovered. In the second part, conducted on different day than the first part, users were again asked to use the powder(s) during cooking and/or eating. This time however, a short list was provided with suggested applications for the powders (see appendix 5). If any of the suggestions had already been used in the first test, the users were asked to choose a different application.

After the tests, the users were interviewed using the following questions (amongst others):

- How did the powders fit in the cooking routine?
- Why were the powders used in the ways chosen?
- How was the flavour experienced?
- Would the powders be fit for regular use?
- What other concerns or problems occur with the use of vegetable powders?

Figure 23 An example of a flavouring sachet as used in Dutch households. Contains salt, dried vegetables and spices.

Figure 24 50ml pots with vegetable powder. The first two contain beetroot and tomato powder respectively.

Figure 25 Professional dehydrator used to make the testing powders. Due to its size, large batches could be made quickly.

Figure 26 Filled coffee grinder used for the testing powders.

RESULTS

When asked about their expectations, users remarked that they did not expect that flavours would be very pronounced, since the powders had no strong smell [which is due to the dried nature of the powder]. As the first test was an open assignment, one user used the powders to flavour pasta water (figure 27), one added the powders to mayonnaise (figure 28) and one to [tomato] pasta sauce. The user who added the powders to mayo, did so to find out what the flavour impact would be; the other two users applied the powders to discover the flavour of the powders as is. The user who used it in the pasta sauce reduced the amount using herbs and spices in the subsequent cooking of the meal.

Users report that the powders resulted in a "rich flavour" and two testers were surprised with the potency of the powders and its effect on the dish.

During the second test the applications were as: an addition to soup [two users] (see figure 29) and as replacement for fresh vegetables in a lasagne. As the users were familiar with the powders, they felt confident in using them. Again, the resulting dish was said to be "enhanced" and "full of flavour", providing added flavour that was "easy to use".

When asked what benefits the powders could have for them, users mentioned flavouring dishes, increase cooking enjoyment, preventing food waste, and adding colour to dishes. The users were less convinced about the nutritional value of the powders. Yet as an added benefit, the person that used the powders instead of fresh vegetables in a lasagne mentioned that it took less time to thicken the sauce.

The users all used around a levelled tablespoon with each preparation without having had instructions on how much to use. One user stated that he found it quite hard to figure out how much to use.

The users were asked to rate aspects of the powders and their potency to: flavour dishes, prevent food waste, provide nutrition, and increase cooking enjoyment. Virtually all responses were positive, i.e. the powders would present benefits to each marked aspect, with the exception of the added nutrition, where one user was doubtful that the powders could provide this. This mostly stemmed from the unfamiliarity with the effects that the drying process has on the nutrients in the vegetables.

When asked if they would consider making these powders themselves using peels and other vegetable scraps, the users all responded positively, stating that it would be feasible if the process is quick and the tools needed were small and easy to use.

In the two weeks that followed after the interview, the users themselves asked if the powder pots should be returned. Surprisingly, all users had emptied the jars and used the all of the powders [the biggest portions even after having conducted the test].

CONCLUSIONS: SECOND USER TEST

Overall the users were very positive towards the powders. That the participants finished all the powder, after completing the test illustrates their inclination to use the powders. Yet some issues were brought to the attention that will need to be tackled in the final detailing phase.

Figure 26 Celery powder being added to boiling pasta water, seemingly with a knife.

Figure 28 One user mixed different powders with butter to make a 'veggie spread'.

Figure 27 Leek and tomato powder are added to mayonnaise.

Figure 29 Beetroot and carrot powder are added to chicken soup.

QUANTITY

Vegetables are around 90% water, causing their powdered form to be significantly smaller in size. For instance a heaped tablespoon of beetroot powders is about one large beetroot. Because some vegetables have a high sugar [e.g. root vegetables] or salt content [e.g. celery], their effect on a dish can be significant. This should be taken into account when designing the way the powders are applied in the kitchen.

NUTRITION

Participants were sceptical about the nutritional value of the powders. Effects on nutritional value of vegetables in any cooking method, depends on the state in with the food is prior to processing. In section Concept evaluation (page 36), the effects of drying on the nutritional value is further discussed.

APPLICATIONS

The powdered vegetables added to virtually any meal. The participants had no problem in using the powders without instructions, yet less adventurous home chefs might find it challenging to use the powders. Similarly the function of the powders might not be the same as the function of their fresh counterparts. Two of the participants used the powder as a substitution, once as fresh vegetables and as herbs and spices. Technically, the powders could be used as a replacement of part of the fresh vegetables, but they are not intended to replace vegetables fully. Herbs and spices on the other hand should still be used in compliment to the powders for optimal flavour. As both herbs, spices and vegetable powders are dry powders, they can be most naturally used in conjunction. The final product should not only be able to make powders, but also clarify the role of the vegetable powders in cooking to the end users.

STORAGE

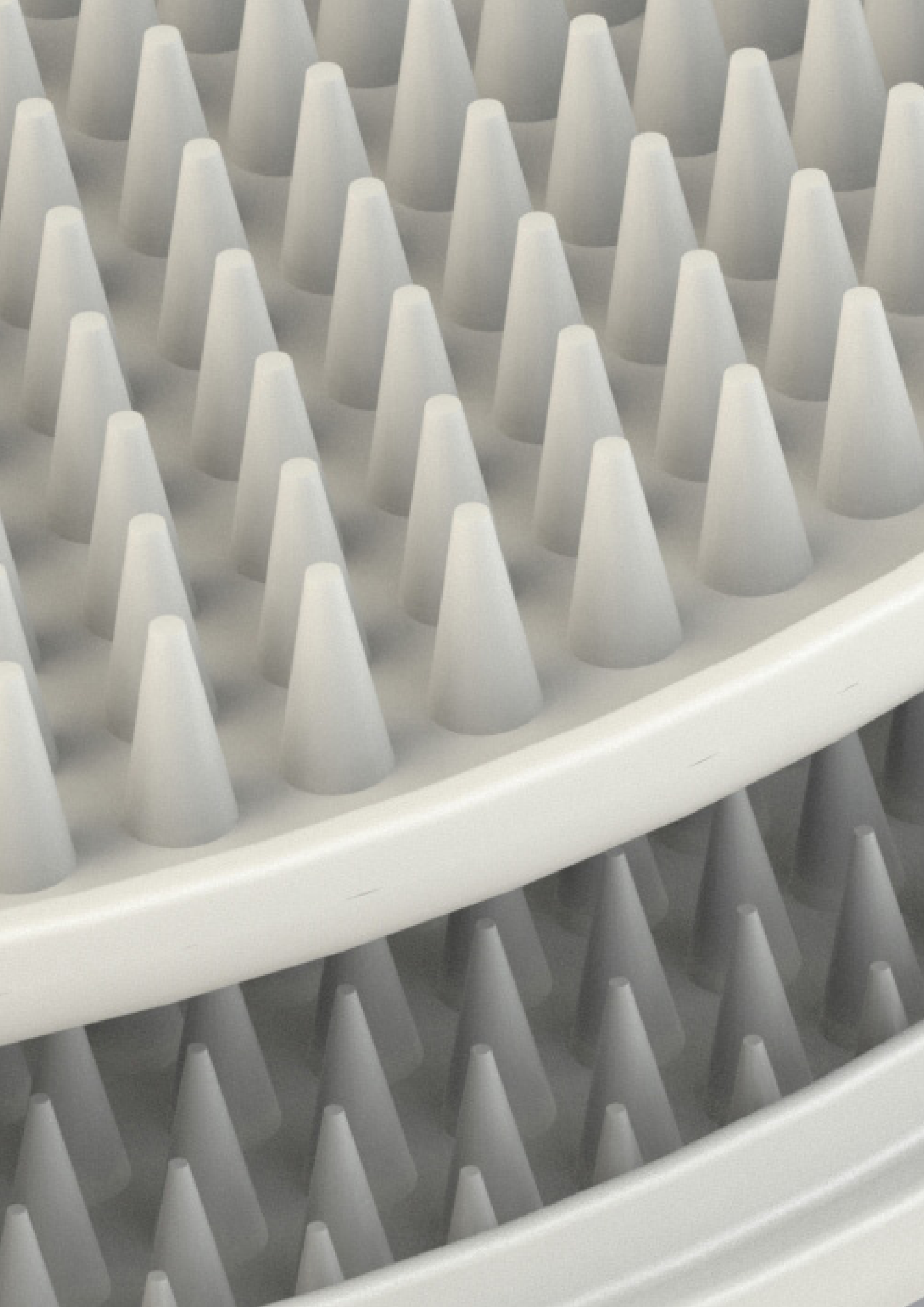
One of the participants was unsure about the shelf life of the powders. This would of course be dependent on the storage methods as the powders are affected by moisture, oxygen, and UV light. So in the next phase it will be important to take these concerns into account when designing the final vessels the powders will be stored in.

