



CHALMERS
UNIVERSITY OF TECHNOLOGY



Understanding Household Food Waste: Setting Data into Context for Effective Eco-feedback

Master's thesis in Infrastructure and Environmental Engineering

DIVIA PATRICIA JIMENEZ ENCARNACION

BOMX02-17-98
Department of Architecture and Civil Engineering
Water Environment Technology (WET)
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2018

REPORT NO. BOMX02-17-98

Understanding Household Food Waste:

Setting Data into Context for Effective Eco-feedback

DIVIA PATRICIA JIMÉNEZ ENCARNACIÓN

Department of Architecture and Civil Engineering
Water Environment Technology (WET)
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2018

Understanding Household Food Waste:
Setting Data into Context for Effective Eco-feedback
DIVIA PATRICIA JIMÉNEZ ENCARNACIÓN

© DIVIA PATRICIA JIMÉNEZ ENCARNACIÓN

Technical report no BOMX02-17-98
Department of Architecture and Civil Engineering
Water Environment Technology (WET)
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Telephone + 46 (0)31-772 1000

Cover:
High-resolution photo of street, fruit, orange, food, produce. The image is released free of
copyrights under Creative Commons CC0
Gothenburg, Sweden 2018

Understanding Household Food Waste:
Setting Data into Context for Effective Eco-feedback
DIVIA PATRICIA JIMÉNEZ ENCARNACIÓN
Department of Architecture and Civil Engineering
Water Environment Technology (WET)
Chalmers University of Technology

ABSTRACT

Increasing concern over human-induced climate change calls for innovative solutions to reduce greenhouse gas emissions. Food consumption and the processes that support it are amongst the most polluting human activities, and waste of food implies that the impact of their production has occurred in vain. Thus, reduction of food waste would greatly contribute to the mitigation of climate change, and is included as a step within the environmental targets of several institutions as Gothenburg Municipality. Many authors concur that to reduce food waste, strategies must tackle behaviors within the household context.

FoodWatch is a diary-based online application that collects data on household food flows and estimates their carbon footprint. It is hypothesized the high disaggregation of data within FoodWatch makes it a platform for interventions effective in reducing avoidable and partially avoidable food waste, such as eco-feedback. In this study, the application was modified to support data on the behaviors surrounding household food management. Interventions as displaying footprints and advices were also implemented. A pilot test and interviews were carried out in voluntary students' households in Gothenburg, resulting in quantitative and qualitative data of food flows before and after interventions. While interventions were received positively, setbacks in the data collection prevented a consensus on their effect. Nonetheless, the figures available reinforced the “disconnection between actions and beliefs” mentioned in literature, backing up the need for more comprehensive data for exerting a change in households' wasting patterns. The project suggests modification to the study design and to the application that would aid in assessing the validity of the original hypothesis.

The report is written in English.

Keywords

Food waste prevention, behavioral change, household metabolism, persuasive technology, eco-feedback

Acknowledgments

To the Swedish Institute, for granting me with the scholarship that permitted the completion of my master studies from 2013 to 2015. This thesis is realized under the knowledge that they supported.

To Dr. Jesper Knutson, whose guidance, patience and trust shaped the present work. To my dear study participants, who used the application and provided me with data, with no other retribution than helping someone out.

To my parents, Pedro and Josefina, who forged every meter of the path on which I walk. To Victor and Helen, for gifting me with the time and means to do this right.

To Yoaska, Sheila, Rafael and Kaisa, for listening about my thesis woes for, literally, years. To Calle, who on the last strenuous moments told me to just keep going. To Stefania and Nadia, as shared goals are easier to reach, and to Fathi, for his double agency and cheesecake.

This work is no more than the sum of encouragements from all those who surrounded me during this time. Your every small insight kept me on track. Thank you.

