

# Private Household Food Waste & How to Reduce It

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MASTER THESIS



# Private Household Food Waste & How to Reduce It

Utilizing Smartphone Technology

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**LUND**  
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## Utilizing Smartphone Technology

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# Abstract

More than one-third of all food produced is wasted in the food chain from production to consumption, where private households represent the largest food waste faction. In turn, water, fertilizer and cropland efficiency is wasted as well. Investigating the stated problem, this paper's aim is to reduce food waste.

Using a user-centered design iteration approach, observing, ideating, prototyping in different levels of quality, and testing all produced content puts the user in the midst of the process. Throughout the process, regards to the smartphone stress all live in today have been taken.

The Kotlin-language Android application created utilizes the camera to scan users' receipts. The groceries are then stored in the application, making it easy to keep track of the inventory. The application also offers recipes that are generated based on the current grocery inventory and the user is also advised on how to better store, and use groceries in order to reduce the food wasted.

Focusing on solving a problem in everyday life for regular people is done, keeping track and utilizing current groceries not contributing to food waste and also saving money, hence nudging users toward an environmentally healthier lifestyle. Nudging, letting the user have full freedom of choice but making the better alternative easier to choose, can implicitly help people be more environmentally friendly, and should be used in other areas concerning the environment as well.

**Keywords:** household food waste, user centered design, circular economy, smart home application

# Sammanfattning

Mer än en tredjedel av all producerad mat slösas på vägen från produktion till konsumtion, där privata hushåll utgör den största delen av avfallskedjan. Konsekvenserna innebär slöseri av vatten-, gödningsmedel och odlingslandets effektivitet. En undersökning av det angivna problemet har genomförts och innehåller syftet att minska matsvinnet i hushåll.

Genom att använda en användarcentrerad designprocess med delar som observation, idé-generering, skapandet av prototyper med olika kvalitetsnivåer, och testa allt producerat innehåll, sätts användaren mitt i processen. Under hela processen har hänsyn tagits till smartphone-stressen som alla lever i idag.

Den skapade Android-applikationen skriven i Kotlin använder kameran för att skanna en användares kvitton, lägga till och hålla reda på alla matvaror. Applikationen kan generera recept som baseras på aktuella varor ett hushåll har för tillfället. Råd ges om hur livsmedel kan lagras för att hålla sin hälsa intakt under en längre period.

Genom att fokusera på att lösa ett problem i vardagen för individer, bevaka och framförallt använda matvaror i hemmet för att minska matsvinn men också spara pengar, nudgas användarna mot en miljömässigt hälsosammare livsstil. Nudging, låter användaren ha full valmöjlighet men gör ett alternativ enklare att välja, kan implicit hjälpa människor att vara mer miljövänliga och den bör användas på andra områden angående klimatfrågor.

**Nyckelord:** matsvinn i hushåll, användarcentrerad design, cirkulär ekonomi, smart hem-applikation

# Preface

This research paper has been conducted during the fall of 2018 into the spring of 2019. It is presenting the work of the Master Thesis work by me, Peter Skopal, and with its completion finishing my studies in Information & Communication Technology at the Department of Design Sciences, Faculty of Engineering LTH, Lund University.

The work has been done at Jayway by Devoteam in Stockholm, Sweden. I would like to say a big thank you to my supervisors, Linn Lindfred and Carl-Johan Walleby as well as all the people at the office helping me with regards to participating in workshops and giving relevant feedback. The office space successfully made me feel like a member of the team, and it has truly been a pleasure writing my Master Thesis there.

I would also like to thank my supervisor at LTH, Joakim Eriksson, which has guided me throughout the thesis with relevant feedback and ideas.

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# 1 Introduction

More than one-third of all food produced is wasted in the food chain from production to consumption, where private households represent the largest food waste fraction [1, 2]. Back in 2012, the food wasted every year was approximately 1.3 billion tonnes, which when converted to calories, corresponds to roughly 24% of all food produced, i.e. 614 kcal/capita/day. Food waste is highest in the NAO region (North America and Oceania), and lowest in SSEA (South & Southeast Asia) [3]. In Sweden, the amount of food wasted is one million tonnes a year, whereof 70% is produced in private households [4].

Not only are food waste accompanied by loss of food for people in the need of it, but also crop land efficiency, water waste, fertilizer waste etc. Water-wise 27 m<sup>3</sup> water used for crops is wasted per capita and year, and fertilizer-wise one-fifth is wasted (4.3 kg/cap/year) [2].

But how is the food waste taken care of in our current society? Since the '90s municipalities around Sweden have started to collect food waste as a separate waste type, apart from residual waste [5]. The collected waste is transported to biogas plants and via anaerobic digestion it produces both fertilizers and biogas [4]. The collection of waste solution is quite good according to the EU waste hierarchy, in fact it is actually right in the middle of the hierarchy in the category *recycling* [6]. A similar process is food waste recycling in households involving a compost, where the produced soil conditioner is a very good and natural fertilizer.

A step further up the hierarchy comes *preparing for reuse*, slightly better than recycling recovery. Many products can be refurbished and used again, e.g. printers and refrigerators. Clothes are a perfect example to be reused as well, many second-hand shops implement this category in the waste hierarchy. However, dependent on domain, reuse is not applicable to food waste since food is a consumable substance, which cannot be reused, only recycled, hence the waste itself is the main source of the problem. To really solve the problem at hand humanity needs to aim at the highest level in the hierarchy, *prevention* of production of food waste [6].

The digital society we live in today is constantly increasing its use of smartphones and smartphone applications [7]. Further on, social activities on our smartphones such as texting and calling has been proven to be linked with depression, anxiety, and stress. Applications that make practical issues easier in everyday life does not have the same negative impact on humans [8]. The fact that we can practice smartphone usage wherever around the world even further creates the possibility of a negative impact on humans.

The current problem with food waste can be solved at many different stages along the food chain, in different levels of EU's waste hierarchy, and all together in many different ways. Being that households stands for most of the food waste, the largest

amount of people who can affect the current stage rapidly are regular individuals. This leads to the research question of this paper.

- How can we, with the help of today's technology, reduce food waste and at the same time affect interest and consciousness about food sustainability for individuals positively?

## 2 Scope and Goal

Conceptually evaluate how to approach the food waste issue in households with the help of today's technology, is the main task in this paper. The main challenge is to change humanity's approach to food in general, what is good practice, and what is bad, involving simple or advanced advice.

Due to the limited scope of the thesis, some parts of an eventual implementation will intentionally be left out or less implemented, such as grocery lists, including pet food etc. To add, since the main focus of this report and the prototype application will be to reduce food waste, other aspects of food consumption such as health and economy are not included in the study. However, health issues and the economic implications of a changed food consumption are possible subjects for future studies and could work as a great supplement to, and incitement of reducing food waste, being that food really affects the human body's second brain, the gastrointestinal flora [9].

### 2.1 Goals

The main goal is to reduce food waste. Sub-goals to achieve this bigger goal are:

- Raise food-connected sustainability consciousness amongst users.
- Raise concern about the growing problem of waste in general.
- Use nudging to facilitate for the user to make more environmentally friendly decisions without causing distress.

## 3 Background

World hunger is on the rise again, increasing by 9.5% from 2015 to 2016 instead of decreasing, which makes a reduction of the world's food waste even more important. Furthermore, food waste is often the result of lack of knowledge and planning [10]. The objects introduced in this section will cover and hopefully have an impact on United Nation's Sustainable Development Goals 2 - zero hunger, 6 - clean water and sanitation, and 12 - responsible consumption, and production [10], see Figure 1 for the goal logos.



Figure 1: Logos for three of UN's sustainable development goals hopefully affected positively by this project.

The following sections will describe the current state of how rubbish and waste is taken care of and how it affects our environment, but also user-centered design techniques and aspects to take into consideration when developing a digital tool.

### 3.1 Waste

#### 3.1.1 Circular Economy

The world is, to a large extent, a linear economy, which implies products being produced and after usage discarded. Naturally linear economy is bad practice since the world's resources are limited, and will not endure humanity living with companies following such a model [11]. A circular economy model focuses on reusing materials that in a linear approach would be disposed of. One could follow EU:s waste hierarchy model described in Section 3.1.2 getting inspiration on how to achieve progress with ones' transition from linear to a circular economy. The circular economy introduces opportunities to reuse materials, recycle them etc., see Figure 2.

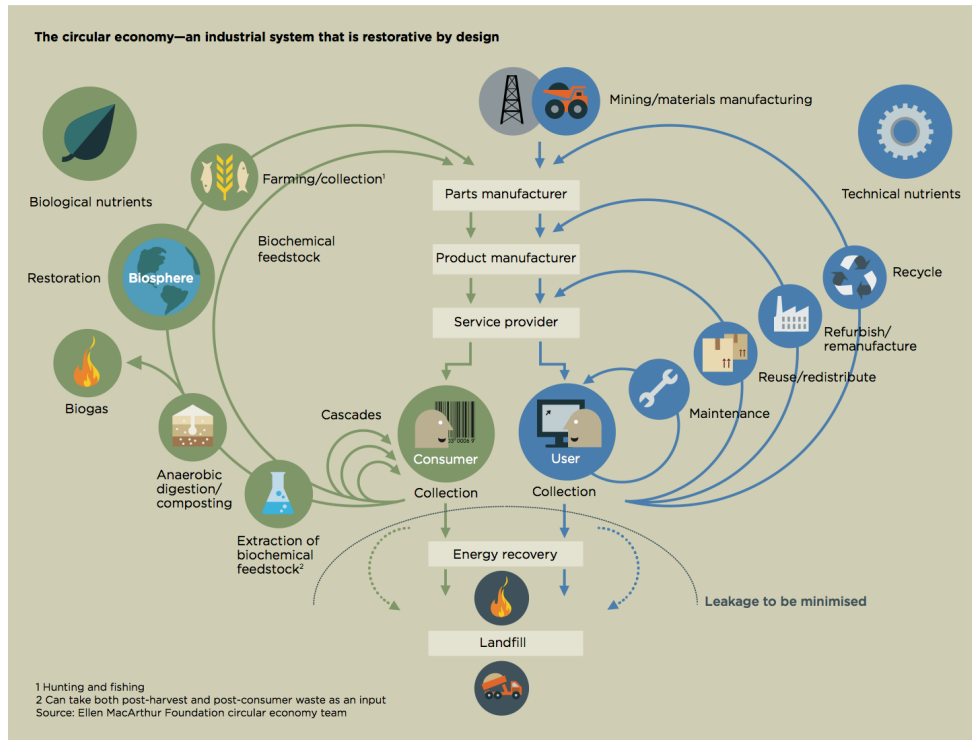


Figure 2: A continuous flow of technical and biological materials [12]. In the biological cycle all products are consumable and returned to nature through processes like anaerobic digestion and composting. In the technical cycles products, components and materials are recovered and restored through strategies in dropping quality, like reuse, repair, remanufacture or recycling [13].

### 3.1.2 EU Waste Hierarchy

As waste generally is a rapidly growing problem the EU has stated a strategy to reduce and someday have a completely circular economy society where no waste at all will be left to disposal. Altogether the EU, including construction-, manufacturing-, water supply and energy waste, generates 3 billion tonnes of waste every year [6]. As individuals, Swedes produce 441 kg of rubbish every year [14]. Individuals do not tend to take care of these problems themselves and that is why the EU has defined a strategy with a clear waste hierarchy depicted in Figure 3. When speaking of food waste, Sweden are currently working with recycling most of the waste, benefiting other parts of the society, as described in Section 3.1.3. An improvement to this way of taking care of waste is to completely prevent the waste from occurring in the first place, jumping over *preparing for reuse* in the hierarchy model since food is difficult to reuse in that sense.

Hazardous substances are the biggest challenge within waste management, and the EU is trying, with different processes and banishment of materials, to reduce this kind of waste [6].

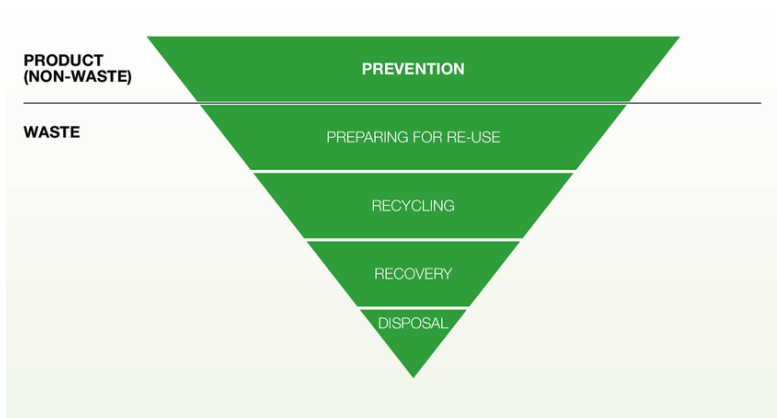


Figure 3: EU waste hierarchy.

### 3.1.3 Food Waste

More than one-third of all food produced is wasted along the way from production to consumption, where private households represent the largest food waste fraction [1, 2]. In Sweden, this fraction stands for 70% of the food waste, and in fact food waste is often the result of lack of knowledge and planning [5]. This means that the ones capable of making the biggest impact on this problem are in fact individuals themselves.

According to UN *hunger* needs to be fought, and the matter is prioritized as the second most important sustainability development goal [10]. This is definitely a factor affecting how one should go about developing a solution to the food waste problem today. The EU has highlighted some initiatives, e.g. *Menu Dose Certa*, by LIPOR in Porto, which aims to support restaurants to reduce food waste by looking over menus and advice them to change it towards a more sustainable approach [6]. As mentioned in Section 3.1.2 this initiative is aiming to prevent waste, which is the best possible way to approach this issue according to the EU.

Aforementioned paragraphs talk a lot about the problem in itself, but what is actually done in order to recycle the food waste? In Sweden, 40.33% of all households recycle food waste which gets transported by the municipality to biogas plants [4, 5]. On these biogas plants, utilizing the natural anaerobic digestion, biogas is produced and the rest product is a very good fertilizer. The biogas can be used as a fuel for vehicles after some carbon dioxide has been removed from the gas making it more efficient, and also following certain standards [15]. Fertilizers are used in the agriculture industry.

The large amount of food wasted results in other types of waste than merely the eatable food. Also croplands, water and fertilizers are wasted to a high extent. To explain, if one third of all food is wasted, that roughly means that one-third of all cropland used to produce the food is used in vain. This is especially crucial in the areas where deforestation becomes the result of laying cropland. Cereal production probably has the biggest impact on biodiversity and the deforestation is all in vain if we, either way, waste the food [2]. Further on, water and fertilizers wasted is

affecting UN's 6<sup>th</sup> sustainability development goal, which strives for clean water and sanitation for everyone [10].

### 3.1.4 Changed Behavior

Getting individuals to change this behavior could be a huge step in resolving this matter, but one needs to be careful. Emotions and habits play a key role here, where the fact that people who feel more guilt wasting food, actually end up wasting more compared to otherwise [16]. Unintentionally people let their feelings affect habits negatively instead of the other way around. This makes it of the highest importance that this project's solution does not initiate negative feelings towards throwing away food, but instead focus on giving important insights in how to preserve or use already bought food better.

A study in Italy has made it clear that a relatively large proportion of people are susceptible to adjusting their food waste routines to some system with processes of leaving it a certain place [17]. Proving peoples susceptibility to these kinds of changes creates great opportunities to solve the food waste issue at hand. Policy proposals have been made to *"educate consumers about food, food chains, effects on the environment, sustainability, waste management and packaging"* and solutions proposed to reduce waste have been made: vegetarian day, less but better meat etc. [18].

## 3.2 Food Storage

Several articles mention how food storage can be done in a manner improving sustainability of it, e.g. lowering fridge temperature to 4 degrees Celsius would lengthen groceries life time. However, lowering the temperature uses a lot of energy, but in the current state of society where a great amount of food is wasted, the food saved lessens the carbon footprint more than the energy of lowering the fridge temperature. The previous statement is true if one puts groceries in the fridge, that not normally is put in the fridge. The groceries in mind include apples, citrus fruits, carrots, cabbage, cauliflower, peppers, other root vogs. etc. together with not putting bananas in the fridge [19].