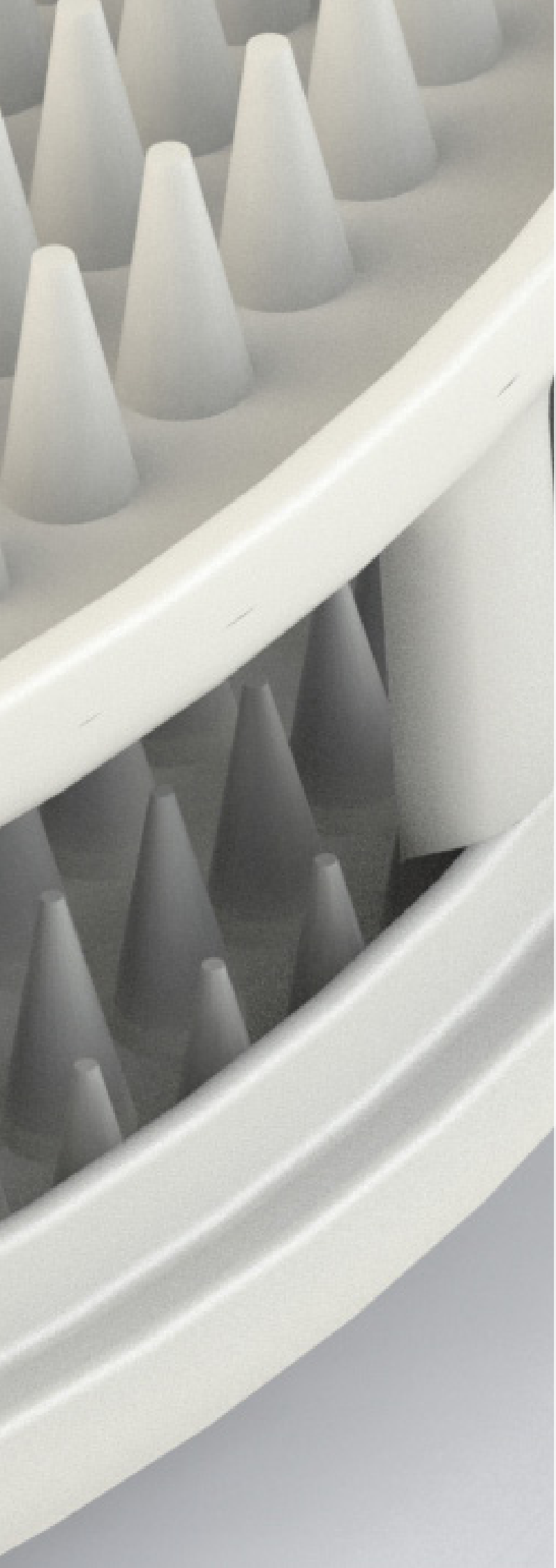
MAKING THE POWDERS

The users were excited and expressed enthusiasm to use these powders at home. One of the users was even surprised the powders were not yet readily available in the shops. The main advantage of the powders for the users was the added flavour and their ease of use. Yet they also expressed difficulty in using the right quantities in the dishes, but was expressed after using the powders the first time.

CONCEPTING CONCLUSIONS

The user test revealed a general enthusiasm about the powders, together with potential issues and concerns related to the use of vegetable powders. Overall the use of powders showed promising results. Participants were positive towards the applications and flavour of the powders. Key concerns when finalising the product have to focus on how the powders can be integrated into home cooking, how to dose properly, how to facilitate ease of use, how to store the powders appropriately, and how to fit the product into the kitchen space.





DETAILING

INTRODUCTION

In this section the powder grinder goes through further refinement as it goes from concept to final design. By doing so, the design will become more user friendly a more attuned to the context of family homes. With the third user test, the design is tested by a selection of possible end users. The section will end with recommendations derived from the user test and an evaluation.

CONCEPT DEFINITION

PARTS

The product consists of three parts being the two grinding discs and a cap for easy filling. In figure 30 the elements can be seen apart from each other. The diameter of the grinder is 200mm.

USAGE OF THE PRODUCT

To have an idea on how the product it is best to see it in operation. It starts by layering the scraps onto the two main parts (figure 31). After drying in an oven set to 60 degrees and cooling down, the grinder is closed (figure 32). The grinding is done by rotating the leavers (figure 33). After opening the grinder, the cap can be placed on the bottom part (figure 34) so the powder can be tranfered onto it by flippig the grinder over (figure 35). Now the powder can easily be put into a container for future use (figure 36).

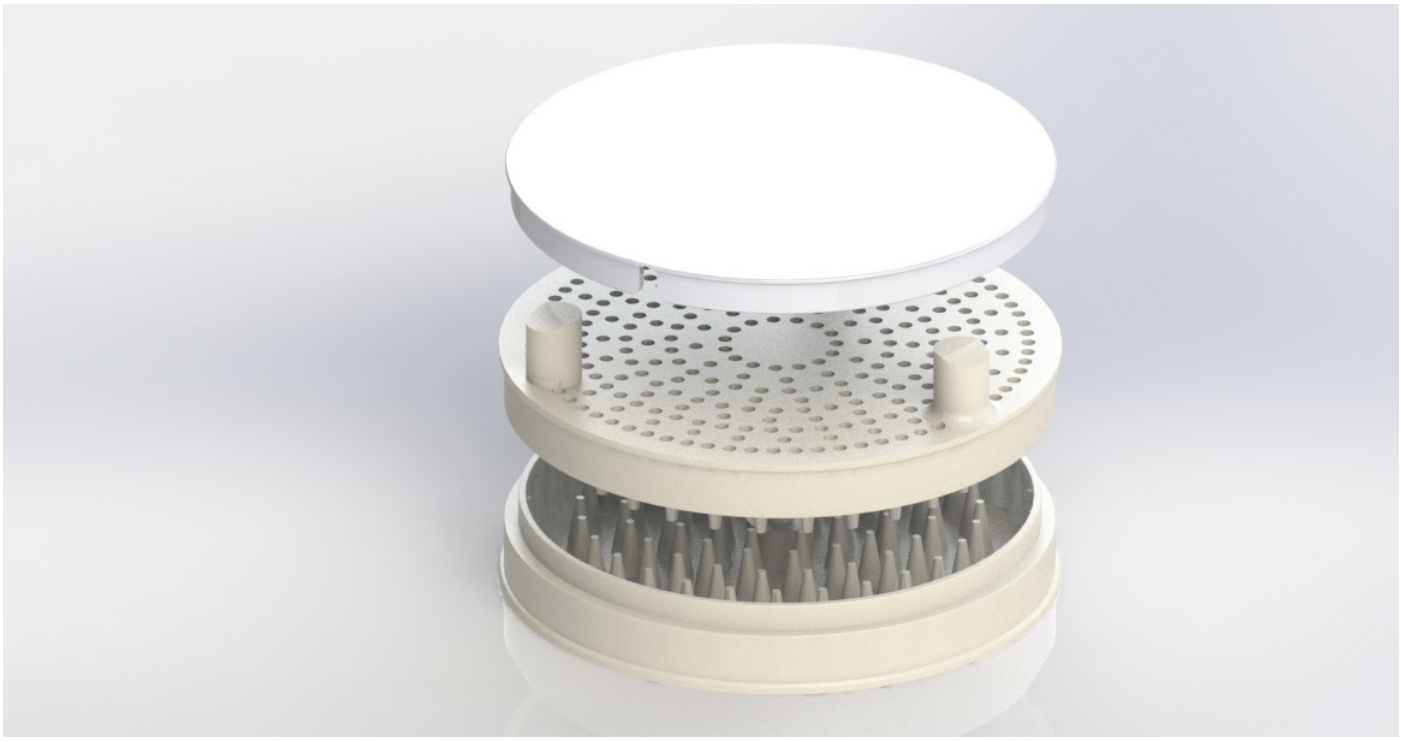


Figure 30 Grinder comprising of three parts. Starting at the bottom are the two grinding and drying parts, followed with the cap on top

Figure 31

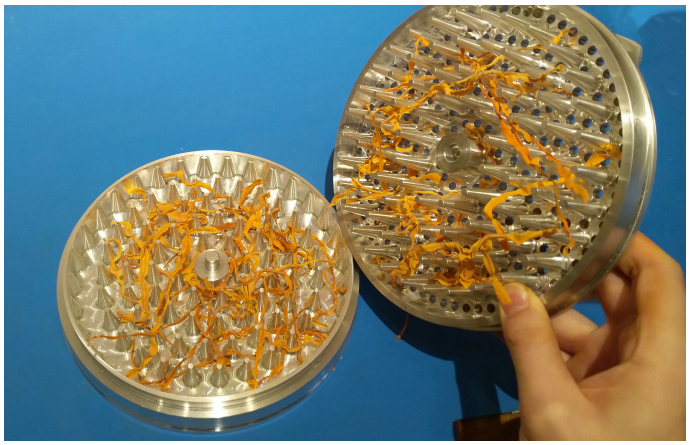


Figure 32

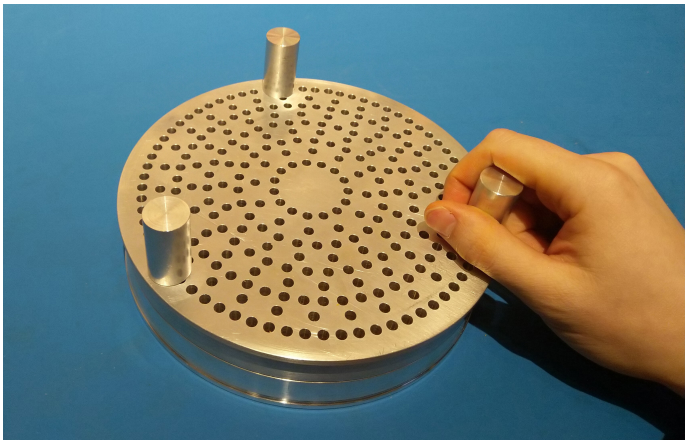


Figure 33

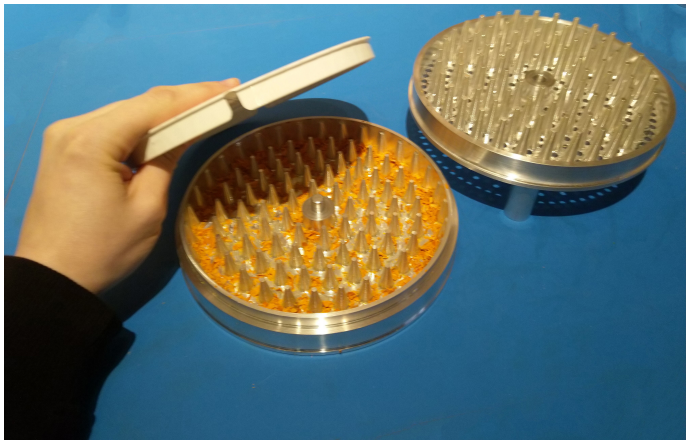


Figure 34

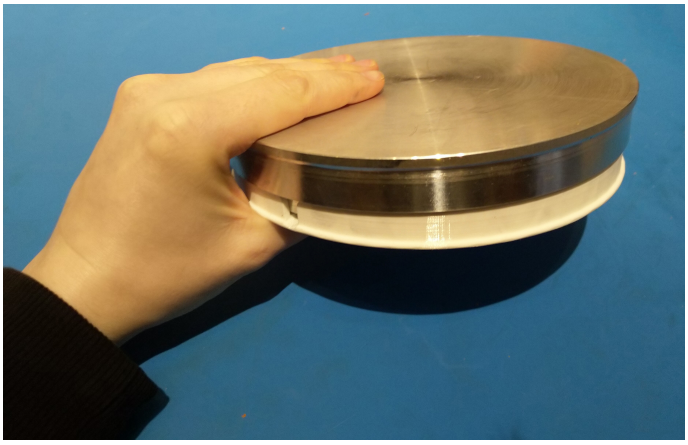


Figure 35

Figure 36

FUNCTIONAL TESTING

To test out the functional performance of the grinder a prototype was manufactured suitable for testing. Restrictions on heat resistance, price, and food safety of the material, did not allow us to create a prototype using simple 3D printing (as mentioned in the preceding). Therefore aluminium (a cost effective, heat resistance, and foodsafe alternative) was selected to make the prototype by means of milling.