Contents

Cover page	1
Abstract	3
Keywords	3
Acknowledgments	4
Contents	5
Figures	7
1. Introduction	8
1.1 Hypothesis	9
1.2 Aim of the project	9
1.3 Research questions	9
1.4 Scope of the study	10
1.5 Thesis outline	10
2. Literature review	11
2.1 Food and Environment	11
2.1.1 Measures for the reduction of food-related environmental impact	12
2.2 Food losses and waste	15
2.2.1 Definition and characteristics	15
2.2.2 Influential factors for food waste	16
2.2.3 Household-centered prevention of food waste	17
2.2.4 Stakeholder-centered prevention of food waste	20
2.3 FoodWatch: a tool for studying food flows in the household	22
2.3.1 Household metabolism studies and household waste studies.	22
2.3.2 FoodWatch Background	24
2.3.3 FoodWatch's current functioning	25
2.3.4 Improvement opportunities and potential applications	26
2.3.5 Similar online applications	26
2.4 Persuasive Technology	28
2.4.1 Eco-feedback	28
3. Methods	30
3.1 Literature Review	31
3.2 Formulation of conceptual model	31
3.3 Modification of the App	33
3.3.1 Purchase sessions	33
3.3.2 Purchase metadata	33
3.3.3 Waste metadata	34
3.3.4 Perception of product stock	35
3.3.5 Feedback functions	35
3.4 Pilot test	37
3.4.1 Households selection	38
3.4.2 Interviews to participants	38
3.4.3 App utilization	39
3.4.4 Boundaries of the pilot test	40
4. Results	41
4.1 Household #1	42
4.1.1 Planning	42
4.1.2 Shopping	43
4.1.3 Storage	45
4.1.4 Preparation and consumption	46
4.1.5 Wasting	46
4.1.6 Environmental impact and attitudes	48
4.1.7 Feedback effects	49
4.2 Household #2	50

4.2.1 Planning	51
4.2.2 Shopping	51
4.2.3 Storage	53
4.2.4 Preparation and consumption.....	53
4.2.5 Wasting	54
4.2.6 Environmental impact and attitudes.....	55
4.2.7 Feedback effects.....	57
4.3 Household #3	58
4.3.1 Planning	58
4.3.2 Shopping	59
4.3.3 Storage	60
4.3.4 Preparation and consumption.....	61
4.3.5 Wasting	62
4.3.6 Environmental impact and attitudes.....	63
4.3.7 Feedback effects.....	65
4.4 Results from aggregated data.....	65
4.5 About FoodWatch and experiment design.....	67
4.5.1 Household #1	67
4.5.2 Household #2	67
4.5.3 Household #3	68
5. Discussion	68
5.1 Food waste reduction as the target for eco-feedback	68
5.2 Implications of the experiment design in collection of waste data	69
5.3 Shortcomings of data collection through FoodWatch.....	71
5.3.1 Equipment related	71
5.3.2 Application related.....	71
5.3.3 User-related factors.....	72
5.3.4 Others	73
5.4 Perception of household metabolism and surrounding habits.....	73
5.4.1 Comparison of qualitative and quantitative results	75
5.5 Use of disaggregated data for Eco-Feedback.....	76
5.5.1 Displaying the footprint of transactions	76
5.5.2 Advice interventions	76
5.5.3 Adoption of new habits	77
5.5.4 Changes in users' attitudes.....	78
5.5.5 Interventions' effects in overall waste and footprint rates	78
5.6 Co-creation.....	79
5.6.1 General	79
5.6.2 Summary of suggestions	80
6. Conclusions.....	81
7. References.....	83
8. Appendixes	89
Appendix 1 - Feedback messages implemented in app:	89
Appendix 2 - Participant protocol:.....	93
Appendix 3 - First questionnaire to participants:	96
Appendix 4 - Final questionnaire to participants:	98
Appendix 5 - Participant interviews transcripts:	100
Appendix 6 - Additional participant comments and interactions during study:	146
Appendix 7 - Data obtained through app:	148

Figures

Figure 1 - Schematic of major flows of food and drink and associated waste routes (Quested and Johnson, 2009).....	24
Figure 2 - Pathways for recording transactions in FoodWatch.....	25
Figure 3 - Capture of product information in the FoodWatch application.....	26
Figure 4 - Overview of methodology for the project.....	31
Figure 5 - Flow diagram of food behaviors in the household.....	32
Figure 6 - Characterization of waste.....	33
Figure 7 - Saved session message.....	33
Figure 8 - Questions associated with shopping session.....	34
Figure 9 - Adding and removing product screen.....	34
Figure 10 - Questions associated with registering waste.....	35
Figure 11 - Waste transaction shown in user inventory.....	36
Figure 12 - Balancing transaction.....	36
Figure 13 - Graphs showing weekly total and waste-exclusive footprints.....	37
Figure 14 - Stages of the field trial.....	37
Figure 15 - Flows of food and drinks within range of study, based on schematic by (Quested and Johnson, 2009). Selected flows enclosed in black line.....	40
Figure 16 - Transactions in Household #1. Red line symbolizes beginning of Phase 2.....	42
Figure 17 - Items per product group in Household #1.....	44
Figure 18 - Character of Waste for Household #1.....	47
Figure 19 - Sankey diagram showing relations between type, reason, stage and stock of waste for Household #1.....	47
Figure 20 - Footprint of purchase and waste transactions per day in Household #1.....	48
Figure 21 - Transactions in Household #2. Red line symbolizes beginning of Phase 2.....	50
Figure 22 - Items per product group in Household #2.....	52
Figure 23 - Character of Waste for Household #2.....	55
Figure 24 - Sankey diagram showing relations between type, reason, stage and stock of waste for Household #2.....	55
Figure 25 - Footprint of purchase and waste transactions per day in Household #2.....	56
Figure 27 - Masses in purchase and waste transactions in Household #3.....	59
Figure 28 - Items per product group in Household #3.....	60
Figure 29 - Character of Waste for Household #3.....	62
Figure 30 - Sankey diagram showing relations between type, reason, stage and stock of waste for Household #3.....	63
Figure 31 - Footprint of purchase and waste transactions per day in Household #3.....	64
Figure 32 - Comparison of households' length (in weeks) of active participation in the study.....	65
Figure 33 - Items wasted per shopping session in Household #2.....	66
Figure 34 - Screen capture taken by participant #1, showing unsuccessful submission of a transaction.....	146
Figure 35 - Screen capture taken by participant #1, showing unsuccessful submission of waste of fresh pasta.....	146