Research has also come up with the conclusion that a great way to reduce food waste is to freeze the goods. Some concrete advice has been given to several types of food which is depicted in Table 1 [20].

Table 1: Freezing compatibility on different food categories together with data on possible defects and life-time. This table is a replica of one in [20].

Product	Suitable for freezing	Main detrimental issues during freezing	Range of Product lifetime (months)
Bread	Yes	Staling, dehydration	0.5 to 8

<i>Freeze in air-tight packaging. Freeze when as fresh as possible. Freeze in portions to speed up freezing rate and for ease of use.</i>			
Pork (cooked sliced ham, bacon, raw & cooked sausage)	Yes	Rancidity, oxidation	1 to 6
<i>For best quality, freeze when fresh. Safe to freeze up to use by date (defrost and use within 24 h). Wrap in air-tight packaging. Defrost in fridge. Remove as much fat as possible prior to freezing.</i>			
Vegetables	Generally yes (if blanched)	Loss of flavour, color, texture	1 to 18
<i>Some high water content vegetables not suitable for freezing, but many can be chopped and successfully frozen. Freeze as soon as possible to retain vitamins/nutrients. Blanching prior to freezing is essential to inactivate enzymes. Wrap in air-tight packaging. Freeze in small volumes for best results. Most vegetables can be cooked directly from frozen. Individually freeze items if possible as freezing is faster and portioning is simpler, then transfer to bags.</i>			
Fruit	Mostly yes	Loss of structure	4 to 24
<i>Wrap in air-tight packaging. Freeze as soon after harvest/purchase as possible. Individually freeze fruits if possible to accelerate freezing rate and reduce loss of structure on thawing, then transfer to bags. Consider making fruits into sauces or purees to freeze, to save space and to utilize fruits that are likely to lose structure after thawing.</i>			
Pasta meals (home-made)	Mostly yes	Separation of sauces, texture of pasta	2 to 4
<i>Cool rapidly after cooking. Freeze in portions, freeze in air-tight container or bag. If preparing food specifically to freeze, undercook meal to allow reheating after meal is thawed. Keep thawed product in fridge for up to 1 day before eating.</i>			
Rice meals (home-made)	Mostly yes	Bacteria growth prior to freezing	2 to 4
<i>Cool rapidly after cooking. Freeze in portions, freeze in air-tight container or bag. If preparing food specifically to freeze, undercook meal to allow reheating after meal is thawed. Keep thawed product in fridge for up to 1 day before eating.</i>			
Chilled ready meals	Yes	Separation of sauces, texture of meal	No data



<i>For best quality, freeze when fresh. Safe to freeze up to use by date (defrost and use within 24 h). Cook from frozen or defrost in fridge.</i>			
Milk	Mostly yes	Separating and curdling	1 to 4
<i>For best quality, freeze when fresh. Safe to freeze up to use by date (defrost and use within 24 h). Freeze in small quantities if possible. Leave headspace/decant into suitable container. Thaw in fridge. Shake after thawing to re-combine.</i>			
Store-bought yogurt	Mostly yes	Texture and separation	1 to 2 plain, Up to 5 if flavoured
<i>Freeze as soon as possible after purchase. Freeze in small quantities if possible. Freeze in air-tight container. Thaw in fridge. Stir after thawing to re-combine. Consider making yogurt ice cream or lollies to use up spare yogurt.</i>			
Fruit juice	Yes	Thickening	4 to 12
<i>Freeze as soon as possible after purchase. Pasteurize fresh juices. Freeze in small quantities if possible. Freeze in air-tight container. Thaw in fridge. Shake after thawing to re-combine. Consider making lollies to use up spare juice.</i>			
Ambient cooking sauces	Mostly yes	Separation of sauces, texture of meal	No data
<i>Freeze unopened sauces as soon as possible after purchase. Decant sauces in glass jars to plastic containers/bags. Once opened, refrigerate immediately, use/freeze within time indicated on the label. If made into meals, follow guidance for home-cooked meals.</i>			
Meat joints (raw and cooked)	Yes	Rancidity, oxidation	1 to 12
<i>Freeze when fresh. Safe to freeze up to use by date (defrost and use within 24 h). Freeze in small portions if possible. Remove as much fat as possible prior to freezing. Wrap in air-tight packaging. Cook and eat soon after thawing or cook smaller portions from frozen.</i>			

### 3.3 Usability and Design

#### 3.3.1 Psychological Design

**Nudging:** Conceptually one could get *nudged* into doing something that otherwise would not have been done. An example can be to nudge people in a grocery store

to choose healthier products in order to prevent or cure obesity [21]. Basically, to nudge, one makes the healthier or more environmentally sustainable alternative easier to choose for customers. It is important to note, that even though nudging can be seen as a soft paternalism, one always have full freedom of choice, therefore it is not considered manipulation of mind [22].

**Benefits and risks with Smart Home apps:** A large problem within current society's rapid growth is the use of a smartphone and its implications. Many businesses have a smartphone application enhancing functionality of a product, usually resulting in the user having many applications. This makes it of importance that the application will not affect the user in a stressful way. Research depict several standards one can comply to if wanting to develop a nice smartphone application. The standards include that the application:

- is reliable and easy to use.
- guarantee privacy and confidentiality.
- securely holds all data collected.
- can be controlled and overridden.
- come with performance warranties.
- is made by credible manufacturers [23].

### 3.3.2 General Design

Throughout the application workflow, everything needs to be easily accessible making the user understand, and know how to do what. Norman has defined the *Seven Fundamental Design Principles* which have helped many designers create their products [24]. These seven design principles are described below, which ease the development of products and are a solid guideline in the design process, together with observations of potential users.

**Discoverability:** The current state of the application is informing the user what actions are possible.

**Feedback:** Giving the user a result of actions continuously as well as the current state of the product. The next state, after an action is performed, is easy to determine for the user.

**Conceptual Model:** Visualizing and projecting all the information needed leading to understanding and a feeling of control for the user, utilizing a good conceptual model for the system. Discoverability and evaluation of results are both improved by a good conceptual model.

**Affordances:** To make a desired action possible affordances need to exist.

**Signifiers:** Signifiers can help ensure discoverability as well as enhance feedback communication and comprehensiveness.

**Mappings:** Controls and actions are often confused, hence good mapping is essential for improving the usability of the product, simplifying the relationship between controls and their actions.

**Constraints:** Introduce constraints in a cultural, semantic, logical and physical way to easier let the user interpret the product guiding actions.

## 4 Method

To achieve a full user-centered design process, different methods have been used throughout the project.

### 4.1 Human-Centered Design Process

Using a human-centered design process implicates an iterative product development circle, see Figure 4. This iterative approach includes four different steps, namely *observation*, *idea generation*, *prototype*, *test*, with an added step *evolve* explicitly letting us know we should evaluate and evolve the product [24]. The general concept of iteration is used here, learning from failures, or rather learning experiences, enabling requirement modifications in time [24].

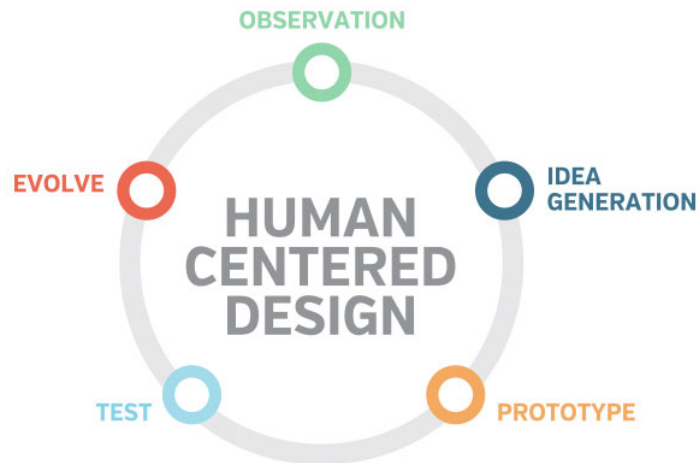


Figure 4: Human-centered design process circle, with an iterative approach. One additive step *evolve* compared to Don Norman’s model clarifying the model [24].

### 4.1.1 Observation

The first step of the human-centered process is *observation* where one needs to observe current behavior within the subject of development. Observation should with benefit be done focusing on current behavior at potential end customers.

A survey was conducted during the project, simply making observations of what people generally value throughout the process of buying, cooking and wasting food. Trying to make the survey a quick experience for the test group, closed questions were formulated, also making the subject take a stand to the statement [25].

### 4.1.2 Idea generation

Idea generation was performed after the observation and prototyping step in the process. From the design requirements brought up to attention through observation, potential solutions was made in this step. The main method broadly used around the world is brainstorming. Creativity is critical in this step. Brainstorming is the main method, but this phase can be broken up into two activities: conceptual and physical design, where the conceptual part of it includes an abstract outline what people can perform with the product and how to interact with it, and the physical is more about sounds, colors etc. [25].

### 4.1.3 Prototyping

This technique achieves understanding one's product better. There are very different techniques within this area and two are going to be used throughout this project. To help simulate some prototypes a common technique called *Wizard of Oz*, from L. Frank Baum's classic book *The Wonderful Wizard of Oz*, will be used. The wizard in this method is not a wizard per se but one can fake appearances for the human mind by using fake magic [24, 26, 27]. This is what especially the Lo-Fi prototyping technique utilizes, a fake shell of the product not actually functionally working, but one could fake the functionality.

**Lo-Fi prototyping** is a very cheap and quick variant making it possible to easily mock a product and test it. E.g. paper-based prototypes are very simple to produce but very effective in finding out the main purpose of a product.

**Hi-Fi prototyping** is a more expensive prototype to produce since more effort is needed to produce a more real-like prototype, letting the user feel like its interacting with an almost complete product, but most features are mocked.

### 4.1.4 Test

An important step in the human-centered design process, giving valuable feedback to producers both in early and late stages of production, is testing. In Lo-Fi prototype testing, one often gets hold of large problems within the current idea and need to rethink the actual product's functionality. Since the problem arises at an early stage huge costs can be avoided, because of a change of a large scale at a later stage would be devastating for a development team. The testers should observe the testees

during the testing process instead of guiding them through the product is not to go unnoticed, this way problems with valuable feedback arise easier [24].

Different kinds of testing are applicable to all products, e.g. exploratory testing is really good for discovering a regular user flow of how to explore the product and how a user understands it. Another approach is to give the user a task to perform on the product and measure different aspects of the performance: time to complete the task; number and type of errors, completion of task etc. Then a summary of the data can be made finding out which parts of the products needs to be focused on improving on the next iteration [25].

## 4.2 Brainstorming

Brainstorming sessions have been used throughout the project utilizing several techniques. Initially brainstorming was made drawing up a mind-map with several small features, as mentioned in Section 5.

Later on, workshops have been conducted with several techniques. Normally during brainstorming workshops, often a few people do most of the talking [28]. Therefore the techniques conducted needs to be very inviting to all people participating, even those which otherwise often keep their ideas to themselves.

### 4.2.1 Starbursting Workshop

A starbursting type of brainstorming session focuses on brainstorming questions instead of answers, dealing with the who, what, where, when, and why. An example question generated can be 'Why have our competitors not tried this already?'. New ideas normally generates a lot of questions, which is a good thing as long as the questions are asked in a systematic and comprehensive way [29]. Very effectively this method covers a lot of sections within a new product otherwise easily forgotten.

Followed by the mentioned starbursting brainstorming a simple discussion, starting out with the largest thoughts about the questions generated, and eventually involving more and more of the other categories from before. This way, simple questions generates interesting discussions about the subject and often answers a lot of otherwise forgotten questions. To keep track of ideas presented notes were taken together with an audio recording of the sessions.

### 4.2.2 Feature Brainstorming Workshop

This workshop was split into two sessions, where the first session was all about brainstorming and the second session about prioritizing. Before brainstorming begun an introduction about what the goal for the project together with its basic concepts was presented. The introduction's purpose was to point the participants in a direction of brainstorming specific features.

The 6-3-5 brainwriting method was used, though slightly modified, utilizing peoples different ideas without them talking to each other. Four people were set up in a room, with one piece of paper, a bunch of post-its and a pen each. 8 rounds á 80 seconds were to be made, where every round consisted of quietly putting down

feature ideas on post-its, putting them on the paper, and when the time was up for one round, one sends the paper over to the left to the next person in the circle. As one gets a new paper handed to oneself new ideas and features is presented which essentially is what is key in this technique nourishing creativity [30].

After the brainstorming some prioritization was made, simply grading the ideas from all the papers putting them either in a category named *top three* or *nice to have*.

# 5 Chronological Lo-Fi Development

## 5.1 Initial Ideation

At an early stage of the project, initial ideation was made, simply stating the current state of how food is processed today and what could possibly solve some problems. As seen in Figure 5 some features have been drawn out depending on preferences and latest purchases trying to raise consciousness for the end user. Important to note is that the level of difficulty in the complete application is dependent on the user's current level of knowledge. The brainstorm mentioned resulted in several feature proposals.

Further on conceptually speaking an initial brainstorming session was held to think about plausible reduce waste-advice and some were crossed out, considering the scope mentioned in Section 2. Some ideas were left out intentionally to keep this brainstorming session simple, results are depicted in Figure 6.

### 5.1.1 Survey - Household Food Habits

A survey was made, as described in Section 4.1.1, trying to plot what people value when shopping groceries. Trying to get a hold on what people value when cooking the food was also mapped, together with recycling habits with all rubbish created in the household. Questions asked, together with answers, is found in Appendix A. However, some conclusions of the 143 answers and comparisons between all-eaters and others (vegetarians/vegans/pescetarians) have been made in Figure 7. As can be seen, conclusions can be made that people who are not all-eaters, tend to care more about the environment when purchasing food, but also tend to value that cooking food should not take too much time. Otherwise, much is similar between the two groups, but it seems people not eating meat more often actively try to reduce their food waste.



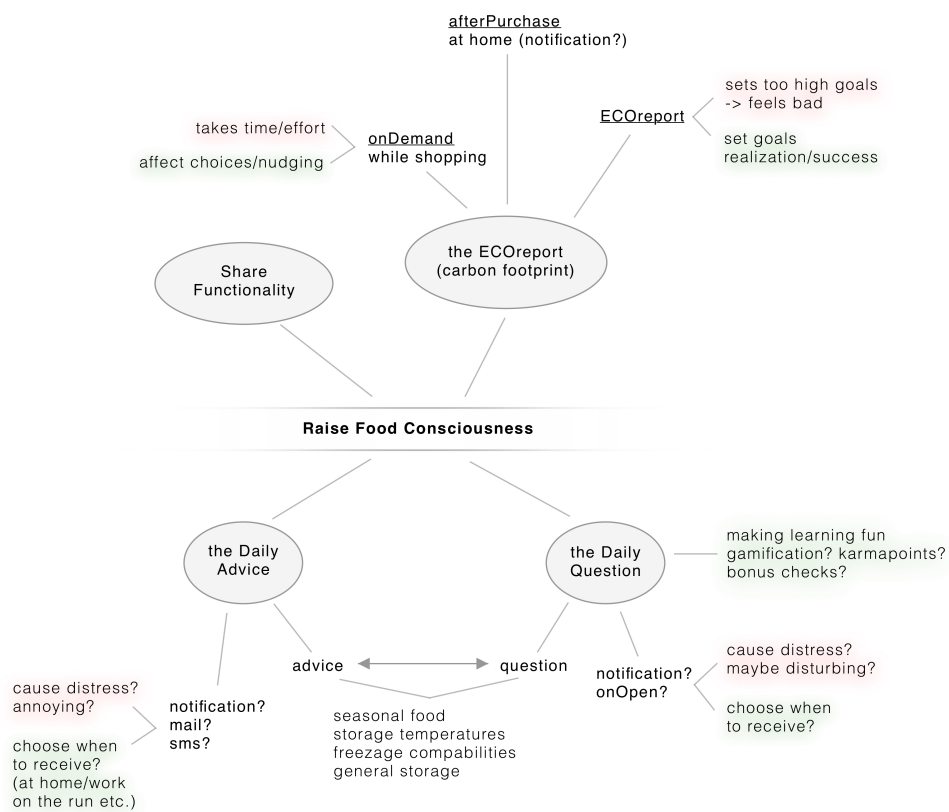


Figure 5: Initial brainstorming session on how to raise the common knowledge within the area food, including four simple features. Green-lighted areas are pros about a sub-feature and red-lighted areas are cons.