The aluminium prototype was first tested on carrot peels (see figure 37). Due to the coarse geometry of the grinding teeth, the strips of peel would fall through to the bottom instead of balancing on the protrusions. This is not desired as it will block air circulation around the peel which hampers drying. The grinder was placed in a 60°C oven until the peels were determined dried enough for grinding (so they would be crushed rather than squashed) after 40 minutes. After a five minutes cool down period, the grinder had reached room temperature and was gyrated to pulverize the carrot peel (see figure 38 and 39).

The peels were successfully ground into a coarse powder that constituted of fine (<3mm) to larger (≤7mm) shreds (see figure 40). The occurrence of these relatively large bits are probably due to distance between the gyrating teeth of the grinder. The distances between the teeth were constrained by the manufacturing method of the prototype, as the milling process did not allow the teeth to be placed closer together. Earlier trials using a commercial 'herb grinder', yielded a much finer result as can be seen in figure 40.

To enable the grinder to process the peels into a finer powder, smaller and tighter fitting teeth will be applied in the subsequent iterations.

Figure 37

Figure 38

Figure 39

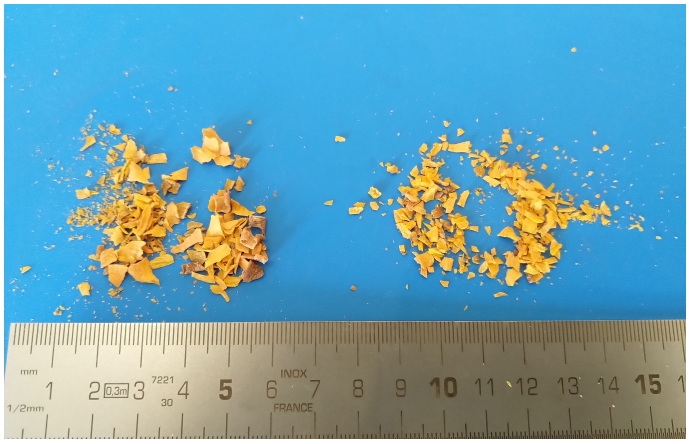


Figure 40 Carrot peel ground with the aluminium prototype (left) and the 'weed grinder'.

ITERATIONS

MATERIAL

The material the product will be made out of will have to meet certain restrictions and requirements regarding the price, the maximum servicing temperature of the product, food safety, and processability. To create the intricate shape of the grinder while preserving a refined surface finish, injection moulding or die cast moulding will be processing methods of choice. Hence, plastics and some alloys will be considered as materials the grinder can be made out of. During the use, the product is subject to temperatures typically between 50 and 60 degrees Celsius, but up temperature can reach up 250 degrees if the oven is not properly configured. Thus, the product must withstand these temperatures, to anticipate proper functioning even after improper usage. Aluminium and zinc alloys will qualify, together with the high performance plastic PEEK. PEEK is unfortunately rather expensive and will not be economically feasible due to its relatively high cost (see appendix 6a).

Out of the remaining alloys, Zinc-Aluminium alloy 7 has the best specifications and with chosen as material of choice, keeping food safety in mind (see appendix 6).

This section covers the changes the grinder concept has been subject to during the detailing phase. During the iterations, the design was named suitably and additional features were added to make the grinder more suitable for household use.

NAME

The design has been named 'the Zesturn'. The name is a symbiose from the words 'zest' and 'turn', referring to the action of scraping off the peel ('to zest') and subsequently turning of the device ('to turn'), capturing the very essence of the device. Moreover, the word 'zest' has the additional meaning of 'flavour' and a beneficial connotation that indicates enthusiasm, two nouns that have characterized the vegetable powders by the participants in the testing phase.

GRIP

Due to the size of the of the Zesturn, the grinding will commence, after sufficient cooling down, by placing the product on a flat surface such as a kitchen counter. To prevent the Zesturn from skidding over the counter, a silicone strip (heat resistant) is added to the bottom of the design, see figure 41.

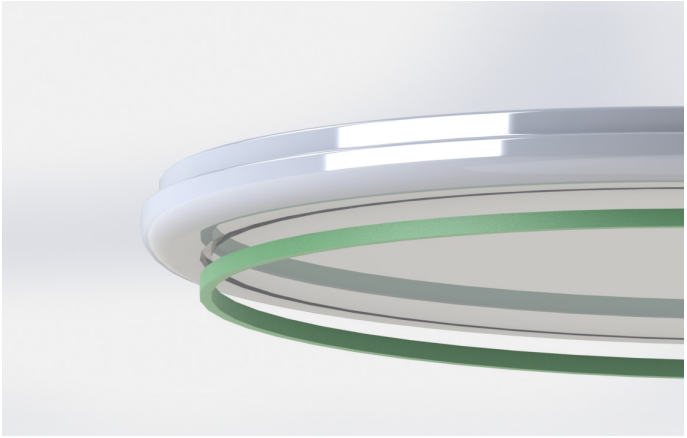


Figure 41 The Zesturn as seen from below. The silicone ring (green) fits in the circular slid.

RESIZING

The first prototype of the Zesturn turned out very bulky and hefty. Even though the weight of the product did give a nice handling and feel to it, it was clear that it had been over dimensioned for its purpose. By decreasing the length of the grinding teeth, the height of the Zesturn can be significantly reduced to a third the size of the prototype. Moreover, reducing the size of the teeth has the added benefit of increasing the fineness of the powder produced. As can be seen in figure 3, the flakes become trapped in between the spikes during the grinding procedure, which prevents them from being ground finer. Hence, the fineness of the resulting powder is determined by the size of the voids in between the grinding teeth, which in turn is set by the separation of the top and bottom grinding teeth and their length. The spikes were first put on a circle with 7mm in between each, they are now a mere 2.5mm apart. This should result in flakes of around maximum 2-3 mm in size.

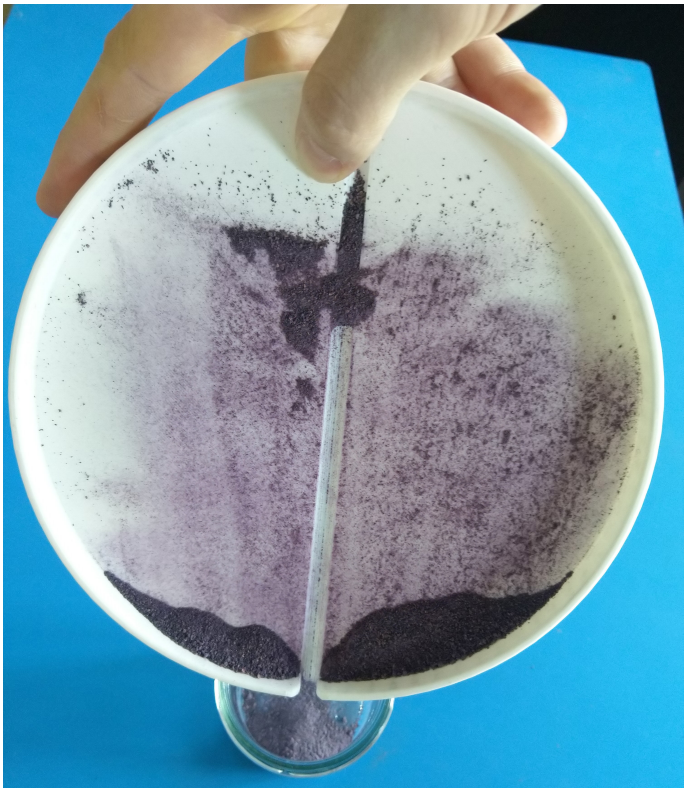


Figure 42 Powder of red cabbage that slides into the jar using one of the jars openings. [The 3D printed cap lacks the flexibility to bend much further without breaking.]

FILLING CAP

Once the vegetables are ground in the ZesTurn, they need to be transferred into a vessel for future use. To enable this, a cap is used that fits the bottom part of the grinder. By removing the top set of grinding teeth and capping the bottom set with the filling cap, the Zesturn can be flipped over and the powder will fall into the cap. The cap has a living hinge so it can be folded at a slight angle that allows the powder to slide right into the vessel without spilling (see figure 42).

LIFTING SUPPORTS AND AERATION

To accommodate the Zesturn into a small oven, both top and bottom parts can be placed on top of each other (in opposite configuration) for the drying of the peel. To allow hot dry air circulation through the Zesturn, the upper part must be supported onto the bottom part with some clearance. The supports rest on the rim of the lower part to prevent damage on the teeth while drying. To further enhance the airflow, aeration holes were included in the top part of the concept design. These aeration holes however might not have a large impact on the airflow, as many ovens already have some air circulation of their own. Even though for mass scale production, the aeration holes will save material, for prototyping the hole constitute an extra processing step and are thus omitting in the prototyping stage. Therefore the holes are left out in the final design.