1. Introduction

An increasing concern over human-induced climate change has created the need for strategies to reduce overall greenhouse gas emissions. The patterns of modern food and beverage consumption are responsible for 19 to 29% of the CO₂ footprint per capita (Vermeulen et al., 2012). Many ways of lowering the GHG emissions associated to food consumption have been studied: a reduction of animal-sourced foods and limitations in the caloric intake per capita, among others, would lead to considerable reductions of environmental impact (DEFRA, 2008, Carlsson-Kanyama, 1998). One of the most approachable and effective strategies studied is the reduction of food waste.

It is estimated that at least 30% of all food items that are produced will end up being wasted (IMEchE, 2013). Loss of edible resources originates at every step of the food system, from agriculture to the transport phase. Nonetheless, when food waste is categorized according to its source, households are directly responsible for 42% of the total losses in the European Union. (Monier et al., 2011) classify food losses in four sectors: agricultural, households, food processing and retail, attributing the following percentages: 42% of the waste is done by households while 39% is in food processing, 5% in retail and 14% in food services sectors. For Sweden, as much as 38% of the food waste is produced by households (Bernstad and Andersson, 2014). This represents a waste of caloric potential and land and water use; but it also means that the emissions related with the harvesting, production, transport, etc. of this product have occurred “in vain”. The way in which food waste is treated after disposal might cause an additional impact on the environment: In Sweden, about 27% of food waste is used as a resource to produce biogas and for recovery of nutrients (Elander et al., 2016), but when the waste becomes part of landfill, additional emissions of methane can be expected. In times of food insecurity, water scarcity and danger for irreversible climate change, food waste is not a luxury to be taken.

There are few studies that explore the reasons that lead people to waste (Graham-Rowe et al., 2014), or that combine measurements of the waste with investigative questionnaires (Beretta et al., 2013). Not knowing the characteristics of waste in Europe hinders effective prevention (Halloran et al., 2014), which makes paramount the investigation of food waste from a perspective that includes analyses of the composition of waste, as well as the parameters which govern its production.

Ultimately, the study of waste means very little if not applied for prevention, and so the results of existing research have been applied to different extents. Some initiatives have tried to strengthen public's association of food waste to climate change, in an effort to encourage more sustainable practices, i.e. Live Well (Macdiarmid et al., 2011) and the Cooking up a Storm report (Garnett, 2008). However, providing individuals with information bears little effectivity in garnering action from them, unless such information is accompanied by tools that facilitate environmentally friendly habits (Quested et al., 2013). While some projects in Sweden have attempted to provide both information and tools for users to minimize their daily carbon footprints, as “One tonne life” (2014), not many have analyzed a scenario concerning food waste specifically. Eco-feedback, a type of intervention where users' habits are measured and used as a base for customized feedback, could be a promising technique to aid consumers in minimizing their waste related footprints.

FoodWatch, as an online application, was conceived to gather household food management data in a simple way. It allowed users to track their food flows in detail, namely purchase, consumption and waste of items. The app's product database includes associated footprint values for each food group (Harder, 2013), which means that the user can store their food transactions history and easily access information on how much land, water and carbon footprint is carried in each transaction. (Hunter et al., 2006) see the potential of footprint data collected through diary to make households aware of ways to reduce their environmental impact. Considering this, FoodWatch could be a suitable platform for the implementation of strategies to minimize households' food-related footprint (Knutsson, 2016). Eco-feedback, a type of persuasive technology, could empower households to reduce their waste on their own devise. Therefore, this project will use FoodWatch as a platform for this type of intervention and observe its effect on households.