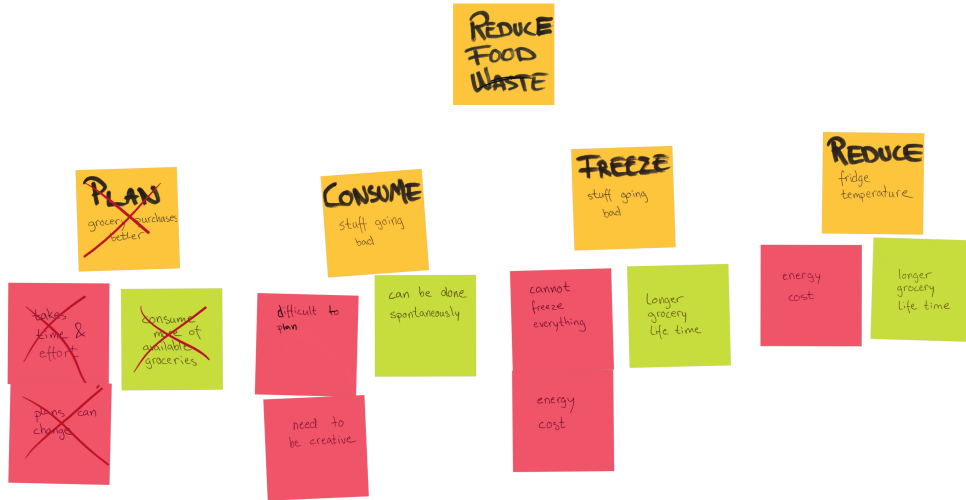
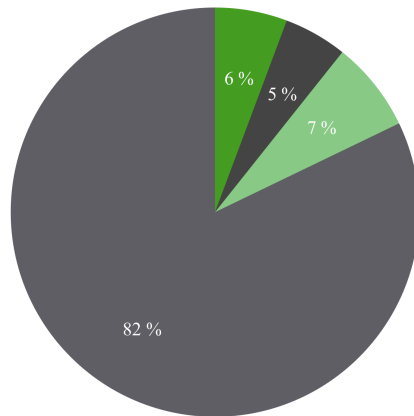


Figure 6: Brainstorm with post-its stating four different techniques to reduce food waste, accompanied by pros and cons, green and red post-its. The crossed out *PLAN* is not within the current scope.

### What are your food preferences?

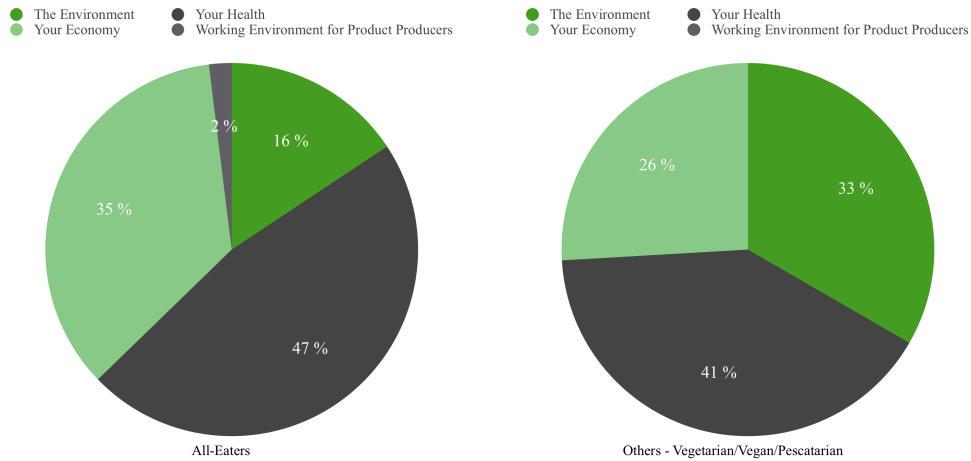
● Pescatarian ● Vegan ● Vegetarian ● All-eater



(a) Distribution of food preferences.

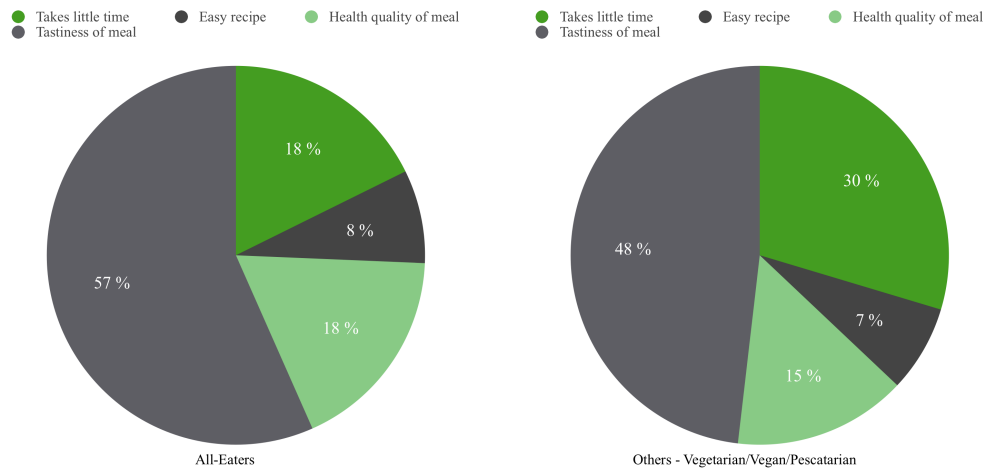
Figure 7: Survey - Household Food Habits: Results.

What do you value when *purchasing* your food?



(b) Answer on what people value the most when purchasing food. To the left is answers from all-eaters and to the right, others.

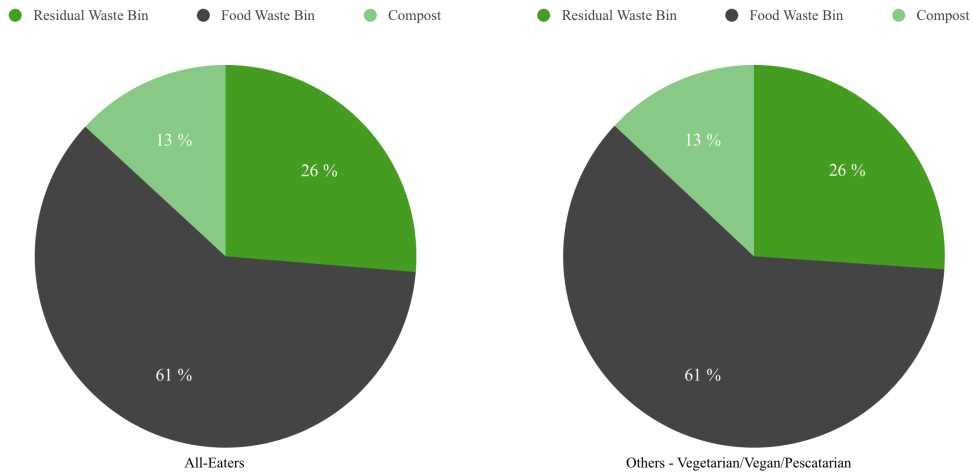
What do you value when *cooking* your food?



(c) Answer on what people value the most when cooking food. To the left is answers from all-eaters and to the right, others.

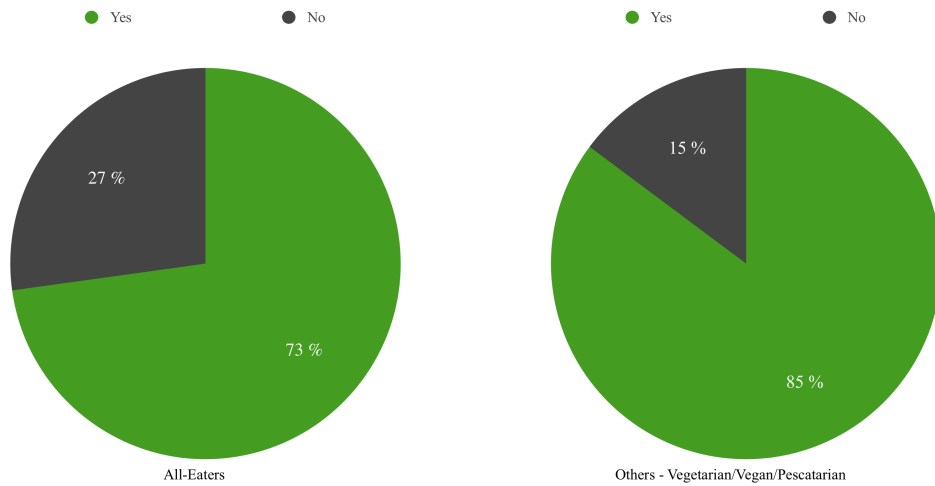
Figure 7: Survey - Household Food Habits: Results. (cont.)

How do you mainly throw away your food waste?



(d) Answer on how people mainly throw away their produced food waste. To the left is answers from all-eaters and to the right, others.

Are you actively trying to reduce your food waste today?



(e) Answer on if people actively try to reduce their food waste. To the left is answers from all-eaters and to the right, others.

Figure 7: Survey - Household Food Habits: Results. (cont.)

### 5.1.2 Workshop Session - Concepts

Setting up the first workshop was all about brainstorming about a concept. At first, a focus group had to be set up, which naturally contained some people from the Jayway office. All the main goals were set up and explained for the workshop attendees being present throughout the session. The starbursting technique used in this particular workshop is mentioned and described in Section 4.2.1.

Two sessions were hosted with two participants, excluding the project member, spanning over 45 minutes, whereof 15 was spent on an introduction and starbursting, and the rest on discussions. Introducing the subject and goals to the participants initially, giving them a background to think about when presenting the starbursting technique, was needed giving them a context. This was as simple as describing the main goal of this project, helping individuals reduce food waste with the help of a mobile smartphone application.

Approximately 10 minutes or until the participants were ready, was spent on brainstorming questions with the starbursting technique individually writing down questions on a paper. The most common and most discussed questions are depicted in Figure 8. After the brainstorming, a discussion was held talking about possible solutions and answers to the questions, starting with the participants first and biggest thoughts about any question they had written down. The following questions and possible solutions were discussed the most:

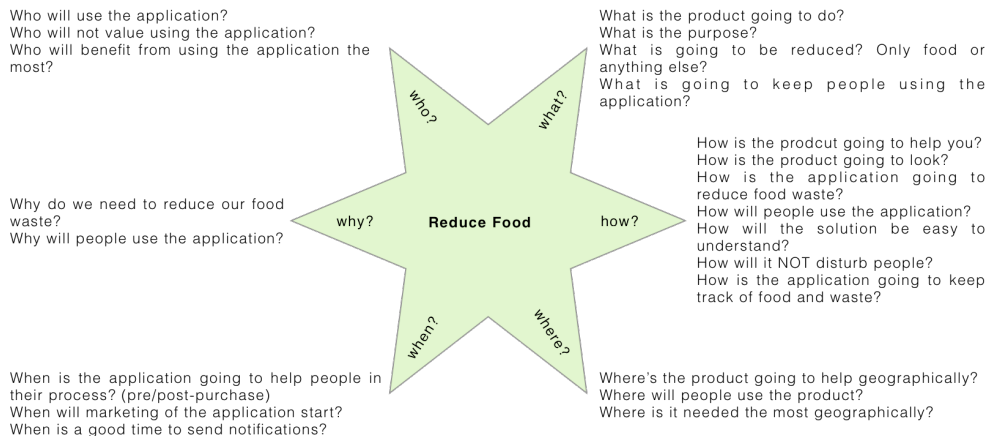


Figure 8: Questions generated at the conceptual workshop sessions mentioned in Section 5.1.2, with the highest priority after some discussion with the workshop participants.

**Where is the product going to help geographically?** Would poor or wealthy countries be of any difference in this context? Depending on what is most needed, but also the scope of this project together with the fact that the project is conducted in such an area, wealthy countries are to be considered. Especially information gathering will benefit from this decision and be easier. However, can the solution from this project be used for a solution in third world countries as well?

**Where/when are people going to use the application?** There are multiple alternatives when or where people can use the application in mind. The three main stages for the food: pre-purchase, post-purchase, and after consumption. The three stages have different opportunities and difficulties in how to affect human behavior and need to be further researched to come to an answer. Applicable features to the different states are:

- Pre-purchase: get information about groceries, holding data about environmental impact and maybe if you already have it at home, i.e. limit purchase amount to necessary levels.
- Post-purchase: get information about how current groceries at home can be used in the best way possible, minimizing food waste. Possibilities to inform about how to conserve current food, or advice the user to put food in the freezer etc. are also an alternative.
- After-consumption: get information about how to recycle the best way possible, and also review how purchases next time can be altered to reduce the waste you produced this time.

When people actually are going to use the application is a difficult question, hence customizability will be important. The four main stages of location or activity to use the application are: at home; at work; at the grocery store or on the run (moving from point A to B).

**When does the application help the user the most?** The same three stages as mentioned above will be used here. In this case, considering the impact of the current state of a potential user's fridge, post-purchase is the state where most impact can be done, helping the user from proposing recipes to recommend freezing some groceries.

**How will it NOT disturb people? When is a good time to send notifications?** Some people don't want to get notifications mentioning their groceries will expire, since some users may already have everything under control. Rather notifications about seasonal groceries could be of interest here raising consciousness. Customizability will be important in this case, e.g. letting the user decide to get fun-facts or reminders on current groceries, etc.

**How will people keep using the application?**

**Simplicity:** To keep the application simple enough but with enough valuable features is a key point in this project, creating beneficial value for the user. One way to keep it interesting and showing progress is to gamify the application, giving points on how well users perform environmental-wise in its purchases. Instead of fictional points, another option is to track groceries purchased, using real-life carbon-dioxide equivalent values and give the user a number on how well they perform environmentally.

**Environmental Impact:** Further on advice on better products can be given based on what groceries you have bought before, not being a good alternative environmentally speaking. Some kind of scale including more than two product alternatives spanning from environmentally good to decent would be interesting to include in the application. Important to note here is that anxiousness is not unlikely to happen to the user, if advice is given to improve environmentally, which is not at all wanted in the application, based on research explained in Section 3.3.

**Customizability:** Enabling a lot of customizability to the application would benefit users, such as letting settings like monthly income, food of choice (vegan /vegetarian /all-eater), living conditions, and other general preconditions affect how the application works.

**Integration capabilities:** Some ideas constructed say that the application will need to be integrated with some other platform, creating the opportunity to easily keeping track of food bought in stores, e.g. integrating a specific grocery store log in into the application retrieving groceries bought from that platform.

**Nice Features:** Some features discussed throughout the sessions are: give advice on recipes based on groceries at home; calculate how much money is saved from saving some food from waste; calculate how much carbon dioxide is saved from saving some food from waste; have a nice grocery list functionality.

**When is it a good time to get a notification?** The conclusion was it is very personal since some people would like it at home, others at work or on the run. Giving the application full customizability would be very helpful in this case, to achieve good results. Discussions also led to the conclusion that it probably will be a good idea to customize what groceries the user would like to get notifications on as well, maybe dairy products could be good to track as a default.

**Who is it concerning?** The question brought up the possibility of having pets, which would e.g. enable groceries like dog or cat food. Within the scope mentioned in Section 2, this is not going to be evaluated.

**Who will think the application is boring and not necessary?** Some people will not initially appreciate what the application has to offer. The group thought of probably does not like to cook food, or maybe they do not believe in the matter of global warming.

**How do we get people interested in the purpose of this product?** People not already thinking about this problem will probably not download this application and adjust their lifestyle very easily. To get this application to actually matter to that group of people as well, minimal effort needs to be thrown into this application from a user perspective, showing more data than just the environmental impact, bringing in factors like economy or health.