FINAL DESIGN

The final design of the Zesturn features the two grinding and drying parts, made of aluminium-zinc alloy, supported with a cap made of PC to support the usage of the product and to protect the supports during storage (figure 43).

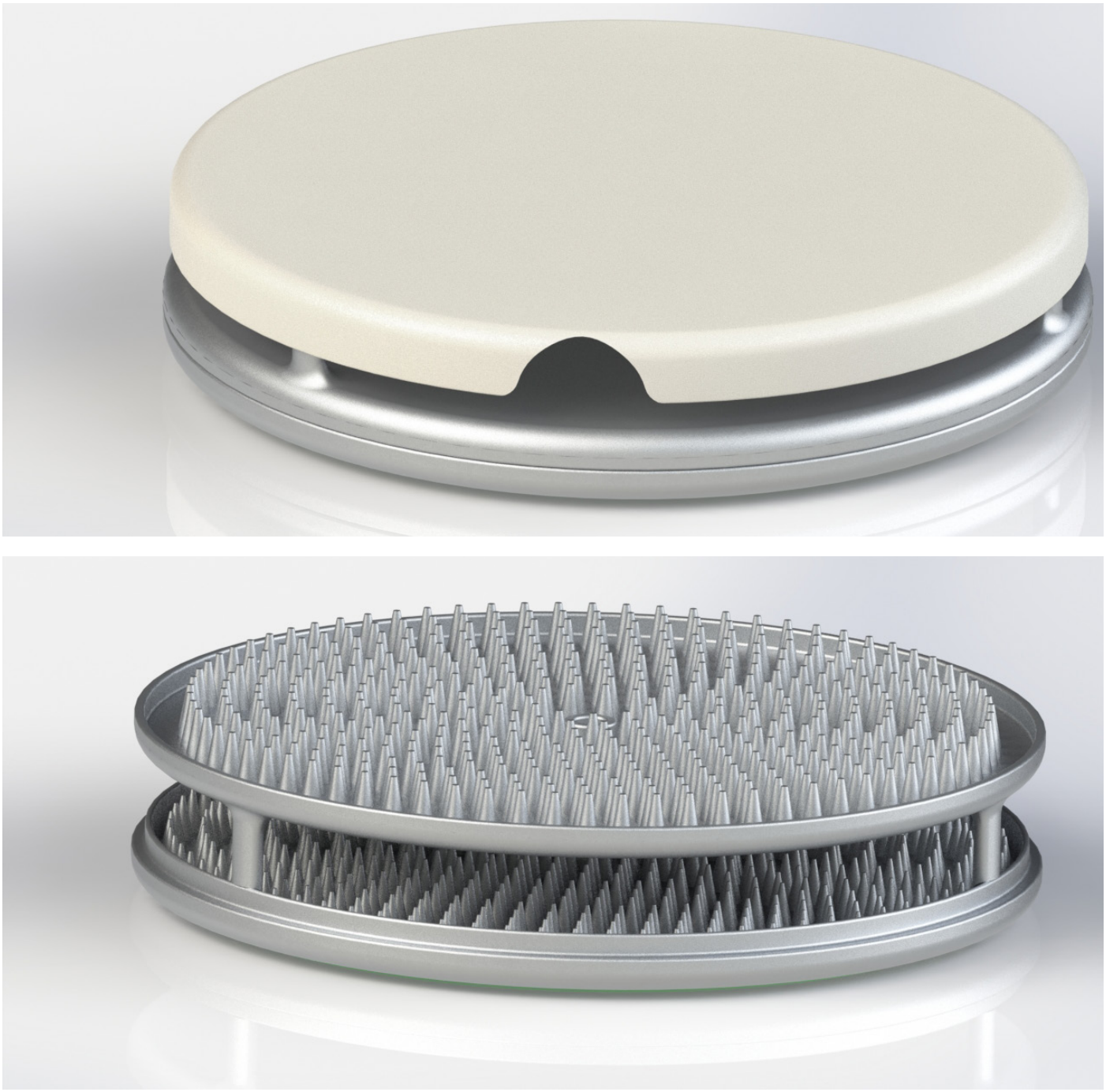


Figure 43 Renders of the final design of the Zesturn.

COSTS

To have an idea about how costly the Zesturn would be, a rough calculation is made. For this calculation, the material costs are calculated using the 3D model in the program Solidworks. The tooling costs have been calculated using an online cost estimator (custompartnet.com). One of the key starting points being the batch size, it is assumed for this calculation that 10.000 units would be produced. These would be bought by a quarter percent of the roughly four million 3+ person households in the Netherlands (CBS, 2018). The production costs are comprised of tooling costs for the three parts and the material costs.

Tooling Zinc-Aluminium parts €85.000
Material costs Zinc Aluminium €39.000
Tooling PC cap €18.000
Material costs PC €2.900
Total costs €144.900
Per unit € 14,49

As the cost per unit would amount to around €15,- the retail price would be between €60 and €75. Considering the price and the novelty of the product, it would befit specialised kitchenware stores such as Kookpunt and Oldenhof.

USER TEST III

This final user test serves to finetune the concept design to the needs of the target user group. As most family households will not be used to the powdering of vegetable scraps and the use thereof, it is critical that the design of the product helps them to incorporate this process in their daily cooking routines.

PARTICIPANTS

One family that participated in the second user test was found prepared to participate in this follow up test. The adults of this family consciously strive to minimize food waste and show particular curiosity as to how the vegetable powders can be made at home using scraps.

RESEARCH QUESTIONS

The usability of the Zesturn design is tested through direct application of the product in home cooking. The task encompasses the several proceedings that the user will have to follow when using the Zesturn, whilst being directly observed by a researcher. The presence of the researcher during the test allows direct observations of explicit thoughts and experiences of the users, which will be the basis for the final adjustments and recommendations to the product. The main questions that on which the research is focused are:

- Do the participants understand the instructions?
- Can they fill the grinder correctly?
- Is the drying procedure executed correctly?
- Are there any issues with the grinding?
- Is the storage container easy to fill?
- How do the users feel about the interaction with the product?
- Do the users have any concerns regarding the product?

PROCEDURE

In this test the participants are asked to create vegetable powders using the vegetable trimmings that are made during a dinner preparation. The test will consist of the following steps:

1. Explanation of the concept;
2. While prepping vegetables, participants cut the trimmings into thin strips;
3. Trimmings are placed onto the grinder;
4. Grinder is placed into the oven (as soon as it is available) on 50-60 degrees for an hour;
5. Vegetables trimmings are checked and taken out if dry;
6. Grinder is taken out and left to cool;
7. Dried trimmings are ground into powder;
8. Powder is placed into the container;

After the tasks are completed, an evaluation with the participants is held to locate elements in the design that need improvement.

RESULTS

The vegetables that were used during the dinner preparations were leeks, parsley, and celery. During the prepping, the tops of the leeks were set aside along with trimmings of the celery and some surplus sprigs of parsley (see figure 44).

The scraps were collected on the two halves of the prototype and were left until the oven, in use for baking an oven dish, was available. After the oven dish was finished and taken out, and the food was placed on the table, the oven was set to 60 degrees and left to cool (cooling down from the original 180°). Subsequently, the grinder with vegetables was placed in the oven (see figure 45).

After dinner (taking ~40 min), the grinder was removed from the oven out to check if the scraps were dry. The vegetables were considered thoroughly dried, and the grinder was left (for 8 min) to cool down on the countertop. Once cooled, the vegetables were ground and transferred onto the cap. The coarseness of the ground vegetables varied greatly. The parsley and the celery were successfully ground into small flakes but the leeks were unacceptably coarse. Nevertheless, the test user seemed extremely content with the product and was intrigued and impressed by its abilities and simplicity. This originated partially from the weight and overall aesthetics of the prototype. The product was found to be potentially useful, but a desired for a large capacity was expressed.

During this process, the following issues were identified:

- The leek tops did not all fit onto the grinder due to its limited surface area;
- The two halves had to be placed separately into the oved due to the weight of the prototype (too heavy to put in place with one hand);
- Taking the grinder out of the oven was cumbersome as the hot parts had to be taken out with a potholder;
- While the device was cooling down, the vegetables were able to slightly rehydrate due to the high humidity in the kitchen. This was partially caused by the dishwasher being opened up after a cleaning cycle thus expelling steam;
- Especially the thin leek tops were able to rehydrate which resulted in large flakes (10x50 mm) after grinding;
- The participant stated that the prototype was difficult to handle due to its weight.

Figure 44 Celery stalks being trimmed. Leek trimmings are already placed on the bottom of the prototype.

Figure 45 Prototype is positioned into the oven, one part at a time.

DETAILING CONCLUSIONS

The prototype's substantial weight (2Kg) has to be reduced. The weight of the redesign has been reduced significantly to less than half (850g) of the original prototype, which should result in easier handling while using the product. Nevertheless, the new weight could still prove too heavy for some users and hence the handling can still be a challenging for some. Further weight reduction is thus recommended as weight reduction can improve usability and additionally reduce material production costs.

The surface area of the prototype was determined insufficient, as not all the trimmings of one night's cooking fitted on the grinder. Thus it is advisable to increase the usable surface area of the product. The participant stated that the amount of trimmings that was generated corresponded to a typical amount of daily vegetable scraps. So in order to better serve the needs of the end user, a redesign where the surface area is increased is required.

To facilitate handling of the product when it is hot, the addition of handles is desirable or the use of a different material for the grinder altogether. Moreover, a product that is not hot to the touch or cools faster, will facilitate the grinding of the scraps into powder significantly.

The cooldown of the product is currently too long and should be decreased. The long cooldown time allows the dried vegetables to rehydrate from the moisture in the air. Especially as kitchens can have a high humidity level due to e.g. cooking and dishwashers, it is critical to expose the dried vegetables as little as possible to this atmosphere before grinding such that they can be ground optimally.