Finally, in order to design strategies for the reduction of waste, it is important to understand all the factors that lead to the waste of a food item, including the social, political, cultural and economic context surrounding the consumer (Bulkeley and Gregson, 2009). Decisions taken at any point in the food chain can influence the way the consumer will experience their waste. Municipalities, food and drink producers and manufacturers, packagers, suppliers and retailers, as well as the waste management system, often bear a complicated relation with household food consumption, and consequently, waste (Halloran et al., 2014, Parizeau et al., 2015, Quested et al., 2013, Quested and Johnson, 2009). The politics of every one of these actors affect household waste, while household waste will affect their politics. This is why a holistic approach, achieved by the inclusion of all possible stakeholders within the food chain, is important to achieve reduction of food waste in households (Quested et al., 2013). FoodWatch can provide a platform for integrated solutions, where the stakeholder's positions are considered in order to provide plausible means of waste reduction to the households. A first step towards the inclusion of stakeholders within the FoodWatch project will be the identification of Swedish counterparts.

1.1 Hypothesis

The project is developed under the following hypothesis:

“Disaggregated data of household food flows and their surrounding behaviors can provide data for effective eco-feedback interventions for reduction of waste”

Using this hypothesis as a base have been elaborated the aim, purpose, goals and research questions.

1.2 Aim of the project

The aim of this project is to explore the introduction of waste-focused eco-feedback in an application that captures the household's food metabolism. The purpose is to create a tool which can contribute to the reduction of households' food-related carbon footprint. To achieve this, several objectives have been chosen:

- Reviewing the literature on food waste prevention and techniques for eco-feedback.
- Creating a conceptual model that describes the experience of the consumer in regards to waste production.
- Developing strategies for intervention within the app.
- Performing a pilot test of the application, to obtain a picture of the user's food flows and associated routines; both before and after implementing interventions.
- Assessing the effectivity of the chosen strategies.

The results of this project will help in the optimization of FoodWatch, and will serve as base for more extensive field trials.

1.3 Research questions

For the completion of the project, some key questions should be answered. The question that summarizes the aim of this thesis is:

- What effect does the implementation of eco-feedback within FoodWatch have on household's food wasting patterns?

From this derive other questions, namely:

- What factors contribute to the production of waste in the household?
- How can FoodWatch capture household's food metabolism and related routines?
- In which ways can this data be used to create interventions?
- Can FoodWatch contribute to lowering household GHG emissions due to food waste?
- How do users experience the application, before and after interventions?

- What other modifications can facilitate food-related footprint reduction?
- How can the app involve other actors in the food chain?

The present thesis will aim to answer these questions.

1.4 Scope of the study

The project is carried out under the frame of environmental studies, and accordingly will be concerned with the theoretical aspects behind the development of the app. The interface design, although affected by the project decisions, will not be a focus of the investigation.

Many approaches can be taken to cut back on the environmental impact of household food consumption. Other options, such as a change in diet composition or a reduction of the caloric intake, could be explored within the frame of FoodWatch. However, the present study will only focus in the reduction of GHG emissions associated to preventable and partially preventable food waste.

Literature indicates that in family households with an average of 3.3 members, there are several factors that decrease the amount of food waste per capita (Parizeau et al., 2015). In contrast, the present study evaluates the scenario in single's and/or couple's households. During the field study, the participants are interviewed in person twice. The instructions of the study are also provided personally, in addition to meetings for troubleshooting of the equipment. Given this, the pilot test only includes households from the Gothenburg area.

Another important limitation for the development of this project was the time availability of the users. The data collection for the test trial occurred between July and December 2015. Within this period, the participants used the application for an average of four months. Most resources used for the literature review were collected between January and July 2015, therefore most recent research in the area is not considered in this thesis.

The tasks expected from the user during the experiment subscribe to an additional set of limitations, which are presented in the “**3.4.4 Boundaries of the pilot test**” sub-chapter.

The water, land and CO₂ footprint data obtained from the pilot test is limited by the values related to each product group within the app database (Knutsson, 2016). Consequently, it does not cover variations in the footprint of an item due to differences in its origin, method of production, etc.

1.5 Thesis outline

This thesis is divided into six chapters, in addition to a complete list of the references used and a collection of Appendixes.

After the introduction comes the chapter containing the literature review. This explores what is known about food losses: at what stages of the food chain it can happen, why it is important to study household food waste, what can influence it and what can be done to prevent it. The literature review will also detail the FoodWatch application, present research about persuasive technologies, and will briefly present the private and governmental entities that are at stake when considering the food waste subject.

Chapter 3 will explain the methods utilized for the completion of this study, going from how the conceptual model was elaborated to every procedure followed during the pilot test, among others.

The results obtained in the pilot test are presented in Chapter 4, then discussed in Chapter 5. The concluding remarks, including suggestions for future modifications to the app, are found in Chapter 6.