**How is the application going to keep track of food and waste?** This technicality will impact the way the application works, and how easy it is to use. The best option would be to retrieve purchases directly from any given grocery store, via letting the user log in, and track the exact groceries bought. Another option would be to invest in smart fridges keeping track of everything in your fridge, not making the application in scope very accessible for many people, since the investment one needs to make will scare off many potential users. Scanning barcodes from groceries, retrieving data from an open API was mentioned as an alternative, giving the user full control of what to scan, and what not to scan. However, this solution introduces a double workload for the user, since a scan of all groceries is needed when the user gets home from grocery shopping. Lastly scanning the receipt could be possible, with the technical problem of maybe not successfully retrieving all the information needed.

**How to give advice in a nice manner?** People can be annoyed when notifications tell you to change your habits when buying groceries. Once again customizability is wanted to make the notification customizable, enabling environmental and economy options on what kind of advice you would want on your previously bought groceries.

### 5.1.3 Feature Workshop Session

**Method:** After the concepts have been set up from previous sessions, specific features and functions of the application could be spoken of. Via utilizing the method 6-3-5 brainwriting and some prioritization, described in Section 5.1.3, the following results were created, categorizing features in *Top Three* and *Nice to Have*:

#### Top Three

- Warn if products/brands are bad for environment
  - Get advice on ecological products
  - Help prioritize products with environmental impact based on economy
  - Advise if one really should buy a certain grocery
  - Statistics on carbon footprint progress
- Advice on storage possibilities (fridge, cupboard, etc.) for best sustainability
- Recipe proposals, helping out planning food consumption for a complete week.
  - One could select several recipes, generating a grocery shopping list, and then realizing what possibly would be left-over.

#### Nice to have

- Handle tracking of one's waste, measuring progress
- Scan receipt, scan barcode, scan fridge.
- Generate recipe based on what groceries one have left.
- Notify user when groceries are on its way of going bad.



- Opportunities to compete against neighborhood, friends or the average, on the environmental question.
- One could get inspiration on how to recycle food waste
- General advice, such as current seasonal food, or what grocery could be bought instead of something a user bought previous purchases, improving health or environment.

## 5.2 Prototyping

After the initial ideation phase was over, prototyping was on the table. Some use-cases were constructed based on the ideas from the brainstorming sessions, described in Section 5.2.1, including narrowing down ideas and discarding some due to scope reasons, mentioned in Section 2. Later on a first Lo-Fi prototype was created, depicted in Figure 10 in Appendix B.

### 5.2.1 Use Cases

**Use Case 1:** The user has been in a grocery store shopping and arrives home, wanting to insert everything, except for one grocery which was bought for a friend, into the application’s memory.

**Use Case 2:** The user wants to see what recipes could be used to utilize groceries at home.

**Use Case 3:** The user is at the grocery store, wanting to check what groceries are already at home, avoiding to purchase duplicates.

**Use Case 4:** The user has consumed one of the groceries and wants to remove it from the application’s memory.

**Use Case 5:** The user is in the store, wanting to find out more about a grocery’s environmental impact.

**Use Case 6:** The user wants to check its environmental impact, and learn how to be even better.

### 5.2.2 Testing

Testing was conducted on 8 subjects. During the testing an audio recording was made, due to one person not being enough conducting the tests, taking notes and acting as the *computer* in the Wizard of Oz method used, described in Section 4.1.3. Props available for the tester was a barcode on a piece of paper, and a receipt on a piece of paper. The key points taken out of all the testers was the following:

**Use Case 1** was generally conducted easily. Some pointers were that when in the *My Kitchen* tab of the application, it was a bit confusing for the user having two possibilities to enter the *scanning* screen: a plus-sign aside the *My Groceries* card, together with the *scan*-sign in the bottom bar, all depicted in Figure 10a. One tester wanted to scan all products, being grocery shopping, one by one instead of scanning the receipt, being unsure that the application actually could parse a receipt.

**Use Case 2** seemed to be performed well by the users.

**Use Case 3** was sometimes a bit difficult. The card layout decided to be used for *My Groceries*, depicted in Figure 10a, was a little bit confusing, as some thought of it as only an aesthetic picture, not a clickable picture, hence the signifier needs to be improved.

**Use Case 4** was difficult in the same manner as Use Case 3 were: finding the groceries in the first place. Once the groceries were found, there were no large problems in conducting the specified task. The start screen of the workflow is depicted in Figure 10b.

**Use Case 5** was performed without doubt amongst the testers, in some cases probably due to having seen it before during previous use cases.

**Use Case 6** was also performed well, finding the footprint mark in the bottom bar, depicted in Figure 10m. Finding where to find more advice on how to improve ones footprint was also easy, not finding it difficult to understand the rating system involved in the advice, depicted in Figures 10n, 10o and 10p.

**General comments** mentioned that the waste function, needing to delete a grocery by yourself was not going to be used by the regular user since it needs to much effort. The advice to automatically remove a grocery after estimated sustainability-period was given by some testers.

Further on some stated that they would like to have the opposite functionality of *Generate Recipe*, meaning one could search, choose and add a recipe to a grocery list. Expanded functionality to remove groceries by batch instead of one by one once a recipe was finished cooking, was also brought up by some testers.

# 6 Chronological Hi-Fi Development

## 6.1 Hi-Fi Prerequisites

The first Hi-Fi prototype was constructed as an Android smartphone application with some basic functionality. Some techniques and services were used to make the simple application functionalities work. The following techniques were used:

- **Spoonacular:** An API serving information about different recipes, its ingredients and different steps to cook the meal. Information regarding which recipes matches the current state of a user's inventory at home together with the user's food preferences is a suitable use for this API [31].
- **TAGGUN API:** TAGGUN is an internet service which transcribes a receipt and returns relevant information. This is used to parse a receipt to get hold of which groceries were bought together with prices [32].

## 6.2 Prototyping

Initially, conversion of the Lo-Fi prototype described in Section 5 to a digital format was conducted.

Adjustments from the Lo-Fi prototype are listed below. However, some parts in the conversion from analog to digital were left out due to not being essential in the first version of the Hi-Fi prototype. The complete Hi-Fi prototype can be seen in Figure 11 in Appendix C.

- MyKitchen Screen, depicted in Figure 11a.
  - The plus sign was removed since it made the user uncertain if it did the same thing as entering the scanner view.
- My Groceries, depicted in Figure 11b.
  - The same as above.
  - Removal of groceries is not at all as advanced in the Hi-Fi prototype compared to the Lo-Fi, completely removing the consumption level of a product, letting the user remove groceries via swipe deleting, as depicted in Figure 11c and 11d.

- Recipes
  - No additive graphics, except the recipe title and picture was implemented in this prototype, as depicted in Figure 11e.
  - Missing ingredients and checkboxes on steps on how to cook the recipe are not added in the recipe view, due to simplistic reasons at this stage of the Hi-Fi prototype, depicted in Figure 11f.
- My Waste/Shopping List
  - Since the waste function was not greatly appreciated during Lo-Fi testing as described in Section 5.2.2, this view was completely discarded when converting to the Hi-Fi version. Instead, a shopping list functionality was added to complement the application, depicted in Figure 11g.
- Scanner
  - The functionality to scan a barcode was not implemented in this version of the Hi-Fi prototype, opposed to the Lo-Fi version where one you get information or add or delete specific products based on barcode information.
  - The opportunity to check products in the add products view was not implemented in the Hi-Fi prototype opposed to the Lo-Fi version, as well as actually adding the items was not implemented. See the difference between Figure 10l and 11i.
  - Unintentionally displaying the incorrect title in the scanner view, see Figure 11h and 11i.
- Footprint
  - The only thing implemented in this version of the prototype was the footprint graph. Meaning all the advice to get better within grocery storage handling was left out to this milestone.
- Settings (the following sections mentioned in *italics* are depicted in Figure 10q)
  - *Notification* settings were left out since no notifications were implemented at all.
  - *Knowledge Level* were left out since no advice were implemented.
  - *Your Values* were left out since no advice were implemented.

## 6.3 Testing

Successfully finishing the Hi-Fi prototype, two types of testing were conducted on 8 test subjects, where the methods are described in Section 4.1.4. Firstly the testee was to perform different user tasks, based on the tasks described in Section 5.2.1 but with some slight configuration to fit the new scope and functionality of the application.

**Use Case 1:** *The user has been in a grocery store shopping and arrives home, wanting to insert everything into the application's memory.*

The testers easily found the scanner view, depicted in Figure 11h. The only feedback the user gets after the photo is taken is a spinning wheel, spinning until the response from TAGGUN API is depicted on the screen, shown in Figure 11i. That feedback needs to be more clear and give more information according to several testers. A bug found at this stage was that the spinner stays put in the fragment even though the user switches views, for example to the My Kitchen view.

One other proposal from a tester was to ease the scanning process by taking the image automatically when the camera has focus, though also acknowledging the difficulties to know if there is a receipt in front of the camera or not when camera focus is achieved.

**Use Case 2:** *The user wants to see what recipes could be used to utilize groceries at home.*

Firstly, an observation was made that the generate recipes button has a delay on some couple of 100 milliseconds which confused the user, and many instinctively tried to click twice. Otherwise, the task was explicitly well performed.

Some pointers on the recipe view depicted in Figure 11f was to add the following functionality: when one cooks the recipe one wants to delete all relevant groceries from the storage, or the other way around, add all the relevant groceries to the shopping list to be able to cook that recipe (if one had searched for that recipe instead of automatically generated it). Another idea was to also cross over a specific ingredient within a recipe if it has been used. To visually display which groceries are already at home or are missing was wanted.

Testers seemed to want the functionality to make a recipe a favorite and finding it later on easier.

**Use Case 3:** *The user is at the grocery store, wanting to check what groceries are already at home, avoiding to purchase duplicates.*

This was performed without any doubt amongst all testers.

**Use Case 4:** *The user has consumed one of the groceries, and wants to remove it from the application's memory.*

Many testers thought that the items in the grocery list didn't signify enough that it was possible to swipe to delete, though most found the functionality after some time.

**Use Case 5:** *The user wants to check its environmental impact.*

The view in mind was generally easy to find for the testers. Understanding the graph and its content was not as easy for the majority, mainly due to mentioning the carbon footprint in CO<sup>2</sup>-equivalents, which most people can not perceive correctly. Some adjustment proposals mentioned mentioning or visualizing some kind of average value for a typical Swede, also changing colors so one easier can distinguish different categories.

**General Pointers:** To move the groceries from the *My Groceries* screen depicted in Figure 11b to the home screen instead, was generally thought of as a good idea, since the home screen did not have any special functionality. However, that change would bring with a confusion of which list is what, thinking of both the shopping list and my grocery list.

The functionality to add a grocery to one's shopping list was missing. Some confusion existed when ticking off a grocery from the shopping list since the removal of a grocery was different in the *My Groceries*-list and the *Shopping List*. Another pointer was to add an undo action in the *Shopping List* making an unintentionally removed grocery easy to bring back to its normal state.

The Preferences screen depicted in Figure 11k got the comment of having duplicate titles.

# 7 Chronological Final Prototype Development

## 7.1 Prototype Architecture

The architecture for the final prototype has the structure as depicted in Figure 9.

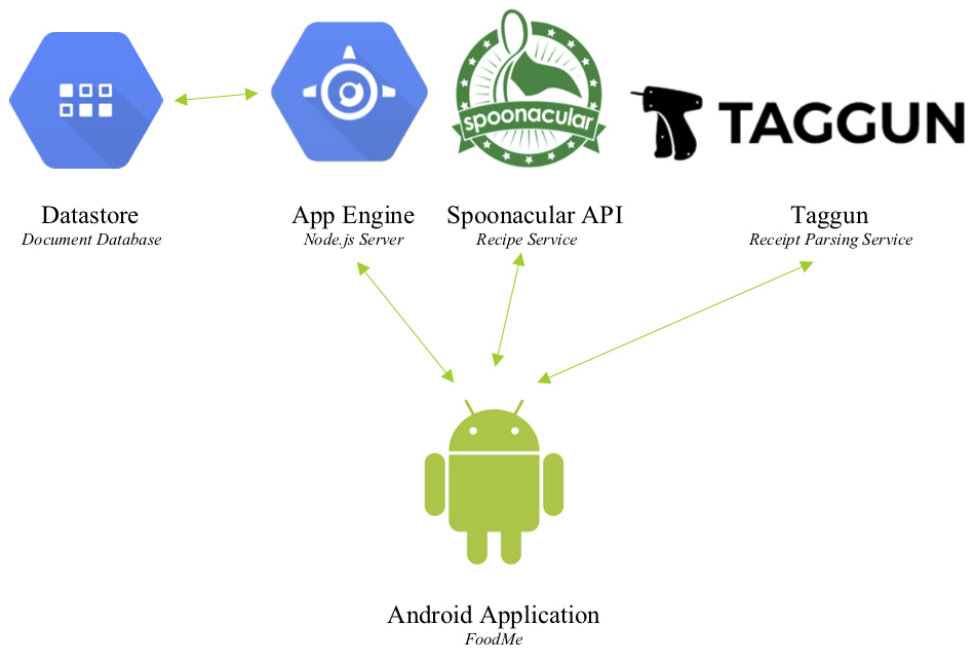


Figure 9: Solution architecture of the application together with its services. To start with the smartphone application is depicted at the bottom of the figure. The arrows from the application depict internet communication, enabling an exchange of information. Google Cloud's product *App Engine* has been used to host a Node.js server, simply connecting the smart-phone application with a database, which in this case is the Google Cloud Datastore. Further on services like Spoonacular API and TAGGUN has been used to get hold of recipe information and parsing receipt data, respectively.

## 7.2 Prototyping

The development progress has in this stage of the thesis been based on previous Hi-Fi prototype described in Section 6, and its testing results described in Section 6.3. The changes made are described below in a short format. The final prototype in its whole, is depicted in Figure 12 in Appendix D.

- Login Screen depicted in Figure 12a.
  - Simply the alternative to logging in and attach specific grocery data to each user has been added.
- My Kitchen Screen, depicted in Figure 12c.
  - Moving the user’s inventory list to the first screen has been made, instead of having a rather dead screen as the home page. See the difference in Figure 11a and 12c.
  - Sorting the groceries in this view is now done, showing the latest scanned at the top of the list, see Figure 12c.
  - Deleting a grocery now actually deletes it, not only mocking as in the Hi-Fi prototype, described in Section 6.
- Recipes
  - The recipe title is showing in the title bar when a recipe has been selected, see the difference between Figure 11f and 12g.
  - Some added rows, spaces and words have been used to simply clarify a recipe instruction, see Figure 12g.
- Shopping List
  - A floating plus-sign button has been added to this view, depicted in Figure 12h. Its intended function is to add an editable item to the shopping list, but that has not been implemented.
- Scanner
  - The title in the title bar has been changed to the correct one, see difference in Figure 11h and 12i.
  - The button color in the view depicted in Figure 12i has been aligned with the rest of the application.
  - The possibility to select and deselect certain items in the result of scanning a receipt has been added, see Figure 12j and 12l.
  - The possibility to edit the spelling on a certain item amongst the scanning result has been added, see Figure 12k.
  - The functionality to add all the groceries selected and edited to a user’s kitchen has been added, see Figure 12l.