Except for the leeks, the test produces small flakes showing a promising result as the final product would yield even finer results because the grinding teeth are spaced closer together in the redesign.

FINAL CONCLUSIONS

This report describes the process from concept invention to prototyping and prototype testing of the Zesturn, a device aimed to reduce food waste in households and enhance home chefs to enhance their cooking. Through converting vegetable trimmings and leftovers into vegetable powders, otherwise disposed parts of produce can be efficiently repurposed into flavour enhancers, reducing food waste whilst enhancing the cooking palette available to the home chef.

The issue of food waste is currently a hot topic. Literature research reveals that food waste causes a large economic loss in society, weighs substantially on our carbon footprint, and triggers sensations of guilt to consumers. Analysis of academic records and context mapping in family households revealed that little is yet in place to tackle this problem at its largest excess: the waste of vegetable produce (leftovers and trimmings) at the household level. While the causes for wasting vary significantly and are by no means uniform, a clear need for a tool aimed at food waste prevention at household level was identified and deemed extremely promising.

From the context factors determined from the earlier analysis, concepts were developed. Vegetables and trimmings have a high nutrition value and hence transforming these discarded parts into ready consumables would be the most natural way of combating wasting. This left an appliance that could transform the vegetable scraps into either soup or powder as most promising options. Finally powdering proved more versatile and effective, after careful consideration of each concept device among selected criteria: ease of use, applicability, kitchen space usage, energy efficiency, shelf life, and innovativeness.

The final design is a tool that enables the drying of vegetable scraps in a household oven and subsequent grinding of the dried scraps. These ground up vegetable powders are saved for further use as flavourings to dishes. A second user test revealed that most home chefs in Dutch households are new to the concept of vegetable powders and are not accustomed to handling them. Users demonstrated a keen interest after an brief introduction to the powders and a willingness to use them, despite their uncertainty about proper use of them. Users discovered these powders to have additional value to cooking and the dining experience and developed a positive attitude towards them.

The final test involved an actual use of a Zesturn prototype in a kitchen household. The test was successful, where dried vegetable peelings of parsley and celery and tops of leek were efficiently ground to powder after drying. Several aspects of the Zesturn required improvement as the product's size and handling were somewhat ill conceived by the user. Despite these minor points of attention, the participants of the different user tests responded extremely positively to the use of the product and the application of the vegetable powders during dinner preparation. These results are encouraging and can be used to further develop the Zesturn into a mature product.

RECOMMENDATIONS

The user tests conducted in this report show promising results, but do by no means represent a finished product. More research and development will be required if the Zesturn is to be developed into a product for larger scale production. Time restriction have limited the number of iterations the concept product has been subject to, and further iterations are left to future work. The following recommendations can be used as a starting point for this.

As mentioned as feedback from the final user test, within the family household more vegetable scraps are generated on a typical day than can be currently fit onto the Zesturn. A larger surface area of the device should be considered. Where the diameter of the grinder is now 200mm, a 300mm diameter would be more fitting, more than doubling the surface area available for drying and grinding. The drawback of a larger Zesturn is that it would become significantly heavier, possibly making the product harder to handle as the concept was on the heavy side already. Using a different lighter material to fabricate the product from would mitigate this problem.

Making the Zesturn out of the Zinc-aluminium alloy, similar to the material the prototype was made out of, comes at a price. Production and material costs would be much lower if the used material would be manufactured from PC or Bakelite. These two materials would have disadvantages in terms of maximum servicing temperature and brittleness respectively. Further research on this should be conducted to select the best material, where also cost effectiveness and a minimized cooling period after drying should be considered. The cooldown time proved important as the dried vegetables can rehydrate with moisture in the air, resulting in bad grinding performance and decreased shelf life.

To help the end users with the application of the ground powders, users will most certainly benefit from a cookbook that explains and suggest uses of the ground powders. As the use of such vegetable powders would be new to most households, some guidance could prove essential for the success of the product.

REFERENCES

Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Barceloux, D. G. (2009). Potatoes, Tomatoes, and Solanine Toxicity (Solanum tuberosum L., Solanum lycopersicum L.). Disease-a-Month, 55(6), 391–402. https://doi.org/10.1016/j.disamonth.2009.03.009

Barrett, D. M. (2007). Maximizing the Nutritional Value of Fruits & Vegetables. Food Technology, 61(4), 40–44. Retrieved from http://www.fruitandvegetable.ucdavis.edu/files/197179.pdf

Bektes, A. (2010). Research and product design to minimize food waste in western domestic kitchens. TU Delft & Middle East Technical University.

Bell, S., Becker, W., Vásquez-Caicedo, A. L., Hartmann, B. M., Møller, A., & Butriss, J. (2006). Report on Nutrient Losses and Gains Factors used in European Food Composition Databases.

Boll, D. (2016). Consuming food instead of wasting. TU Delft.

Carletto, G. (2016). Sustainability and food waste reduction in the kitchen. TU Delft.

CBS. (2018). Huishoudens; samenstelling, grootte, regio, 1 januari. Retrieved January 2, 2018, from http://statline.cbs.nl/statweb/publication/?vw=t&dm=slnl&pa=71486ned&d1=0-2,23-26&d2=0&d3=0,5-16&d4=(l-1)-l&hd=090402-0910&hdr=t,g3&stb=g1,g2

Cheng, M. (2017, January). How the Hawaiian poke bowl became the world's new fast food. HAWAI'I Megazine. Retrieved from https://www.hawaiimagazine.com/content/how-hawaiian-poke-bowl-became-worlds-new-fast-food

de Vrijer, T. (2016). Policy options for sustainable protein consumption in the Netherlands. TU Delft.

Dijksterhuis, A., Smith, P. K., Van Baaren, R. B., & Wigboldus, D. H. J. (2005). The unconscious consumer: Effects of environment on consumer behavior. Journal of Consumer Psychology. https://doi.org/10.1207/s15327663jcp1503_3

Erbach, G. (2018). EU Legislation in Progress CO 2 emissions from aviation.

Evans, D. (2012). Beyond the Throwaway Society: Ordinary Domestic Practice and a Sociological Approach to Household Food Waste. Sociology, 46(1), 41–56. https://doi.org/10.1177/0038038511416150

Go, E. (2017). Veggie Table. TU Delft.

Haraminac, E. (2017). Cooling hot food, do it right to prevent bacterial growth. Retrieved from http://msue.anr.msu.edu/news/cooling_hot_food_do_it_right_to_prevent_bacterial_growth

HLPE. (2014). Food Losses and Waste in the Context of Sustainable Food Systems. A Report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. https://doi.org/65842315

Janssen, A. M., Nijenhuis-de Vries, M. A., Boer, E. P. J., & Kremer, S. (2017). Fresh, frozen, or ambient food equivalents and their impact on food waste generation in Dutch households. Waste Management, 67, 298–307. https://doi.org/10.1016/j.wasman.2017.05.010

Jevšnik, M., Hlebec, V., & Raspor, P. (2008). Consumers' awareness of food safety from shopping to eating. Food Control, 19(8), 737–745. https://doi.org/10.1016/j.foodcont.2007.07.017

Jiang, H., Zhang, M., & Adhikari, B. (2013). Fruit and vegetable powders. Handbook of Food Powders: Processes and Properties. Woodhead Publishing Limited. https://doi.org/10.1533/9780857098672.3.532

Jörissen, J., Priefer, C., & Bräutigam, K. R. (2015). Food waste generation at household level: Results of a survey among employees of two European research centers in Italy and Germany. Sustainability (Switzerland), 7(3), 2695–2715. https://doi.org/10.3390/su7032695

Kendall, P., DiPersio, P., & Sofos, J. (2012). Drying Vegetables. Food and Nutrition Series, 9.308(9). Retrieved from http://nchfp.uga.edu/how/dry/csu_dry_vegetables.pdf

Langley, J., Yoxall, A., Heppell, G., Rodriguez, E. M., Bradbury, S., Lewis, R., … Rowson, J. (2010). Food for Thought? - A UK pilot study testing a methodology for compositional domestic food waste analysis. Waste Management and Research, 28(3), 220–227. https://doi.org/10.1177/0734242X08095348

Meulendijks, A. (2016). Shopping Without Waste. TU Delft.

Mitchell, J. (2016). Millennials' Cooking Skills Gap. Retrieved from https://thecoopblogs.files.wordpress.com/2016/10/100055_coop_food_initiative_brochure_a4_aw_s1.pdf

Nutrient Data Laboratory. (2002). USDA Table of Nutrient Retention Factors, Release 5. National Academy Press, 18. Retrieved from www.nal.usda.gov/fnic/foodcomp/Data/retn6/retn06.pdf

Parfitt, J., Barthel, M., & Macnaughton, S. (2010). Food waste within food supply chains: quantification and potential for change to 2050. Philosophical Transactions of the Royal Society B: Biological Sciences, 365(1554), 3065–3081. https://doi.org/10.1098/rstb.2010.0126

Pesquera, R. M. (2017). The use of IoT principles for reducing food waste in the kitchen. TU Delft.

Phillips, B., Hughes, J., Phillips, J., Walters, D., Anderson, D., & Tahourdin, C. (1996). A study of the toxic hazard that might be associated with the consumption of green potato tops. Food Chem Toxicol, 34(5), 439–48.

Quested, T., Marsh, E., Stunell, D., & Parry, A. D. (2013). Spaghetti soup: The complex world of food waste behaviours. Resources, Conservation and Recycling, 79, 43–51. https://doi.org/10.1016/j.resconrec.2013.04.011

Quested, T., & Parry, A. (2011). New estimates for household food and drink waste in the UK. WRAP, (November), 1–19.