A list of all sources that supported the writing of the project are to be found in the References. Lastly, in the Appendix section are presented the complete files containing the data relative to modifications implemented in the application, the interviews questions and transcriptions, all data obtained through the application, and others files of relevance for the study.

2. Literature review

The literature review centers in four branches that are necessary to investigate for the completion of the study: Food and environment, Food losses and waste, FoodWatch: a tool for studying food flows, and Persuasive technology.

2.1 Food and Environment

This chapter presents an overview of the environmental impacts of food consumption, and presents the solutions that literature offers to this concern. These solutions were regarded as options for the focus that the modification of FoodWatch could take, and therefore are accompanied by their advantages and/or limitations.

Food consumption is identified as one of the most polluting activities that occur within a household (Carlsson-Kanyama, 1998), ahead of leisurely activities, sheltering activities as heating, and private transportation (Guinée et al., 2006). Each step required to bring food to consumers' plates will have an impact on the environment, starting from the harvesting of feed for cattle raising and the production of fertilizers for agriculture; extending all throughout the food chain until storage and cooking at consumers' homes. These processes lead to emissions of the main greenhouse gases: CO₂ in transportation fuels, N₂O in fertilizer use, CH₄ in emissions from cattle and rice harvesting, N₂O and HCFCs; all of which contribute directly and indirectly to climate change (Carlsson-Kanyama, 1998, Quested and Johnson, 2009). In 2006, the average emissions from food consumption of swedes was estimated to be 1,500 kg CO₂e/cap/y (Bryngelsson et al., 2013).

Additionally, the food chain requires plenty of resources to function; such as land, water for irrigation and processing, fertilizers, energy and fuel. Besides the emissions associated with the use of each, other consequences for the environment can be expected, including eutrophication, soil depletion and acidification (Quested and Johnson, 2009). Social impacts as water and land scarcity are associated with this system as well. IMechE (2013) explains how increasing numbers of meat consumption and wasting patterns result in significantly higher requirements of land and water - resources that could be used more effectively. A remarkable situation is that of water use, which in human consumption is devoted 70% to global agriculture, with extensive inefficiency. Thus, tensions between the need for food production and the preservation of the environment are expected to arise. Seeing that the effects of the food chain manifest in different areas, several measurement units are used to express these impacts. Some commonly used units are *global hectares* (gha) for expressing the amount of biologically productive land used for an activity i.e. producing one kilogram of meat; *water footprint* in cubic meters (m³), indicating the amount of water used for an activity, and *equivalent carbon dioxide* (eCO₂), expressing a concentration of carbon dioxide that would have the same effect as the concentration of other greenhouse gases.

Food consumption and the chain of processes that support it, if unmodified, can be greatly detrimental to global ecosystems. Nonetheless, modern societies cannot be sustained without the food industry, and therefore it is imperative to find solutions that make food production less damaging to the environment while maintaining a baseline satisfaction of population's need for nourishment. Climate change is an utmost pressing matter, and considering that up to 29% of greenhouse gas emissions are associated to food consumption (Vermeulen et al., 2012), it's undeniable that both the system and people's habits should be reevaluated to reduce harmful emissions to a minimum.

Certainly, different foods will have different degrees of impact. According to Schmidt Rivera et al. (2014), ready-made foods generally induce more emissions than homemade meals due to the refrigeration, packaging and transport. Meat and dairy are indisputably the food category with the higher CO₂ equivalent emissions, due to the emission of methane during production (Bernstad and Andersson, 2014). Their vegetable counterpart would be rice, also a high emitter of methane during harvesting. Beretta et al. (2013) mentions that in the case of food losses, the impact will be conditioned not only by

type and amount of food, but also at what stage of the food system it is lost and how is it managed afterwards. This concept highlights the necessity of conducting life cycle assessments of food losses to determine priority areas of action. Research that pinpoints where and how the most emissions happen can help identify where the opportunities for improvement are. Below is presented a summary of the measures that have been studied in this regard.

2.1.1 Measures for the reduction of food-related environmental impact

Various sources of literature have focused on reducing the environmental impact caused by the food industry. Optimizations along the food chain processes span from improving productivity in the agriculture stage to the use of clean fuels in transport (Garnett, 2011). However, all processes happening along the food chain are, ultimately, meant to satisfy the consumer's needs; thus, behavior and lifestyle changes within the household have a great potential for the reduction of food-related GHG emissions (Reay, 2005, Prášilová et al., 2015, Garnett, 2011). If adopted by a large portion of the population, these changes could originate backward ripples along the food chain, influencing what and how much is harvested, produced, and so on (Garnett, 2008).