- Footprint
  - A list with advice has been added to this section of the application. Via clicking on the button *Want Some Advice?* in the *Footprint* view depicted in Figure 12m, one gets redirected to the view depicted in Figure 12n. Only advice regarding how to best freeze food has been added, including information pieces regarding expected lifetime and a description on how to treat the product before and after.
- Settings
  - Removal of an unnecessary duplicate header in the settings section has been removed, see the difference in Figures 11k and 12o.
- Loading state descriptions have been added, showing some kind of message to the user, describing the ongoing processing by the application. One example is depicted in Figure 12b. All of them are described below, with the message visualized to the user in *italics*.
  - Logging the user in.
    - *Logging in...*
  - Fetching a user’s groceries from the service described in Section 7.1, happens before the screen depicted in Figure 12c.
    - *Fetching Your Groceries...*
  - Generating recipes based on a user’s inventory of groceries. Happens before the screen depicted in Figure 12f.
    - *Generating Recipes...*
  - Getting recipe instructions. Happens before the screen depicted in Figure 12g.
    - *Getting Instructions...*
  - Fetching a user’s shopping list. Happens before the screen depicted in Figure 12h.
    - *Fetching Your Shopping List...*
  - Processing a scanned receipt. Happens before the screen depicted in Figure 12j.
    - *Processing Receipt...*
  - Calculating a user’s footprint. Happens before the screen depicted in Figure 12m.
    - *Calculating Footprint...*

## 7.3 Testing

Two types of testing were conducted, as described in Section 4.1.4, on 8 separate testers on the final prototype. Firstly the testee was to perform different user tasks, based on the tasks described in Section 5.2.1 but with some slight configuration to fit the new scope and functionality of the application. However, no adjustments to the use cases have been made from the previous prototype mentioned in Section 6.3.

**Use Case 1:** *The user has been in a grocery store shopping and arrives home, wanting to insert everything into the application's memory.*

Some users, being first-time testers as well, experienced it to be difficult to know what to do and how to do it, e.g. how and exactly what to scan. Eventually, after some exploration of the application, they understood and scanned the receipt. It was also a bit difficult understanding that the groceries, once scanned, were editable. To make it easier for first-time users the receipt icon in the bottom navigation bar, seen in Figure 12c, could be exchanged to a scanner icon, looking similar with one at any pay desk at a grocery store. Also some extra information in the camera view was requested, seen in Figure 12i, helping the user take a photo of a receipt. Examples given from testers were some kind of guidance outlining the receipt when it is found.

One user mentioned that the *Add to My Kitchen*-button, seen in Figure 12l should be visible at all times, so the user understands that the groceries can be added.

Some users did not understand the purpose of the numbers out in the far right on each item instinctively, so some kind of improvement of that information is necessary, seen in Figures 12j and 12l.

Generally, there is a lot of text in the response from parsing of a receipt. Some users thought it overwhelmingly much, not really able to take in everything happening on the screen.

**Use Case 2:** *The user wants to see what recipes could be used to utilize groceries at home.*

Some first-time users did not find the button which directs the user to a list with generated recipes based on its groceries, very easily but had to look for it a while.

Thoughts raised were that the user wants to customize the behavior of the list, seen in Figure 12f, more, e.g. enabling the alternative to simply have all the recipes as a list without all the images, or to have the images in two columns instead of one. Design-wise some testers thought that the titles need to be more aligned to make a consistent design behavior, but also add data about a specific recipe's footprint.

In a specific recipe, seen in Figure 12g, some users thought it would be cool to include images of all groceries, or at least have it as an option for users to hide/show.

**Use Case 3:** *The user is at the grocery store, wanting to check what groceries are already at home, avoiding to purchase duplicates.*

This task was performed very well amongst all testers. Some mentioned the idea of making the list searchable.

**Use Case 4:** *The user has consumed one of the groceries, and wants to remove it from the application's memory.*

The workflow of this task was not entirely easy if the user did not pay too close attention. Looking at Figures 12c, 12d and 12e, the button *UNDO* is becoming clickable after a swipe is performed. Mentioned button did for many testers trigger a thought "Are you sure you want to delete?" and clicked it instinctively, which in the end resulted in the grocery not being deleted since the button *UNDO*'s action is to undo the deleting action of the user. Some thought it difficult finding the opportunity to swipe an item, but just out of previous knowledge and experience accidentally found the possibility to swipe.

Some improvement suggestions where that the items should be clickable. Either show information about a certain grocery (image, price, footprint, date bought etc.) or just make the item bounce a little bit to the left, signifying to the user that it is possible to swipe.

**Use Case 5:** *The user wants to check its environmental impact.*

It is generally easy to find the environmental impact a user has, but the meaning of the graph and its numbers, which can be seen in Figure 12m, is not as easy to interpret. Some advice mentioned by the testers was the following: make the graph bigger; work more with icons within the graph to make it playful; ease the action one has to make to see a specific month's impact; compare the numbers with things people understand, e.g. miles driven by car.

To further find advice on how to get better within the area of treating ones food was easy, see Figure 12n. Further development and ideas were to treat areas like what to put in your fridge (together with a fridge-icon) or in your pantry.

**General Pointers:** Once again the advice on how to delete groceries after a recipe has been cooked was given, to delete all groceries used in a recipe from the inventory all at once.

To add a grocery to one's shopping list after deleting, still though making it a choice for the user, was a wanted feature in the future. Also, testers mentioned wanting to have some groceries added to the shopping list on a weekly basis, such as milk or cereal, automatically.

Generally, all the buttons could be bigger and with larger text. For example, the bottom buttons in all views could span from side to side and be a little higher as well.

To further separate the *My Kitchen*-view and the *Shopping List*-view, seen in Figures 12c and 12h, one could change the interface even more, avoiding confusion. The example of simply beginning each view with an illustration was given, a refrigerator for the *My Kitchen*-view, and a shopping bag for the *Shopping List*-view.

Additive functionality suggestions were the possibility to scan a grocery in a store, finding out its carbon footprint and comparisons to other groceries, making it easier as a user to decide what to buy.

## 8 Discussion

This thesis has evaluated a combination of technologies to most efficiently utilize groceries at home, and several different aspects are considered within this discussion. In this chapter, to begin with, the actual question in itself will be evaluated to which extent it is answered, followed by evaluations of the fulfillment of goals, working process and lastly stating future work possibilities.

With the application produced some of the aspects thought of at the beginning of the project has been solved or been made easier. In an easy, and feasible, way insert all of the groceries present on a receipt, to easier keep track of them and also get help on how to best use them in recipes, or how to store them better, makes the produced application a solid candidate on how to reduce your food waste. Simply put:

- By using the receipt scanning technology via the utilization of the TAGGUN API, receipt data can be perceived and used in the application.
- Utilizing recipe databases one can with the help of the application find out what recipes would fit for the current grocery inventory.
- Utilizing research data regarding storage compatibility on different types of food, relevant advice can be given to the user.

This would, in fact, make the grocery managing in a household easier. Still, research needs to be done to evaluate this concept further and validate if this statement is true, and that the application would help the user.

The goals mentioned in Section 2 have been thought of throughout this paper and have helped guide the result.

*Raise food-connected sustainability consciousness amongst users* was the first goal. This has been an important factor during the development of the prototype, inflating the application's core. One could argue that food-connected sustainability thoughts arises when using the application, since it helps one keep track of current food and how to store it. Whilst using it, some kind of consciousness is raised. In extension, if further work would have been done, giving advice on better groceries to buy environmentally wise, could improve the result of this goal.

*Raise concern about the growing problem of waste in general* has not really inflated the final prototype as much as the previously mentioned goal. This probably due to reasons from the next goal, *use nudging to facilitate for the user to make more environmentally friendly decisions without causing distress*, where causing distress

was weighed as very important not to create during this thesis. Informing about the waste problem to users would most likely create anxiousness about throwing away food, and as stated in Section 3 that will most likely cause one to unintentionally throw away even more food. However, by not explicitly informing the user about the food waste problem, but instead letting them realize how much themselves are throwing away, the anxiety problem is somewhat surpassed.

The working process applied in this project has been reviewed by supervisors from both the university and from Jayway. This thesis has been conducted by one person, possibly affecting all the moments throughout the project timeline, hence discussions, ideas etc. may have been unintentionally left out. The help of others in brainstorming sessions or workshops has been utilized to the greatest extent possible, trying to get a larger and broader inclusion of ideas and to minimize the drawbacks on being one person.

A literature study was conducted to find facts about the current problem statement and find possible ways of performing something better than already existing. Some facts may have been difficult to find even though several literature databases were used to find data, possibly constraining the outcome of this project.

The survey created in this thesis is described in Section 4.1.1, its results in Section 5.1.1, and in its whole in Appendix A. When participating in a survey, possible faulty assumptions are easy to make, affecting the total result of the survey. Having a quite large participation audience this possible fault is hopefully small, but still existent. Both questions, and freely text-written answers for that matter, could have been misinterpreted which would result in a somewhat non-accurate result. Also, the participation audience were mainly consisting of technically competent people, being mostly engineering students or employees at Jayway. That obviously affects the outcome of the survey results, not including a broader audience.

The possibility of unintentionally including own reflections or own observations from home or in the grocery store is also a possible fault source in this thesis.

High prioritization has been made on successfully finishing a working prototype, making the application actually usable, and making the concept technically testable, enabling evaluation of the concept in its essence. This has, of course, affected some of the design, not making enough iterations on specifically the Lo-Fi version of the application, mentioned in Section 5.

Producing a final prototype with actual working implementation maybe was not the correct way of evaluating the concept in mind. However, if only a Lo-Fi and Hi-Fi prototype were to be constructed, the technologies needed for the actual application would not have been evaluated at all, e.g. the receipt parsing technology used from TAGGUN and the recipe service from Spoonacular. Some drawbacks have come with the use of those technologies though. Having several steps of parsing and interpretation within the application may cause error. First of all, the receipt parsing service did not at all times parse the receipt correctly, needing spelling and inclusion

corrections from the user. Secondly, the receipts parsed were in Swedish, making the groceries saved in the application in Swedish as well. This quickly becomes a problem, since the only reasonable recipe service available for this project was in English, obviously causing problems when searching for recipes based on Swedish grocery names. To use Google's own translation service would be an alternative, though making the line of corrections to the groceries even longer together with the fact that the translations are not of the best quality, especially when the grocery is misspelled from the beginning. Unfortunately, the problem stated leads to an unusable product in Sweden at least, if the user does not manually translate the groceries to English. The application would work in an English speaking country though.

If there would be an open data service with recipe data in Swedish the extra step of translating the grocery to English, making it usable in a search on an English recipe data service, would not have been needed.

Including the technologies in the prototype development included an extra dimension to the evaluation, not only evaluating the concept in itself of taking care of the current grocery inventory but also to which extent external services exist to complement and support the application and make it complete. Such services would otherwise be very time-consuming to produce by oneself.

The testing techniques used are described in Section 4.1.4. Only being one person conducting the tests was a bit difficult at times, since many different aspects of the testee needs to be observed, also including giving instructions when necessary, making this very reliant on multitasking qualities from the tester. With the help of audio recording together with intensive note taking during the sessions, the fault has been minimized as much as possible.

The testing audience has had, in many cases, an IT-background and easily understands new digital products, and only a few did not have any previous professional IT experience. This, of course, affects the result of the testing sessions, and may falsely cause one to think the application or prototype is better than it actually is. However, including those with professional IT experience could also mean getting higher value comments on things that in the business is a known usability problem etc. The testing audience, in this case, could be both negative and positive for the outcome.

## 8.1 Future Work

Many thoughts resulting from the many brainstorming workshops held, described in Sections 5, 6 and 7, were not implemented during the course of this project. Here are the most relevant ones:

- Implementing a notification service, notifying the user of a: 1) grocery going bad, and suggesting a recipe that would fit; 2) grocery storage advice, making it easier to store and sustain a groceries freshness longer.
- Create some kind of automatic remover from the inventory, not letting the user remove everything by oneself, which inevitably requires a lot of effort.

- Extending the advice section in the application, including advice regarding seasonal food choices, and environmentally better choices in regards to what the user has already bought.
- Add the possibility to scan a certain grocery, informing the user of other substitutes, being better or worse in an economic, health and environmental aspect.
- Further items implementation-wise can be found on the Android and Back-End repositories respectively [33, 34].

## 9 Conclusion

Thinking back to the introduction in Section 1, and its problems and questions stated, why does all this research matter?

Basically, thinking about the way we treat our planet currently, there is something wrong in our behavior. Humans, being lazy in its nature, will not by themselves learn how to be environmentally kind, if not everyone suddenly starts caring about earth, hence raising consciousness about environmentally friendly ways of living. This turnout, however, is not likely in the current state of humanity, though likely for coming generations both being brought up differently and depending on a certain living styles preserving the environment. Therefore, in the present, being able to nudge people together with smart technologies deliberately making them choose environmentally smart alternatives of living, is the current way to go.

Applying this statement to the research question brought up in this paper, mentioned in Section 1: *How can we, with the help of today's technology, reduce food waste and at the same time affect interest and consciousness about food sustainability for individuals positively?*, a nudge toward a more environmentally healthy lifestyle when it comes to food waste is performed by the prototype created in this thesis.

Finding some benefits that people would like to improve, e.g. utilizing all groceries at home to save some money, which in turn lessens one's food waste, is a good way to overcome current problems within this area. Finding these improvement factors is essential for a positive development, basically identifying a need in the current living style, which then can be used to nudge the user in the right direction environmentally life-style speaking.

This report describes how to perform nudging toward a healthier relationship to food waste. With the help of the developed smartphone application some of the food waste otherwise created, can be saved, also raising crop land efficiency, saving water and fertilizer otherwise used in vain. The prototype has gotten splendid feedback both for further improvement, but also the feedback that many people would like to use it. Further on, how would one go about nudging the food consumption even further, extracting meat, fish or chicken from the regular diet, without creating anxiousness?



# References

- [1] Schanes K, Dobernig K, Gözet B. Food waste matters - A systematic review of household food waste practices and their policy implications. *Journal of Cleaner Production*. 2018 February;182:978–991.
- [2] Vilariño MV, Franco C, Quarrington C. Food loss and Waste Reduction as an Integral Part of a Circular Economy. *Wastewater Management, a section of the journal Frontiers in Environmental Science*. 2017 May;5:978–991.
- [3] Kumm M, de Moel H, Porkka M, Siebert S, Varis O, Ward PJ. Lost food, wasted resources: Global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use. *Science of the Total Environment*. 2012 September;438:477–489.
- [4] Avfall Sverige AB. Förbehandling av matavfall för biogasproduktion - inventering av befintliga tekniker vid svenska anläggningar. Avfall Sverige; 2013.
- [5] Ek C, Miliute-Plepiene J. Behavioral spillovers from food-waste collection in Swedish municipalities. *Journal of Environmental Economics and Management*. 2018 March;89:168–186.
- [6] European Commission. Being wise with waste: the EU's approach to waste management. European Union; 2010.
- [7] Anshari M, Alas Y, Hardaker G, Jaidin JH, Smith M, Ahad AD. Smartphone habit and behavior in Brunei: Personalization, gender, and generation gap. *Computers in Human Behavior*. 2016 August;64:719–727.
- [8] Harwood J, Dooley JJ, Scott AJ, Joiner R. Constantly connected – The effects of smart-devices on mental health. *Computers in Human Behavior*. 2014 March;34:267–272.
- [9] Keightley PC, Koloski NA, Talley NJ. Pathways in gut-brain communication: Evidence for distinct gut-to-brain and brain-to-gut syndromes. *Australian & New Zealand Journal of Psychiatry*. 3 September;49:207–214.
- [10] United Nations. The Sustainable Development Goals Report 2018. New York: United Nations; 2018.
- [11] Michelinia G, Moraesa RN, Cunhab RN, Costaa JMH, Ometto AR. From linear to circular economy: PSS conducting the transition. *Procedia CIRP*. 2017;64:2–6.