Rodgers, G. (2017). Nasi Goreng: Indonesia's Rice-Based Breakfast of Champions. Retrieved February 13, 2018, from https://www.tripsavvy.com/nasi-goreng-rice-based-breakfast-1629377

Roozenburg, N. F. M., & Eekels, J. (1998). Productontwerpen, structuur en methoden.

Rudin, D. (2017, April 21). Have Leftovers Gone Bad? The Atlantic. Retrieved from https://www.theatlantic.com/technology/archive/2017/04/have-leftovers-gone-bad/523854/

Sanders, L., & Stappers, P. J. (2012). Convivial design toolbox: generative research for the front end of design. Orbis Litterarum: International Review of Literary Studies (Vol. 61). Retrieved from http://www.gbv.de/dms/bowker/toc/9789063692841.pdf

Sebranek, J. G., & Bacus, J. N. (2007). Cured meat products without direct addition of nitrate or nitrite: what are the issues? Meat Science, 77(1 SPEC. ISS.), 136–147. https://doi.org/10.1016/j.meatsci.2007.03.025

Sharp, A. (2018). 13 Healthy Food Trends That Are Going Mainstream in 2018. Retrieved February 13, 2018, from https://greatist.com/eat/healthy-food-trends-going-mainstream

Spengemann, P. (2011). Reducing Food Waste in the Household Through Behaviour Change. TU DElft.

Stefan, V., van Herpen, E., Tudoran, A. A., & Lähteenmäki, L. (2013). Avoiding food waste by Romanian consumers: The importance of planning and shopping routines. Food Quality and Preference, 28(1), 375–381. https://doi.org/10.1016/j.foodqual.2012.11.001

Stenmark, Å., Jensen, C., Quested, T., & Moates, G. (2016). Estimates of European food waste levels. IVL-report C 186. https://doi.org/10.13140/RG.2.1.4658.4721

Thomas, A., & Garland, R. (2004). Grocery shopping: list and non-list usage. Marketing Intelligence & Planning, 22(6), 623–635. https://doi.org/10.1108/02634500410559015

Timmermans, T. (2018). Interview with Toine Timmermans. ARTE. Retrieved from https://info.arte.tv/de/node/201805

Ventour, L. (2008). The food we waste. Food Waste Report V2 (Vol. 2). Retrieved from http://library.wur.nl/WebQuery/clc/1944512

Voedingscentrum. (2018). Bestrijdingsmiddelen. https://doi.org/10.15713/ins.mmj.3

Wahlen, S., & Winkel, T. (2017). Household Food Waste. Food Science. Retrieved from http://edepot.wur.nl/415177

Wybenga, T. (2016). Respect Bread. TU Delft.

APPENDICES

APPENDIX 1

QUESTION LIST USED AS A GUIDELINE IN THE INTERVIEWS

1. Wat is de samenstelling van je huishouden?
2. Zou je een foto kunnen maken van je keuken?
3. Met welke keukengadgets werk je graag en waarom?
4. Wat zou je aan je keuken willen veranderen?
5. Is het koken in de jaren makkelijker geworden?
6. Plan je qua koken vooruit?
7. Zijn er gerechten die je regelmatig maakt?
8. Wat is het eten in een gemiddelde week?
9. Wat is het verschil tussen doordeweeks en in het weekend koken?
10. Maak je eten met wat je hebt (improvisatie)?
11. Hoe verwerk je rest groenten?
12. Wanneer vind je het leuk om te koken?
13. Wanneer (in de week) heb je juist geen zin om te koken?
14. Zou je een foto willen maken van de inhoud van je koelkast?
15. Als je ook op andere plaatsen eten opslaat, zou je die dan ook willen fotograferen?
16. Wat doe je met aangebroken producten? (bijv. halve tomaat, open blik, etc.)
17. Ben je in de laatste dagen hier anders mee omgegaan dan normaal?
18. Hoe zou je hier mee om willen gaan?
19. Wat heb je allemaal in je vriezer?
20. Is er altijd extra ruimte?
21. Hoe vaak doe je boodschappen?
22. Hoek kom je aan groenten en fruit?
23. Koop je voorgesneden/diepvries/vers/pot groenten?
24. Waar gooi je meer van weg?
25. Wat zou je graag thuis veranderen aan qua eetgewoontes? Meer van..
26. Wat houdt je tegen?
27. Wat zou je minder willen eten?
28. Waardoor gebeurt dat nog?
29. Wat heb je vandaag gekookt?
30. Wat is bij het maken daarvan aan afval ontstaan?
31. Wat is er anders gegaan tijdens het invullen van het boekje? (verleden/heden)
32. Hoe zou je hiermee om willen gaan?
33. Wat valt voor jou onder voedselverspilling? (klokhuis, schillen, nog goed/al bedorven)
34. Wanneer gooi je eten weg? (voorzie geen gebruik/bedorven)
35. Hoe ervaar je het weggooien van eten?
36. Wat doe je om het te voorkomen?
37. Welke groenten gooi je het meest weg?