Various changes to consumer's habits are thought to have potential for reduction of greenhouse gas emissions. DEFRA (2008) identified twelve general behavior goals for mitigation of climate change, three of which pertained exclusively to food: reducing food waste, consumption of more seasonal foods and adoption of a lower impact diet. These are backed up by a variety of studies, which are mentioned below. Some of the literature also considers the reduction of overall consumption, which could also be beneficial to health (Druckman and Jackson, 2010). These, among other notions for reduction of food-related carbon emissions, are discussed below:

Favoring local products: Due to increased food trade, developed countries have access to a wider variety of products to satisfy their nutritional interests. This has allowed people to eat more imported products. Since imported products have more “food miles” than those that are produced locally, this implies additional storage and transport emissions. Choosing to buy more local products could represent up to a 90% of GHG savings, while consuming homegrown vegetables and fruits could increase this reduction up to 100% (Reay, 2005). Buying food online and going to the shops on foot have also been researched (Garnett, 2008). However, eating locally doesn't always correlate with eating a lower impact diet. For example, vegetables grown locally in greenhouses might or might not have more impact than imported ones (Garnett, 2008, Macdiarmid et al., 2011). In the case of buying from local farms, the emissions saved from cold storage might be surpassed by the emissions from driving to such farms, depending on the driving distance (Coley et al., 2009).

Consuming seasonal produce: Modern consumers are usually not restrained by seasonal variations of products (Steptoe et al., 1995), which means that they can consume most vegetables and fruits year-round. Such products, if grown out of season, must be harvested in heated greenhouses rather than from fields. In response to the impact that this causes, literature often mentions a preference for local products in combination with the use of seasonal groceries. Both Carlsson-Kanyama (1998) and MacDiarmid et al. (2011) suggest that the “ideal plate” include seasonal vegetables, the first adding small portions of meat in a Swedish context. Monier et al. (2011) and DEFRA (2008) include it in the model of a low impact diet, as well as (Garnett, 2008); who justifies it with a reduction of refrigeration, transport and amounts of spoilage. The latter, though, makes the distinction that for a lowered GHG emission, such seasonal products should be robust, as opposed to more fragile foods. DEFRA points out that, although this behavior is uncommon, it would be easy to adopt and that different sectors of population seem willing to do so.

Nonetheless, the preference for seasonal products is not seen as a high priority across several studies. DEFRA disputed whether to maintain it as a main sustainability goal, given its very low impact in reduction of CO₂ emissions when compared to other food-related behavior changes. Garnett (2008) only considers it a medium priority behavior, and presents the downside that focusing in locally grown products might affect developing countries' economies. Macdiarmid poses that the adoption of this habit might affect people's health if seasonality leads to an overall decrease in fruit and vegetable consumption. In the same way, there might be difficulties in encouraging this habit. Although Quested

and Johnson (2009) says that price changes might already put costumers off from buying vegetables out of their season, DEFRA sees the perception of an added cost as an obstacle for the adoption of such a habit. Another obstacle could be the lack of knowledge on seasonal patterns.

Reduction of meat and dairy consumption: In 2006, the average emissions from food consumption of swedes was estimated to be 1,500 kg CO₂e/cap/y. Of those, more than half (800 kg) are attributed solely to meat consumption (Bryngelsson et al., 2013). These numbers resemble those of Dutch consumers, whose 50% of food emissions are due to meat and dairy (Garnett, 2008), similar to many others nations in Europe (Guinée et al., 2006). Consequently, a most important behavior to adopt in order to reduce GHG emissions is the consumption of less animal products (Garnett, 2011). According to Carlsson-Kanyama (1998), a low impact diet in Sweden would contain small amounts of animal sourced products, similarly to the “model dish” ideated by Macdiarmid et al. (2011). The adoption of a vegan, i.e. an entirely vegetable diet, could represent a reduction of GHG emissions of up to 30% (Reay, 2005). While complete elimination of animal products would greatly reduce CO₂ and methane emissions; consumers’ nutritional needs, economic availability and habits must be considered. Nonetheless, even the reduction of animal products, rather than complete elimination from the diet, could achieve a considerable impact. Carlsson-Kanyama suggests a more comprehensive approach than reducing certain specific food groups: effectuating a change in diet by looking at the combined impact of the ingredients in a full meal instead of focusing on individual items.

DEFRA (2008) includes the reduction of meat and dairy within the goals for achieving a lower impact diet. They, however, affirm that this measure has relatively low impact in the reduction of CO₂. Additionally, this is a behavior that is highly accessible to the general population, but very few are currently willing to engage in it. The unwillingness to change diets and the lack of knowledge about food substitutes make this a measure with low acceptance across most segments of population.