- [12] Jansson T. Vad är cirkulär ekonomi? CurcularEconomy.se; 2015. Online; accessed 10 September 2018. <http://circulareconomy.se/vad-ar-cirkular-ekonomi/>.
- [13] Ellen MacArthur Foundation. Circular Economy Overview. Ellen MacArthur Foundation; Online; accessed 10 September 2018. <https://www.ellenmacarthurfoundation.org/circular-economy/overview/concept>.
- [14] Statistiska Centralbyrån. HUSHÅLLEN SLÄNGER 4,4 MILJONER TON SOPOR VARJE ÅR. SCB; Online; accessed 10 September 2018. <http://www.scb.se/hitta-statistik/sverige-i-siffror/miljo/avfall/>.
- [15] Bauer F, Hulteberg C, Persson T, Tamm D. Biogas upgrading – Review of commercial technologies. Malmö: Svenskt Gastekniskt Center AB; 2013.
- [16] Russella SV, Younga CW, Unswortha KL, Robinson C. Bringing habits and emotions into food waste behaviour. *Resources, Conservation & Recycling*. 2017 June;125:107–114.
- [17] Borrello M, Caracciolo F, Lombardi A, Pascucci S, Cembalo L. Consumers' Perspective on Circular Economy Strategy for Reducing Food Waste. *Sustainability*. 2017;9(1):141.
- [18] Jurgilevich A, Birge T, Kentala-Lehtonen J, Korhonen-Kurki K, Pietikäinen J, Saikku L, et al. Transition towards Circular Economy in the Food System. *Sustainability*. 2016;8(1):69.
- [19] Brown T, Hipps NA, Easta S, Parry A, Evans JA. Reducing domestic food waste by lowering home refrigerator temperatures. *international journal of refrigeration*. 2014;40:246–253.
- [20] Brown T, Hipps NA, Easta S, Parry A, Evans JA. Reducing domestic food waste by freezing at home. *international journal of refrigeration*. 2014;40:362–369.
- [21] Arno A, Thomas S. The efficacy of nudge theory strategies in influencing adult dietary behaviour: a systematic review and meta-analysis. *BMC Public Health*. 2016;16:676.
- [22] Sunstein CR. Nudging: A Very Short Guide. 37 *J Consumer Pol'y*. 2014 September;583.
- [23] Wilsona C, Hargreavesb T, Hauxwell-Baldwin R. Benefits and risks of smart home technologies. *Energy Policy*. 2017;103:72–83.
- [24] Norman D. *The Design of Everyday Things*. New York: Basic Books, A Member of the Perseus Books Group; 2013.
- [25] Rogers Y, Sharp H, Preece J. *Interaction Design - beyond human-computer interaction, Third Edition*. West Sussex, United Kingdom: John Wiley & Sons Ltd; 2011.

- [26] Wei Y, Le T. Using the Wizard-of-Oz Method for Exploring Deep Customer Experience Preferences. 2018 June;p. 1–8.
- [27] Baum LF. The Wonderful Wizard of Oz. Chicago, Illinois, United States: George M. Hill Company; 1900.
- [28] Wrike. 7 Techniques for More Effective Brainstorming. Wrike;. Online; accessed 14 September 2018. <https://www.wrike.com/blog/techniques-effective-brainstorming/>.
- [29] MindTools. Starbursting - Understanding New Ideas by Brainstorming Questions. MindTools;. Online; accessed 14 September 2018. [https://www.mindtools.com/pages/article/newCT\\_91.htm](https://www.mindtools.com/pages/article/newCT_91.htm).
- [30] Boutanios Z. Creativity Measurement and the 6-3-5 Brainwriting Method. Faculty of Mechanical Engineering and Naval Architecture at FSB, Croatia.; 2014/2015.
- [31] Spoonacular. Food API and Recipe API. Spoonacular;. Online; accessed 19 December 2018. <https://spoonacular.com/food-api>.
- [32] TAGGUN. TAGGUN offers receipt OCR API with real-time receipt processing. TAGGUN;. Online; accessed 19 December 2018. <https://www.taggun.io/product/>.
- [33] PeterSkopal. FoodMe.App. GitHub;. Online; accessed 2 January 2019. <https://github.com/PeterSkopal/FoodMe.App>.
- [34] PeterSkopal. FoodMe.API. GitHub;. Online; accessed 2 January 2019. <https://github.com/PeterSkopal/FoodMe.Api>.

# A Survey - Mapping Household Food Habits

To begin with the actual survey is presented in Section [A.1](#), with its different progress sections. The results from the survey is presented in Section [A.2](#). The survey was sent to numerous places:

- a Facebook Group called D-sektionen LTH with all the members in the Computer Science Faculty at LTH. (Done 13<sup>th</sup> September 2018)
- on Peter Skopal's wall on LinkedIn. (Done 13<sup>th</sup> September 2018)
- in a general channel on Jayway's main source of communication. (Done 13<sup>th</sup> September 2018)

## A.1 Survey

\*

Household Food Habits Hello!

My name is Peter Skopal and I'm currently writing my Master Thesis at Jayway in Stockholm, trying to reduce food waste in our households with the help of today's technology. This thesis will be based upon UN's sustainability goals:

- 2 (zero hunger)
- 6 (clean water and sanitation)
- 12 (responsible consumption and production).

The food is not the only thing wasted but also the 27 cubic meters of water, used for watering crops that eventually is wasted, per capita and year.

The goal of producing this survey is to get a hold on what you value when buying groceries and cooking your meals, but also what kind of habits you have in your household when it comes to recycling your waste.

Thanks for taking this survey, hopefully we can achieve a change that matters!

**Question:** *First of all, what are your food preferences?*

- All-eater

- Pescatarian
- Vegetarian
- Vegan
- Other...

\*

During Purchase

**Question:** *What do you value the most when buying food?*

- The Environment
- Your Health
- Your Economy
- Working Environment for Product Producers
- Other...

**Question:** *In the store, would you buy a fruit or vegetable being imperfect in shape?*

- Yes
- No

### During Cooking

**Question:** *What do you value the most when cooking food?*

- Takes little time
- Easy recipe
- Tastiness of meal
- Health quality of meal
- Other...

### Waste Management

**Question:** *The food waste you are producing, how do you mainly throw it away?*

- Food Waste Bin
- Compost
- Residual Waste Bin
- Other...

**Question:** *What of the following do you recycle and to what extent?*

- Plastic (Nothing — Some — Everything)
- Glass (Nothing — Some — Everything)
- Metal (Nothing — Some — Everything)
- Paper (Nothing — Some — Everything)
- Electronic Waste (Nothing — Some — Everything)

**Question:** *Are you actively trying to reduce your food waste today?*

- Yes
- No
- Other...

**Question:** *If yes, how?*

Text Answer...

**Question:** *If no, why not?*

Text Answer...

## Wrapping up

**Question:** *If a digital platform, supposedly a mobile application, were to be developed helping to reduce food waste, what would you have liked to be the number one feature?*

Text Answer...

**Question:** *Please write down your email address if you agree to be contacted at a later stage in this thesis.*

Text Answer...

## A.2 Survey Results

In total 143 people answered the questionnaire.

**Question:** *First of all, what are your food preferences?*

- 80.4 % – All-eaters
- 5.6 % – Pescatarian
- 7.0 % – Vegetarian
- 4.9 % – Vegan
- 2.1 % – Other...

## **During Purchase**

**Question:** *What do you value the most when buying food?*

- 17.5 % – The Environment
- 42.0 % – Your Health
- 30.1 % – Your Economy
- 1.4 % – Working Environment for Product Producers
- 9.0 % – Other...

**Question:** *In the store, would you buy a fruit or vegetable being imperfect in shape?*

- 76.9 % – Yes
- 23.1 % – No

## **During Cooking**

**Question:** *What do you value the most when cooking food?*

- 19.6 % – Takes little time
- 7.7 % – Easy recipe
- 53.8 % – Tastiness of meal
- 17.5 % – Health quality of meal
- 1.4 % – Other...

## **Waste Management**

**Question:** *The food waste you are producing, how do you mainly throw it away?*

- 58.7 % – Food Waste Bin
- 12.6 % – Compost
- 25.2 % – Residual Waste Bin
- 3.5 % – Other...

**Question:** *What of the following do you recycle and to what extent?*

- Plastic ( [8.4 %] Nothing — [37.1 %] Some — [54.5 %] Everything )
- Glass ( [3.5 %] Nothing — [9.8 %] Some — [86.7 %] Everything )
- Metal ( [5.6 %] Nothing — [18.2 %] Some — [76.2 %] Everything )
- Paper ( [7.7 %] Nothing — [43.4 %] Some — [49.0 %] Everything )
- Electronic Waste ( [4.2 %] Nothing — [20.3 %] Some — [75.5 %] Everything )

**Question:** *Are you actively trying to reduce your food waste today?*

- 74.8 % – Yes
- 24.5 % – No
- 0.7 % – Other...

**Question:** *If yes, how?*

Generally the following answers were given:

- By eating up everything I've bought before it goes bad.
- By freezing things I know I won't have the time to eat up before it goes bad.

**Question:** *If no, why not?*

Generally people who did not actively try to reduce their food waste, did on this question answer that they did not have that much food waste to begin with.

## Wrapping up

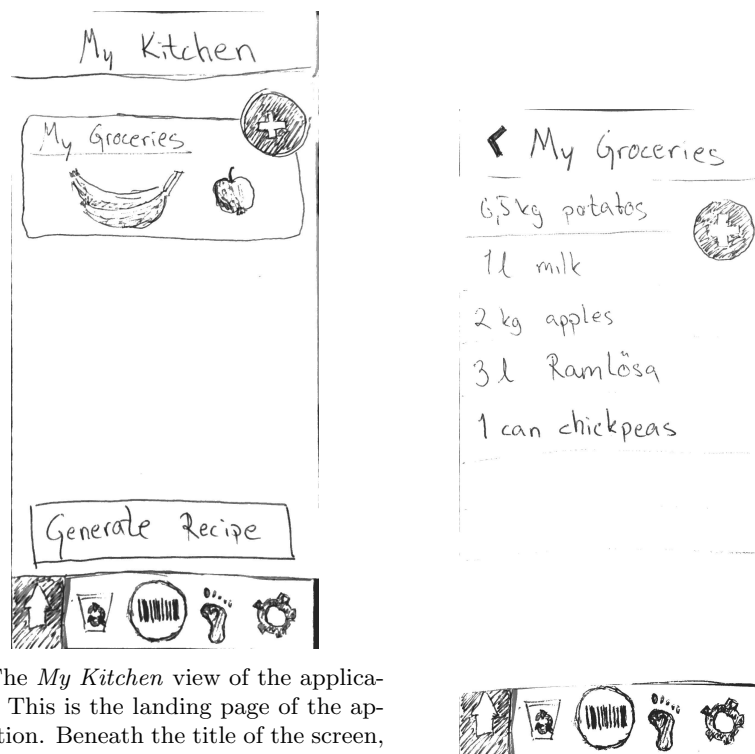
**Question:** *If a digital platform, supposedly a mobile application, were to be developed helping to reduce food waste, what would you have liked to be the number one feature?*

Survey participants had somewhat similar opinions within this area. Here are several subjects that were mentioned the most:

- Notifications telling the user that a grocery item is soon going bad, or over its due date.
- Automatically generate recipes based on groceries one has at home.
- To raise consciousness about the environmental impact food has and how selective grocery shopping can change your habits and impact.



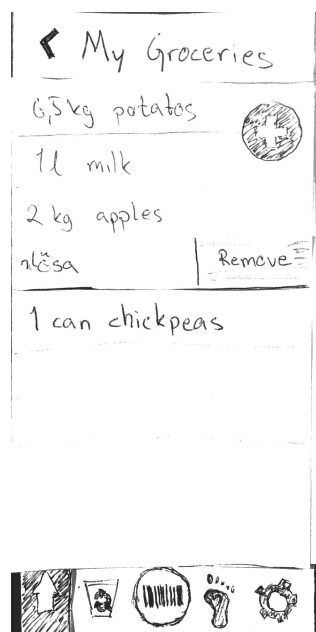
## B Lo-Fi Prototype



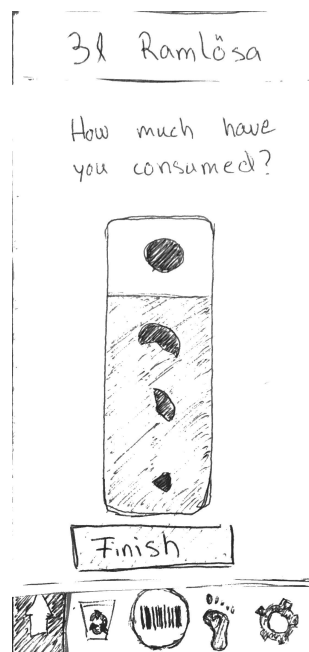
(a) The *My Kitchen* view of the application. This is the landing page of the application. Beneath the title of the screen, there is a card containing a picture of general food. If one presses mentioned card, one is directed to *My Groceries*, depicted in Figure 10b. If the plus button, or the scan sign in the bottom bar, is pressed, the user is directed to the scan screen, depicted in Figure 10h. If the button containing *Generate Recipe* is pressed, one is directed to a recipe screen, depicted in Figure 10e.

(b) The *My Groceries* view of the application. This is basically a list containing a user's inventory of groceries at home. If the plus sign is pressed the user is directed to the scan screen depicted in Figure 10h.

Figure 10: Lo-Fi prototype.

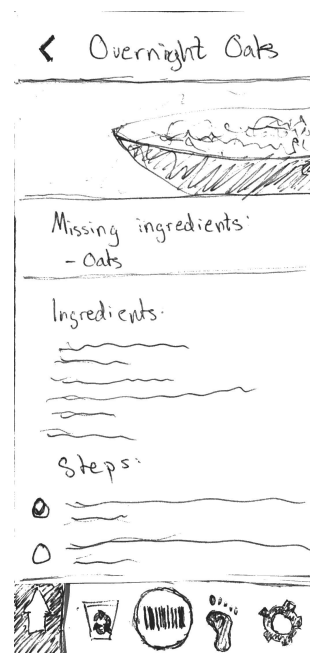
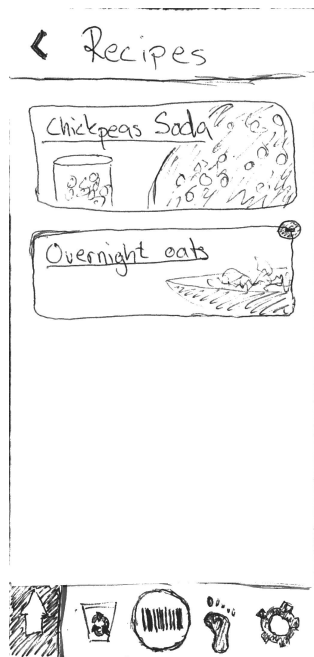


(c) The *My Groceries* view of the application. The user has in this case swiped on a grocery revealing an opportunity to remove it. If the user proceeds and click the new button, a direction to the screen depicted in Figure 10d is made.



(d) A screen making the user decide on how much of a certain products has been consumed before throwing it away. Pressing the finish button one is directed back to the *My Groceries* screen depicted in Figure 10b.

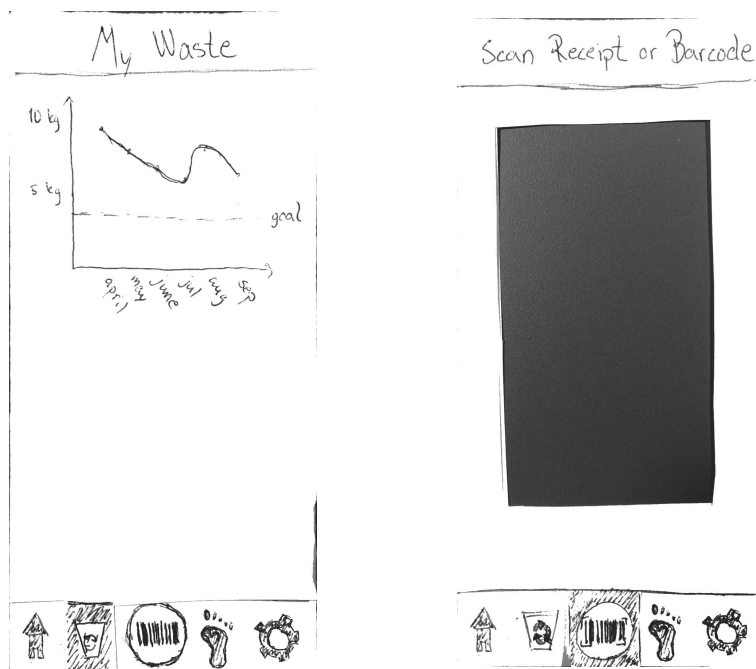
Figure 10: Lo-Fi prototype. (cont.)