38. Zou je geïnteresseerd zijn in een product waarmee je voedselverspilling mee kunt voorkomen?

APPENDIX 2

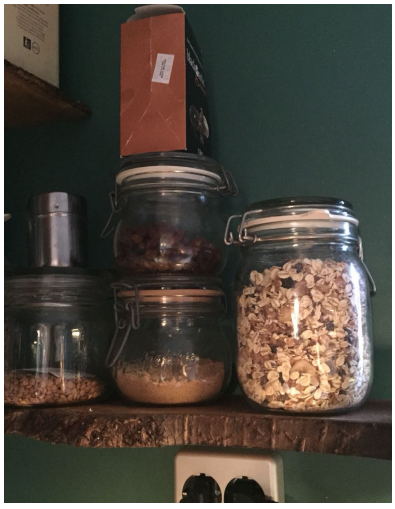
PICTURES FROM THE CONTEXT MAPPING

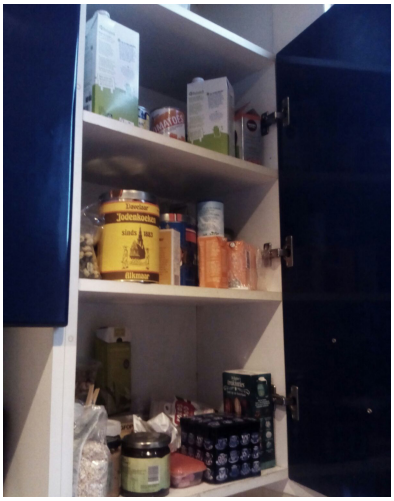










Miele

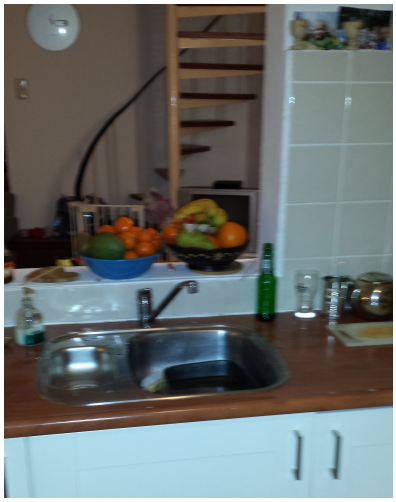


Piccolinis



Br. Hamburger
Pizza
Spag Tom


GREEK STYLE YOGURT
Milbona
GREEK STYLE YOGURT




COFFEE CREAM
BOER LAND

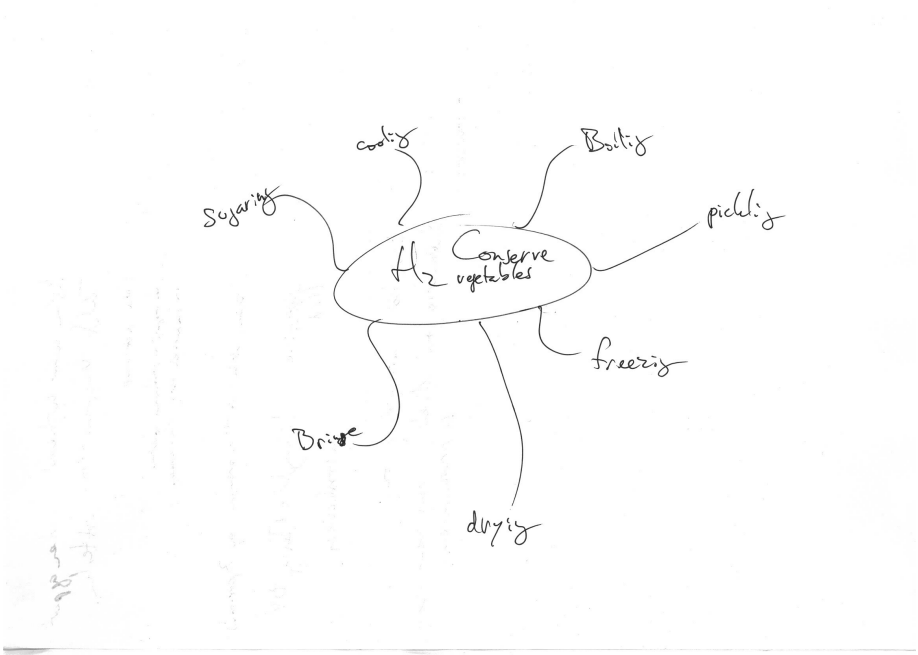

Modena
LUNGO
Bio
Tuc
Crispy

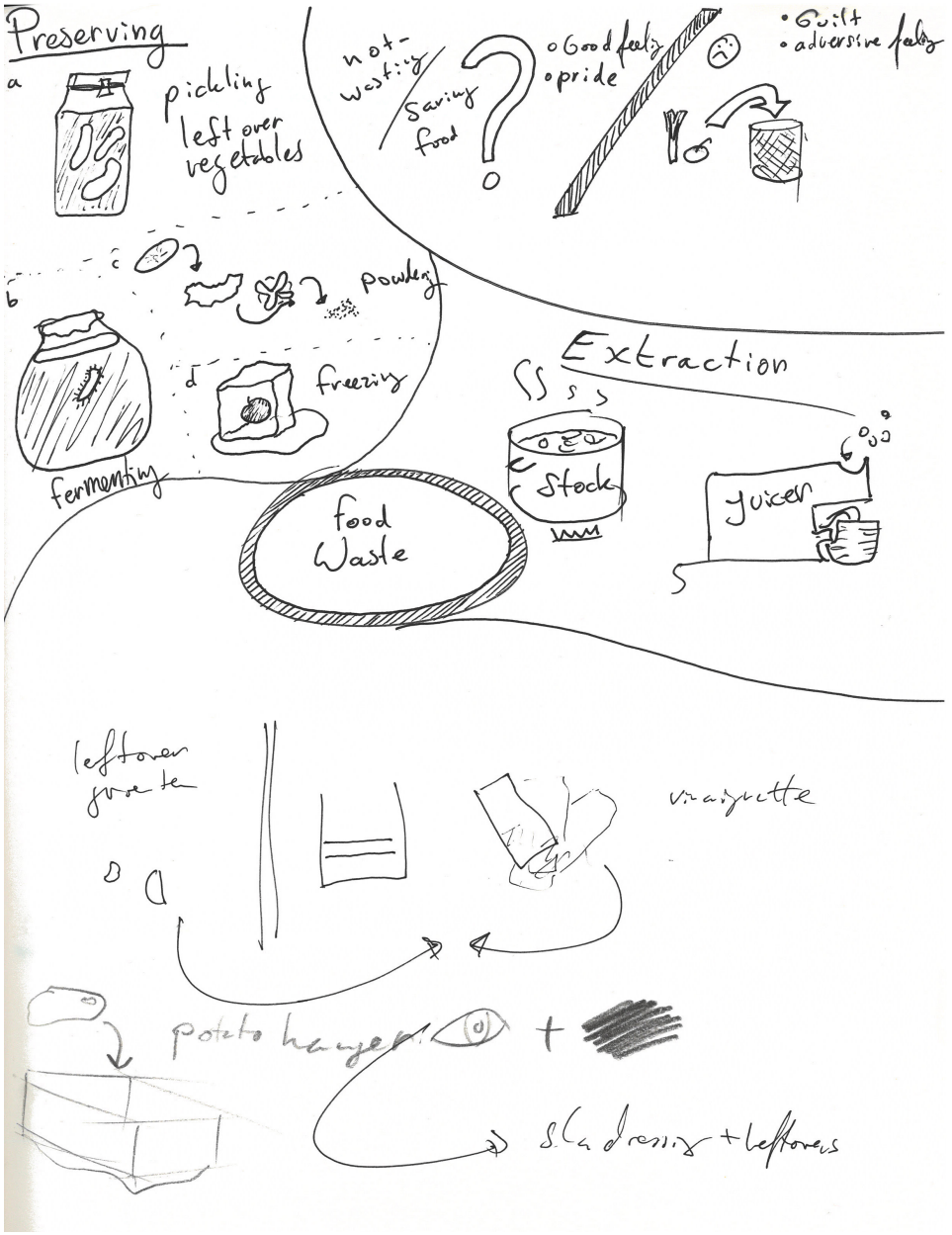

Winkel

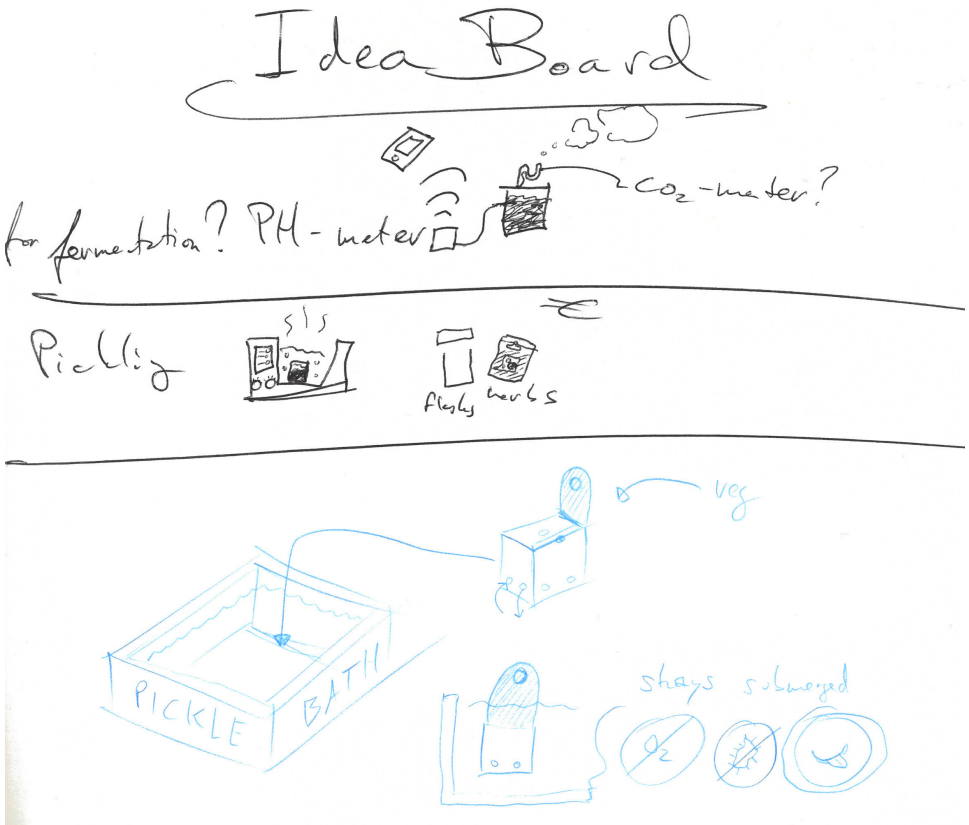

GREEK STYLE
YOGURT

APPENDIX 3

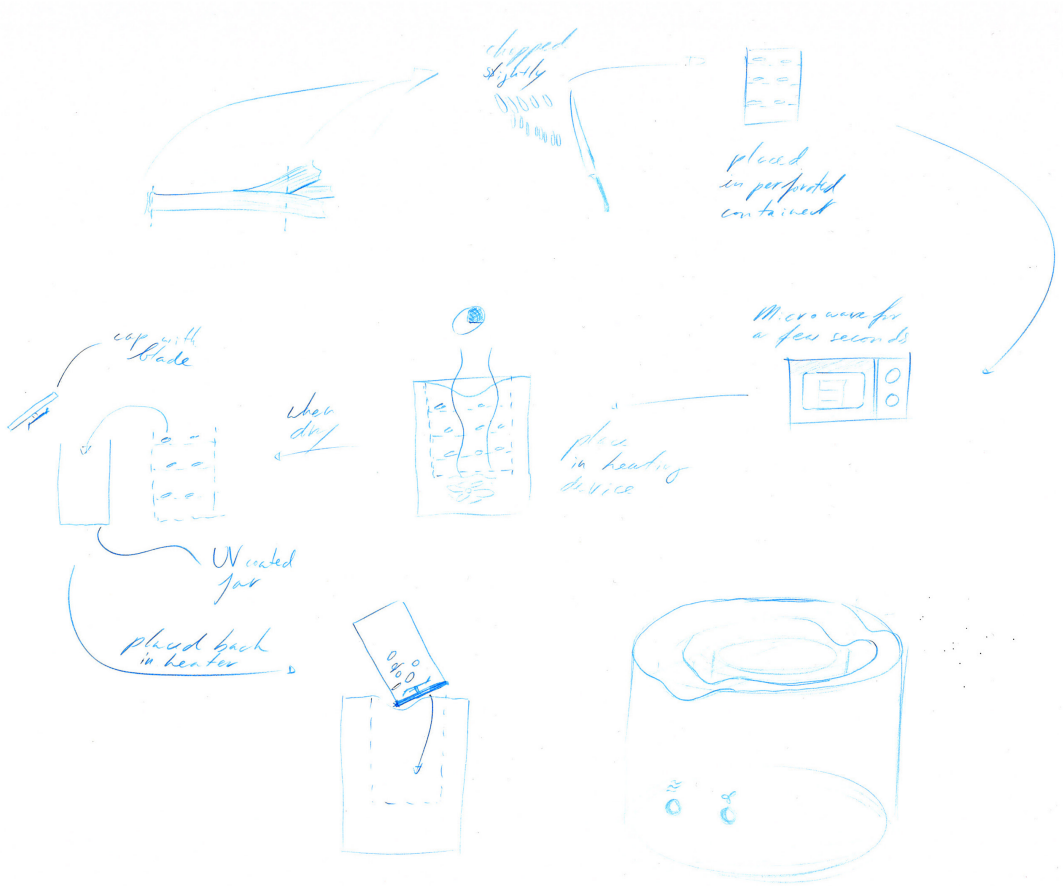
3A: HOW TO'S AND OTHER IDEA SKETCHES

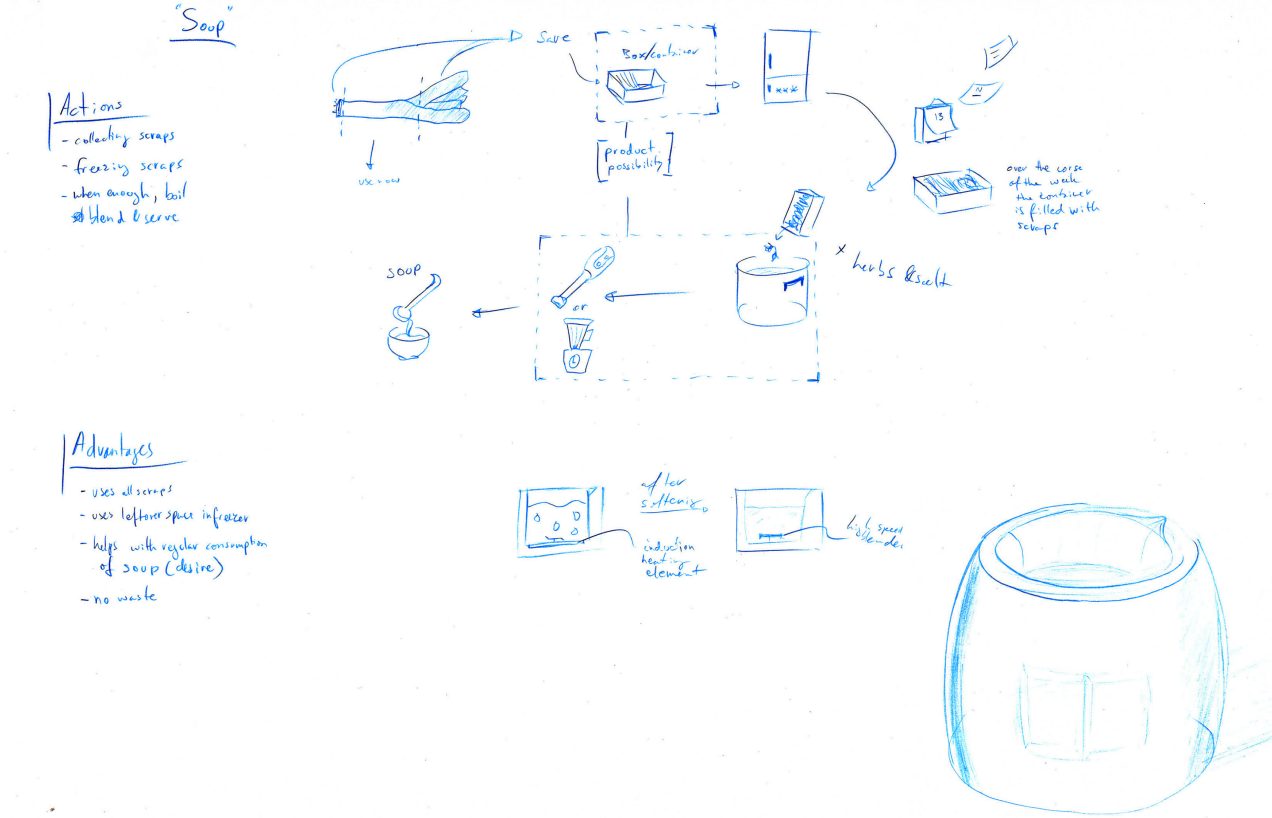



Preserving
a
pickling
left over
vegetables
not-
wasting/
saving
food
Good feelz
pride
Guilt
adversive feelz
b
powder
c
d
freezing
fermenting
Extraction
stock
juicer
food
Waste
leftover
greens
vinaigrette
potato hanger
+
sl. dressing + leftovers


Idea Board
for fermentation? PH-meter
CO_2-meter?
Pickling
fleshy
herbs
veg
PICKLE
BATH
stays submerged
O_2

3A: CONCEPT SKETCHES





APPENDIX 4: ENERGY CONSUMPTION

With these calculations a rough estimation is made to have an idea about how much energy the two concepts would use on a weekly basis. In practice the costs should be slightly higher. For this calculation the price of 1KWh is assumed to be 20 cents.

SOUP MAKING

Taking a weekly preparation of 1 litre of soup where the heating goes from room temperature to 100° C. Keeping the soup at this temperature until the soup is made is disregarded as well as the possible (in)efficiency of the heating element.

Specific heat of water = 4.186 J/Kg/°C
dT= 80°
1KWh = 3,6e6 J
4186J * 1Kg * 80° = 3,35e5 J ≈ 0.1 KWh

POWDER MAKING

Here the pre heating in the microwave and the grinding of the dried vegetables are neglected. The assumptions are that the drying takes 30 minutes and runs at 100W. The 100W are derived from conventional dehydrator ovens and scaled to the size the product would have. This is tripled as it is assumed the product would be used three times a week.

100W * (60*30)s * 3 = 5.4e5 J ≈ 0.2 KWh

POWDER GRINDER

Here a typical convection oven is used as an example as can be found in many fitted kitchens. The wattage of these ovens vary from 2.000W-3.000W. For this example a 2.500W is used, running at 60°C for one hour.

2.500W * (60*(6*3))s = 2.7e6 J ≈ 0.75 KWh

APPENDIX 5:
HANDOUT OF USER TEST 2

USER TEST A

First of all, I would like to thank you for participating with my research.