Other downsides are the possible shift of meat production overseas, and the risk of placing more pressure on vulnerable fish species (Garnett, 2011). As for achieving the goal, encouraging people to diminish their animal sourced food consumption is unlikely to work by itself, and important social, political, economic and cultural changes are necessary for a significant effect (Garnett, 2008). Garnett also mentions that any possible decrease in live-stock generated GHGs would, in a future, be cancelled out by the growth in demand due to population growth.

Reduction of food amounts and/or calories - Prášilová et al. (2015) advocates that “sustainable consumption” is more desirable than what is called “sustainable development”, framing sustainable consumption as giving up on the consumption of unnecessary items. Reducing household consumption, including that of food, is identified as a solution to reducing GHG emissions. A reduction of food consumption would imply a reduction of caloric intake. Lettenmeier et al. (2012) mentions that a growth of 8.8 % in calories consumed per capita is to be expected by 2030, next to a 52% growth in total calorie consumption. An important fraction of these calories is unnecessary and could affect general health in populations. Garnett (2008, 2011) mentions “eating less” as a behavior highly prioritized for a less GHG-intensive society.

Druckman and Jackson (2010) modelled a reduced consumption scenario, in which appropriate nutrition standards are maintained, and concluded that this would lower the related GHG emissions in the UK by a 37%. This scenario doesn’t include reduction of meat and dairy, which would result in an even higher reduction. It can be dangerous to encourage such a behavior, though, if it results in guilt-inducing and body shaming attitudes (Garnett, 2008). Garnett also includes a similar behavior on her list: the reduction of foods with little nutritional value (chocolate, coffee, tea). However, it poses the question of intervening with consumers’ free will.

Reduction of food waste - Between a 30% and 50% of all food produced is lost before consumption (IMEchE, 2013, Gustavsson et al., 2011). At a global scale, this means that 30% of cereals; 40-50% of roots, fruits and vegetables; 20% of meat and dairy; and 30% of fish are being wasted (Gustavsson et al., 2011). Only by avoiding these losses, food supplies could increase by 60-100% (IMEchE, 2013).

Food losses and waste are often measured in terms of mass, but these figures can also be presented from nutritional, environmental and economic perspectives. Beretta et al. (2013) sustains that due to food losses, only a 16% of the calories that have been produced end up being consumed, and that 25% more calories could reach consumers if all edible parts of foods were used. Kummu et al. (2012) also mentions that the 614 kcal/cap lost daily around the globe account for the loss of 24% of the freshwater resources used, 23% of the cropland areas and 23% of the fertilizer used. In light of widespread food scarcity (FAO, 2014), these figures highlight the importance of reducing food losses. Reducing food losses might free up areas of land where deforestation might otherwise happen and could help increase food, land and water security (Quested and Johnson, 2009, Quested et al., 2011). From an environmental perspective, the loss of such amounts of food implies that the greenhouse gas emissions during the production of these foods have occurred in vain (Gustavsson et al., 2011), in a time where climate change mitigation is imperative. The effect of food losses in household economy have also been studied: in UK, for example, 480 pounds/household are spent every year in purchases of food that could've been avoided (Quested and Johnson, 2009). Britz et al. (2014) also studies how food losses can only occur on a system that is economically balanced.

While in developing countries, food losses occur due to limitations during the harvesting and production phases, in developed countries they are mostly caused by consumer behavior (Graham-Rowe et al., 2014, Quested and Johnson, 2009, Beretta et al., 2013) and lack of coordination between actors in the food system (Gustavsson et al., 2011); as the “disconnect between supply and demand” mentioned by (Beretta et al., 2013). Though waste can originate at different sectors and for different reasons, households are responsible for the most food waste by global averages. In Europe and North America, household food waste ascends to 95-115 kg/person/year (Halloran et al., 2014), and accounts for the loss of almost half of the calorific potential produced (Beretta et al., 2013).

The European Union averages at a 34% of food waste being produced at the household (Gustavsson et al., 2011), though rates of food loss can vary greatly between countries (Beretta et al., 2013). For example, in Denmark households are responsible for 50% of the total food losses (Halloran et al., 2014), while in Sweden they cause only a 38% (Gustavsson et al., 2011). Nonetheless, Sweden has the highest percentage of waste per national production of food within the European Union (Britz et al., 2014).