(e) A screen depicting generated recipes based on the current inventory of the user's kitchen. The minus sign on the second card *Overnight oats* indicates that the user lacks some groceries to be able to cook that recipe. If one clicks on any of the cards a redirection is performed to a screen depicting instructions to perform that recipe, depicted in Figure 10f.

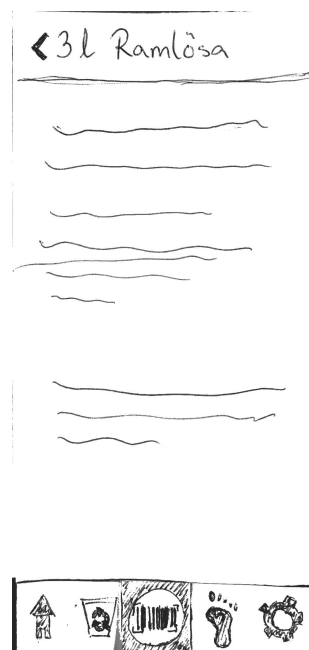
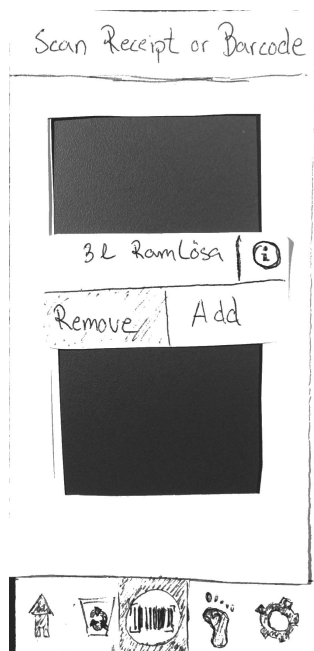
(f) A specific recipe containing missing descriptions of ingredients needed, and step instructions to cook the recipe.

Figure 10: Lo-Fi prototype. (cont.)



- (g) This screen is depicting a user's produced waste, based on information gathered from the *My Groceries* section and its waste measurements, depicted in Figure 10d.
- (h) This screen is depicting a view containing a camera-preview. The camera would auto detect a receipt or bar code in front of it redirecting to either screens depicted in Figure 10i or 10k.

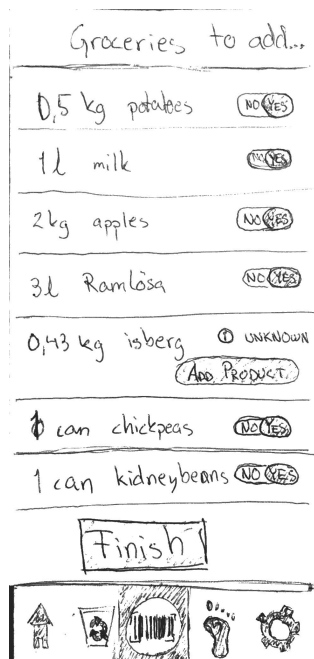
Figure 10: Lo-Fi prototype. (cont.)



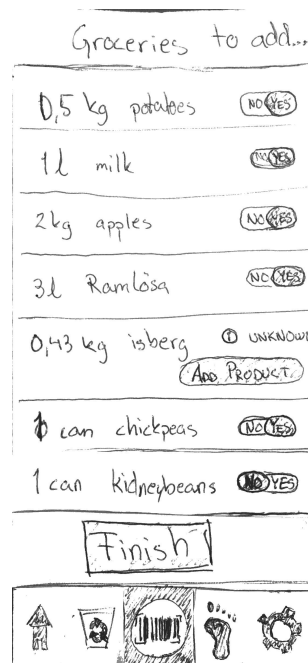
(i) This pop-up is shown for the user when a barcode has been successfully scanned. If the grocery exist in the user's inventory a remove button is shown, and if clicked the user is directed to the screen depicted in Figure 10d. Otherwise the user can either get information about the grocery, depicted in Figure 10j or add to its inventory.

(j) Screen depicting information about a certain grocery.

Figure 10: Lo-Fi prototype. (cont.)

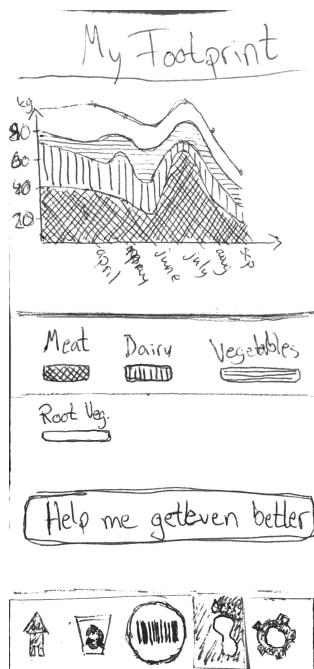


(k) Screen containing the groceries scanned on a specific receipt. The opportunity to select certain groceries to be included to the inventory addition together with adding products not previously known to the application is available. Clicking the *Finish*-button will add all selected groceries to the user's kitchen inventory and redirect to the *My Kitchen*-screen depicted in Figure 10a.

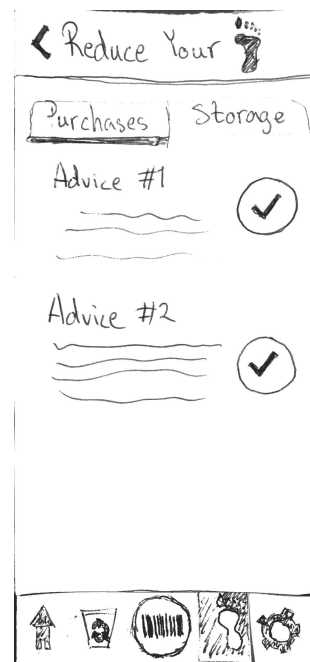


(l) Depicting how a certain grocery in the list in deselected, not going to be included in the addition of groceries to a user's inventory. Clicking the *Finish*-button will add all selected groceries to the user's kitchen inventory and redirect to the *My Kitchen*-screen depicted in Figure 10a.

Figure 10: Lo-Fi prototype. (cont.)

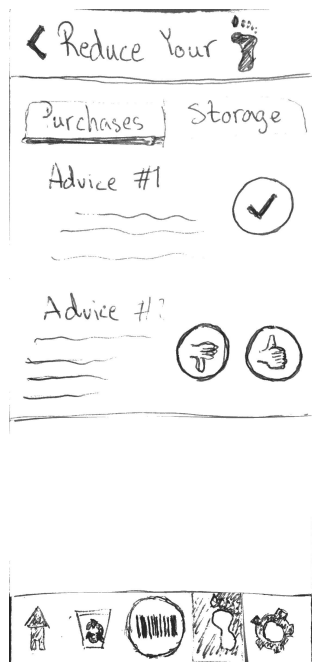


(m) This screen depicts a users impact on the environment, specifically measured in CO<sub>2</sub> equivalents. The graph is depicted in a way where different categories of food represent different sections or shares of the total impact. If the user presses the *Help me get even better* button one is directed to the screen *Reduce Your Footprint*, depicted in Figure 10n.

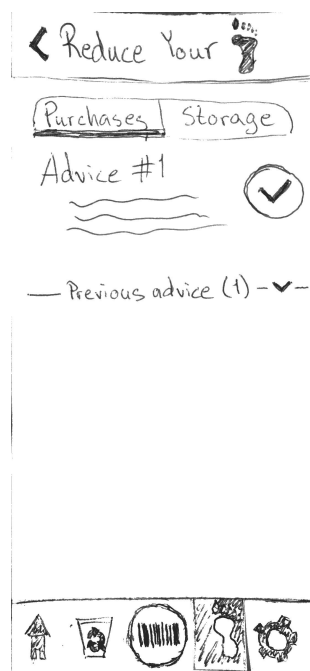


(n) This screen depicts different advice, all depending on a users latest purchase. If one presses the check mark on Advice #2 one is directed to Figure 10o.

Figure 10: Lo-Fi prototype. (cont.)



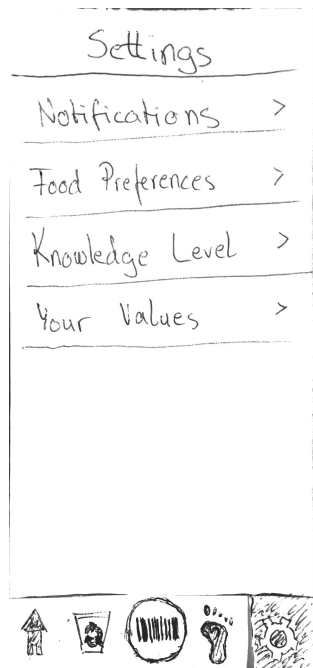
(o) Once in this screen the user is expected to rate the advice previously having a check mark, with either a thumbs up or down. Clicking one of those the user is then redirected to the screen depicted in Figure 10p.



(p) Depicting one current purchasing advice, concerning how to lower carbon footprint on certain grocery categories, and the opportunity to show previous advice.

Figure 10: Lo-Fi prototype. (cont.)

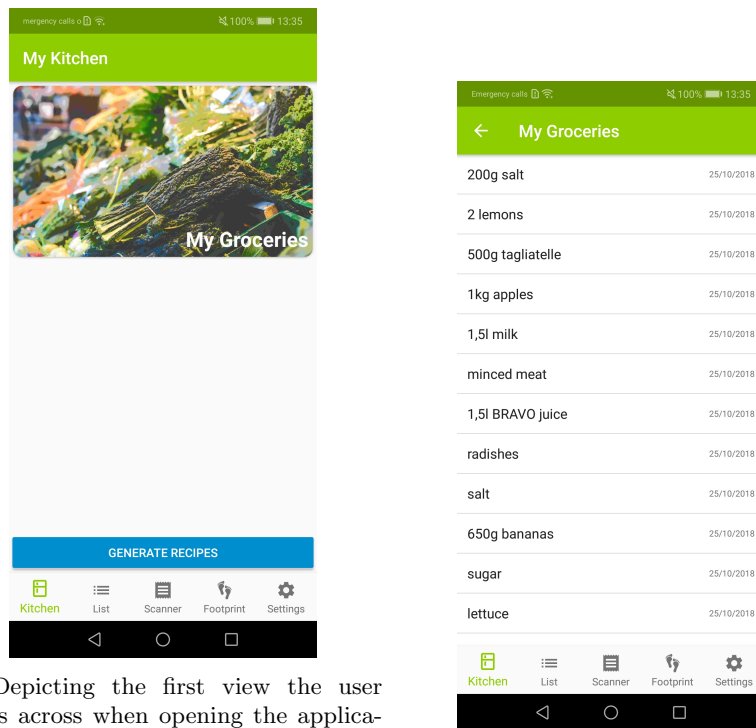




(q) Showing a settings page, including settings such as notifications, food preferences or allergies, knowledge level within how to be environmentally smart within the area, and what the user value in the process of buying food to how to cook it.

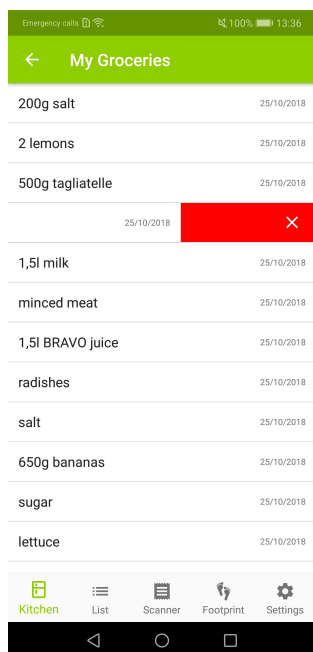
Figure 10: Lo-Fi prototype. (cont.)

## C Hi-Fi Prototype

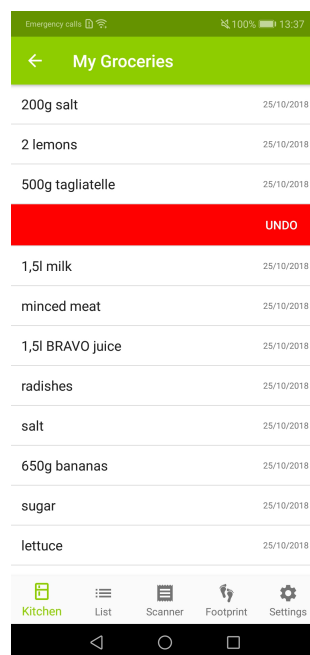


- (a) Depicting the first view the user comes across when opening the application. If one presses the card *My Groceries* one is redirected to the view depicted in Figure 11b, or if the button *Generate Recipes* is pressed, to the view depicted in Figure 11e.
- (b) Depicting a list with the user's current inventory of groceries at home.

Figure 11: Hi-Fi Prototype.

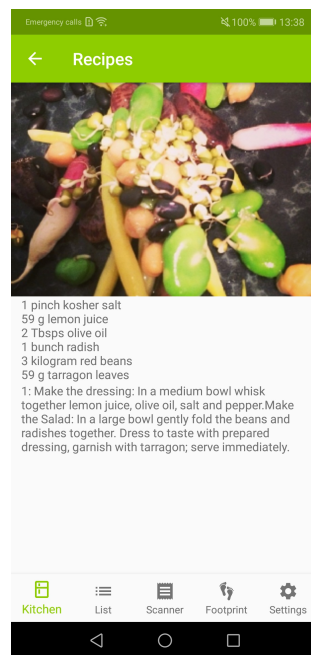
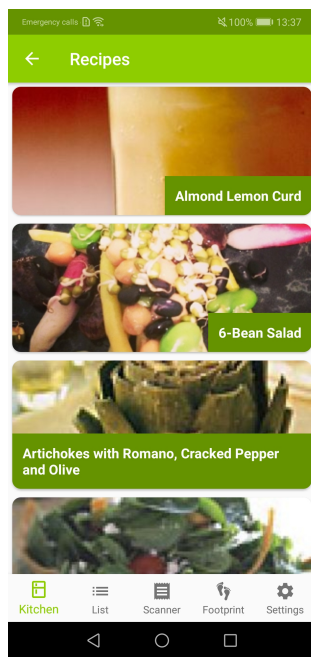


(c) The groceries are possible to delete by swiping an item.



(d) It is possible to undo the action of deleting a grocery within a time of 3 seconds.

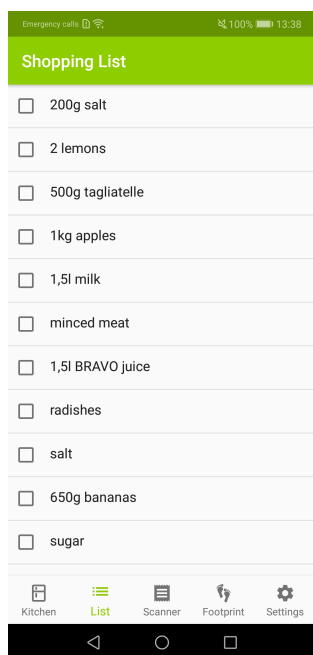
Figure 11: Hi-Fi Prototype. (cont.)



(e) This view is depicting a list of recipes, based on what groceries the user currently has at home. By clicking a recipe of choice the user is redirected to the view depicted in Figure 11f.

(f) Depicting instructions, including groceries needed and steps to perform, to cook a certain recipe.

Figure 11: Hi-Fi Prototype. (cont.)

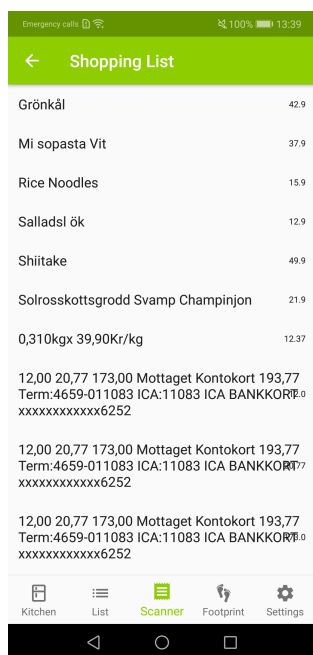


(g) Depicting a shopping list, having clickable check boxes which when clicked, removes an item from the list.