The research topic is Food Waste and focusses on vegetable (trimmings). The goal is to find alternative ways to use vegetables to prevent vegetable (trimmings) from being wasted. One of way of doing so is making powders out of vegetables and incorporating these in daily meals.

The vegetable (trimmings) have been carefully dried and powdered by me personally. In the drying process, minerals and fibres have been preserved while water soluble vitamins are mostly kept. Only 100% organic vegetables were used and were raw when dried. All edible parts were used (including peels).

Test #1

When making and having dinner, try to use (some of) the powders while cooking and while dining. The way in which you do this is at your own discretion.

When using the powders, you are kindly asked to capture the moment with your phone (picture or video).

Test #2

On another day, open the envelope marked “Test #2” before you start cooking. Kindly read the instructions and execute the final test.

After having completed the two test, please let me know when we can make an appointment to briefly evaluate the tests.

Thank you again for participating and have fun with the tests.

If you have any questions you can always contact me by phone or mail:

+31 638168174 a.f.vandijk@student.tudelft.nl

USER TEST B

Hopefully you managed to use the powders during the first test. To guide you with the usage of this 'new' product, some applications of the powders will be given. Generally, the powders work best if combined with a 'wet' component. When combined is such a way, the powdered vegetables can be an addition in terms of flavour and colour.

Assignment - choose one (or more) of the following ways to incorporate the powders in your next meal:
(if you already applied the powders in one of the mentioned ways, choose a different one)

- Add to soup
- Mix with mayo
- Mix with butter
- Scatter over pasta dish (mimicking parmesan cheese)
- Add to sauces

When using the powders, you are kindly asked to capture the moment with your phone (picture or video).

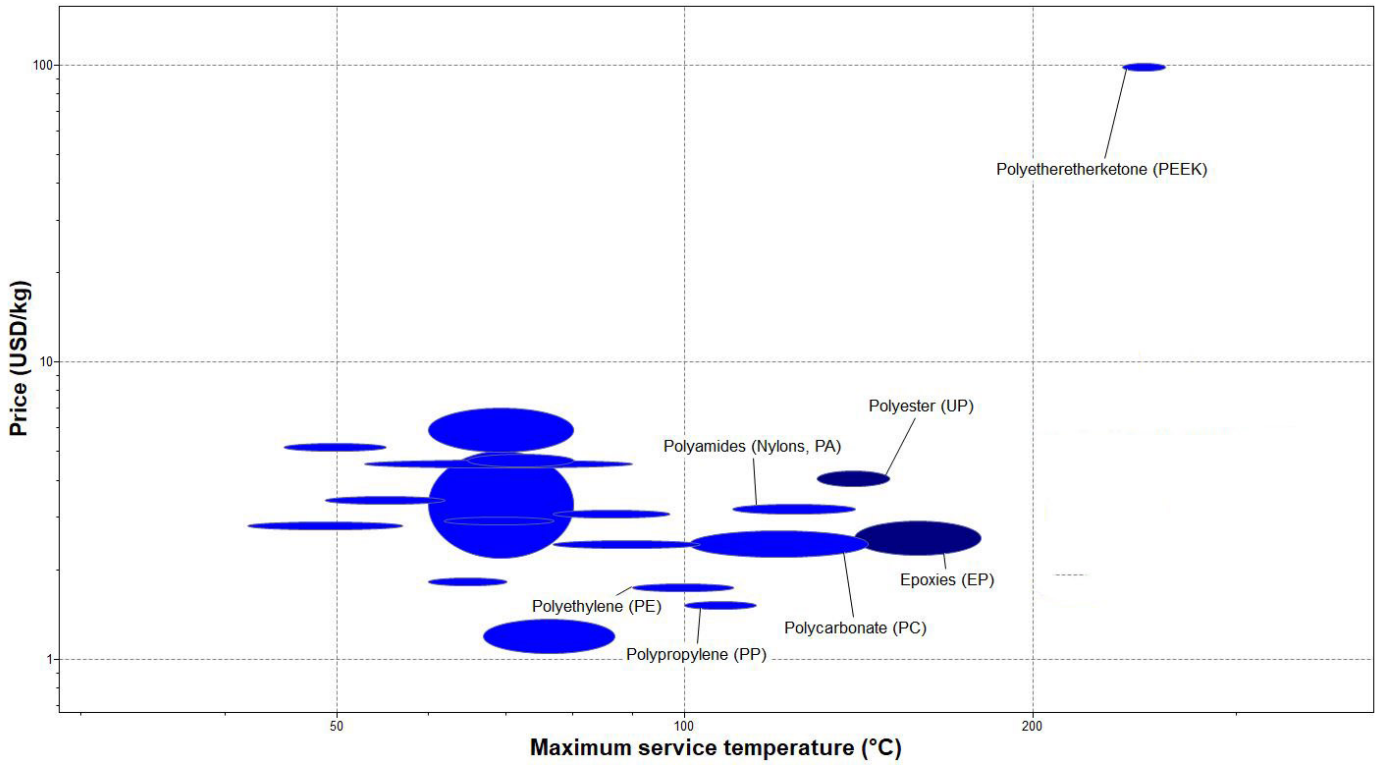
If you have any questions you can always contact me by phone or mail:
+31 638168174 a.f.vandijk@student.tudelft.nl

APPENDIX 6 MATERIAL AND COSTS

A: MATERIAL

Using CES plastics were examined in regard of their maximum service temperature and price.

While PEEK passes when it comes to service temperature, the price for this product is unacceptable. This would lead to around 30 euros per product in materials alone.



A: TOOLING COSTS

These tooling cost estimations were made using the website www.custompartnet.com, yielding bulk figures to have an idea about the magnitude of these costs.