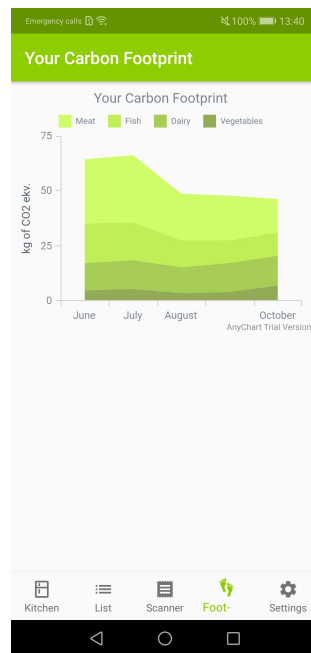


(h) Displaying the scanner mode of the application. In this prototype, as can be seen, the title is incorrect in this view. Via focusing on a recipe and clicking the button *Take Picture* one gets redirected to Figure 11i.

Figure 11: Hi-Fi Prototype. (cont.)

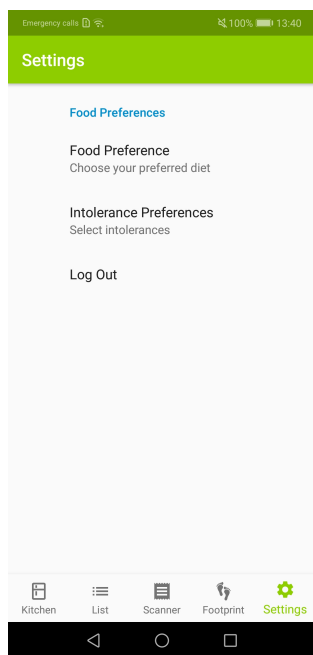


(i) Depicting scanning results from the receipt in Figure 11h. No further actions can be taken in this state.

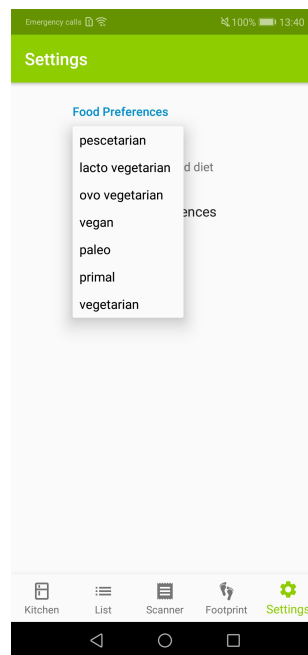


(j) Depicting a graph containing information about a user's carbon footprint only taking food consumption and different food categories into consideration.

Figure 11: Hi-Fi Prototype. (cont.)

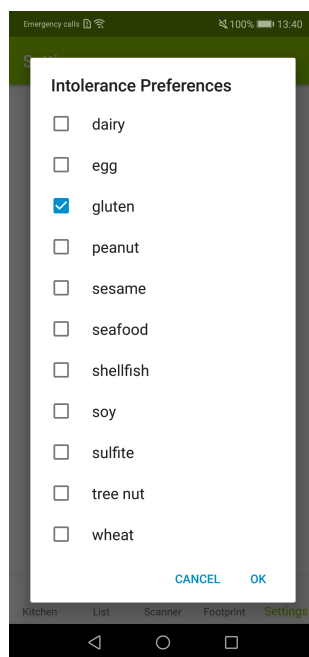


(k) Depicting the settings section of the application.



(l) Via clicking the settings category *Food Preference* seen in Figure 11k, this drop down menu appears, allowing the user to let the application know about any preferences.

Figure 11: Hi-Fi Prototype. (cont.)

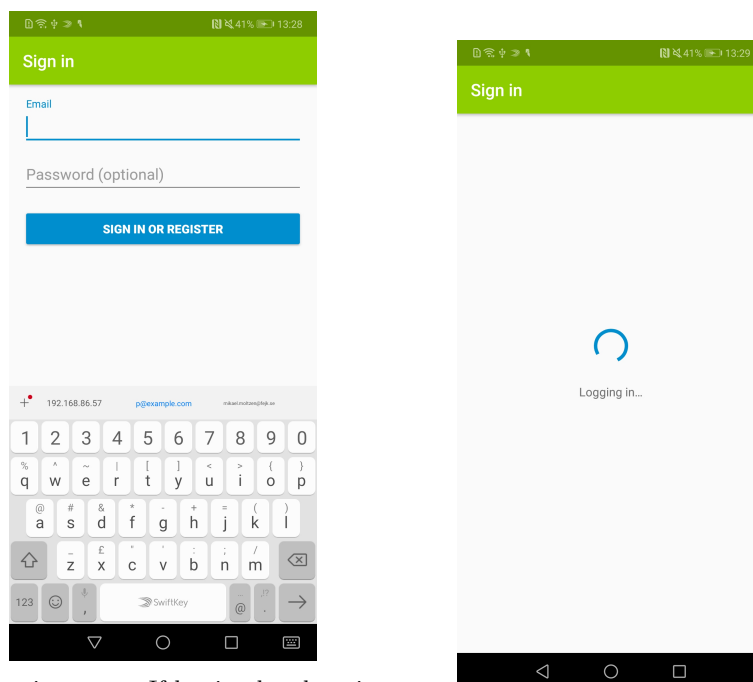


(m) Via clicking the settings category *Intolerance Preferences* seen in Figure 11k, this multiple check box pop-up appears, allowing the user to let the application known about any preferences.

Figure 11: Hi-Fi Prototype. (cont.)

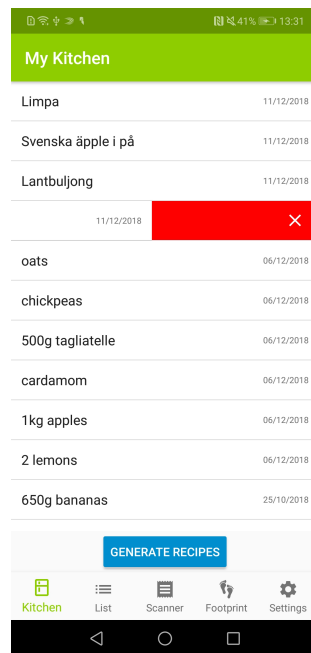
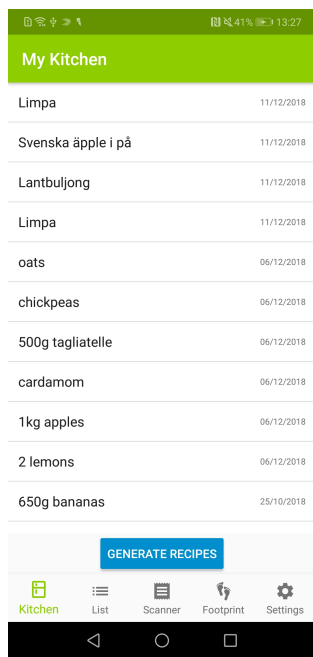


## D Final Prototype



(a) Log in screen. If log in already exist data can already be bound to the email, (b) Log in screen shows a loading spinner otherwise a new log in will be created on when trying to log in to the service online. button-click.

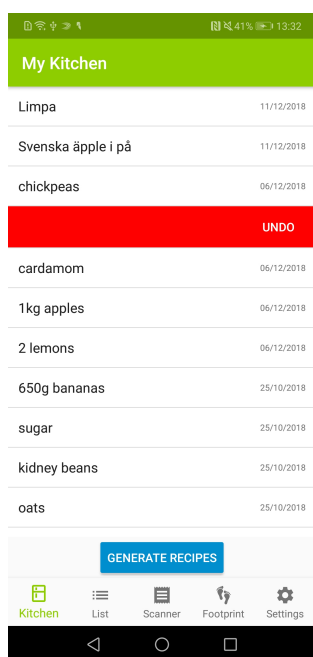
Figure 12: Final prototype.



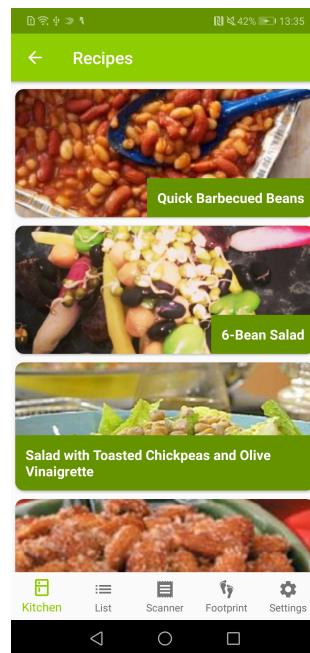
(c) This view is showing directly after logging in to the application from the view depicted in Figure 12a. The view is showing what groceries exist in your kitchen at the moment.

(d) It is possible to swipe on the groceries in your kitchen, deleting an item.

Figure 12: Final prototype. (cont.)



(e) After a swipe on an item in your kitchen, the swipe is possible to undo, if the user changes its mind.

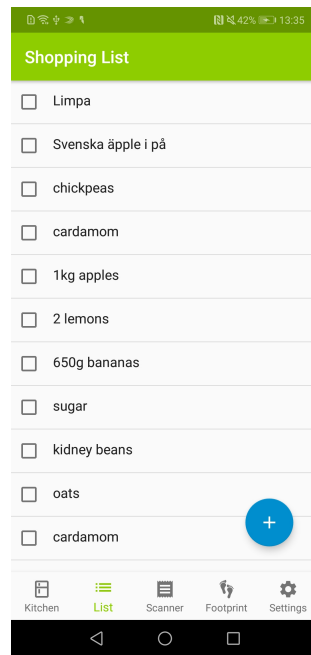


(f) It is possible to generate recipes based on a user's groceries, via clicking the button *Generate Recipes* depicted in Figure 12c, 12d and 12e.

Figure 12: Final prototype. (cont.)

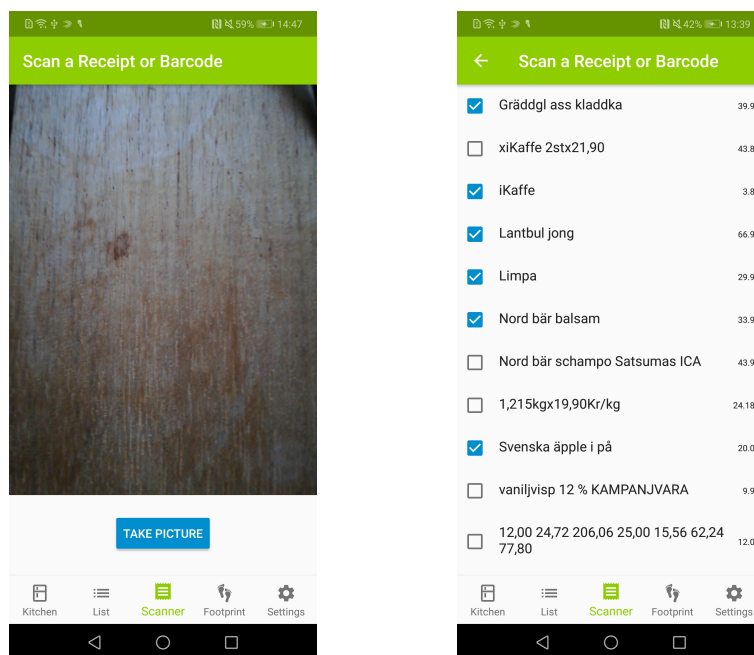


(g) A recipe from the generated list depicted in Figure 12f.



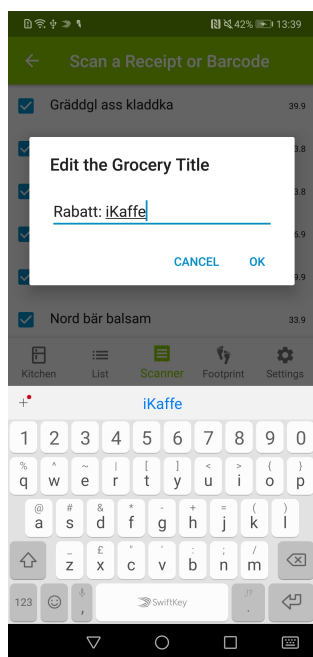
(h) A shopping list. The checkboxes can be clicked and the item then disappear from the list. Adding an item is not supported, however the visual button to do fake the functionality is placed in the bottom right corner.

Figure 12: Final prototype. (cont.)

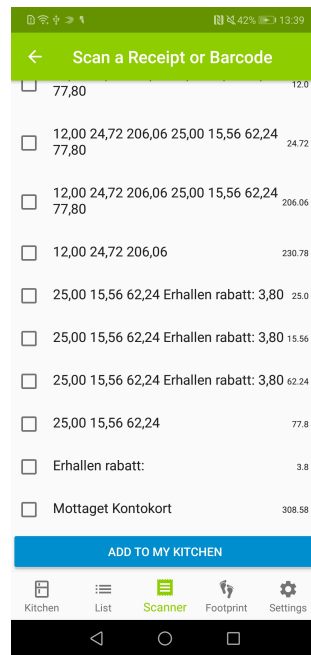


(i) The scanner view of the application. (j) The result of scanning an arbitrary receipt. Focus on a receipt and press take photo. The possibility to go through the lines and choose what to include exist.

Figure 12: Final prototype. (cont.)

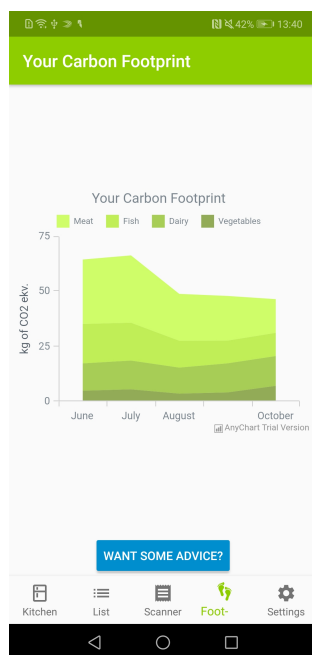


(k) Editing of a scanning result is possible, via clicking an item in the list depicted in Figure 12j or 12l.

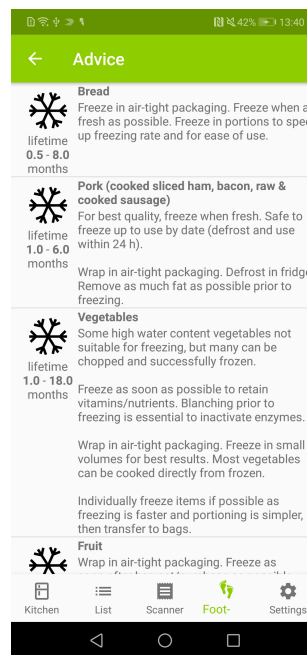


(l) After editing of the necessary groceries of the scanning result one can add all the wanted items to the kitchen inventory, doing that successfully one gets redirected to *My Kitchen*, depicted in Figure 12c.

Figure 12: Final prototype. (cont.)

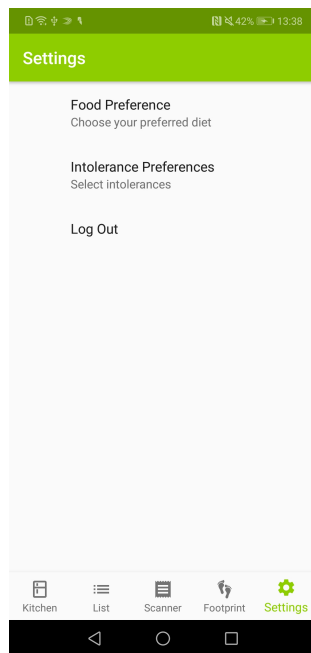


(m) Visualizing the user's carbon footprint, based on the groceries inserted via scanning receipts.



(n) Via clicking the button *Want Some Advice?* in Figure 12m the user gets advice, currently only supporting how to package and freeze groceries not going to be used in a couple of days.

Figure 12: Final prototype. (cont.)



(o) Settings page of the application. Same functionality exist as in the Hi-Fi prototype described in Figure 11l and 11m.

Figure 12: Final prototype. (cont.)