The destination of waste masses will also vary. The losses of food at pre-consumption level, although big, can sometimes be repurposed e.g. for animal feeding (Beretta et al., 2013). In some countries, source separation of food waste is increasingly growing (Parizeau et al., 2015), to be used in anaerobic digestion leading to production of biogas, or, for centralized or decentralized composting (A. Bernstad, 2011). In places where food waste is not separated, disposed flows often end up at landfill or incinerated. Depending on this, it is possible that reductions of losses represent an additional impact. The study by (A. Bernstad, 2011) compares the effects of incineration, composting and anaerobic digestion, showing that, for example, biological treatment will reduce GHG emissions but will increase nutrient enrichment and acidification, therefore still giving a certain impact. Bernstad and Andersson (2014) pose that if there is less food content in streams that are processed through anaerobic digestion for fertilizer production, the lower content of nutrients might reduce the possibility to replace chemical fertilizers, and produce similar amounts of GHG emissions. Similarly, reduction of household waste could cause a rebound effect, where the reductions of footprint associated to food waste might be counterfeited by the emissions of services or products that people obtain once they have saved money on food (Bernstad and Andersson, 2014). Britz et al. (2014) also mentions that the environmental cost of technological adjustments to facilitate reduction of food losses are often not considered in studies.

Nonetheless, food waste prevention produces better results than incineration and anaerobic digestion in environmental terms (Bernstad and Andersson, 2014, Quested et al., 2013). Reduction of food waste saves 8 times the GHG emissions than if the food had gone to anaerobic digestion (Quested et al., 2011), and therefore is a measure of worldwide interest. Considering such extensive amounts of food being wasted at the household level, along with the previously mentioned consequences to the environment, reduction of food waste is identified as a desired behavior to counterfeit global warming. It is also considered a relatively simple measure that has great potential for reduction of GHG emissions. DEFRA describes reduction of food waste as a behavior which has a high impact in reducing carbon

emissions – it is an advantageous strategy and considered easy to encourage, as most people are already willing to act on it and have the possibility to do so. Amongst the segment of population that has a high ability and willingness to act on environmentally recommended behaviors, reducing food waste was identified as a goal with high acceptability.

2.2 Food losses and waste

The following chapter provides a background on food losses and food waste, and emphasizes on the latter. It presents the strategies against food waste that were identified during literature, and serves as a base for the conceptual model that is presented in the “Methods” chapter.

2.2.1 Definition and characteristics

Before further characterization of prevention strategies, it is important to distinguish between **food losses** and **food waste**. The definition varies across authors, often depending on which point of the food chain the loss occurs. Britz et al. (2014) does not differentiate between these terms and defines food waste as all the discarding of food materials along the supply and consumption chain. According to Parfitt et al. (2010) food losses refer to those occurring along the supply chain of food, namely after harvesting, during production and processing; while food waste refers to the loss of food in the final stages of the food system, i.e. retail and consumption stage. In this thesis, however, **food waste** will only refer to what happens exclusively at the consumption level while everything previous to this stage will be classified as food loss, similarly to Bernstad and Andersson’s definition (2014). In all cases, it should be noted that food losses and waste only include foods and parts of foods that are intended for consumption by humans (FAO, 2014), and therefore do not include that destined for animal feed.

Studies often categorize food losses by the edibility of the foods disposed (Halloran et al., 2014). Many divide food waste in avoidable and unavoidable, while others include the category of “possibly avoidable” as well. These categories also apply to food losses along the food chain: Britz et al. estimate that 60% of food losses along the chain are avoidable, which in Europe is estimated as 280kg/cap/year (Gustavsson et al., 2011). Quested and Johnson, on the other hand, describe unavoidable losses as those that cannot be avoided even with top technologies within the food value chain. In a household context, the categories of avoidable, unavoidable and possibly avoidable waste represent the following:

Unavoidable waste is the one composed by parts of foods that at no point were edible and often result from the preparation process of foods. Some examples are bones, egg shells, coffee grinds, trims and some seeds (Quested and Johnson, 2009).

The category of “**Possibly avoidable waste**” is included in some studies, as in Beretta et al.’s (2013). It is defined by Quested and Johnson as the waste that some people would eat and some others wouldn’t, often depending on the culture of the consumer. Some waste that could be considered as possibly avoidable are potato peels and the leaves of certain vegetables, as well as fatty parts and skin of meats. The latter, for example, is considered as unavoidable by Bernstad and Andersson, which shows how this category is often hard to delimit. Some literature proposes that the waste of these items could be avoidable depending on the way of preparation of the food, or on changed standards of quality e.g. acceptance of “ugly” vegetables (Beretta et al., 2013).

Avoidable waste refers to the food that is thrown away because it is no longer wanted, but was edible at a prior point (Quested and Johnson, 2009). At the time of disposal, it could be entirely, partially or not at all spoiled. Avoidable waste is often sub-divided depending on different factors. In the study by Bernstad and Andersson (2014), the avoidable waste is divided into sub-categories depending on the life-stage of the food disposed: *unopened packaging*, *opened packaging*, *half eaten food*, *prepared food* (which constitutes 27% of the avoidable waste in Sweden), *non-packaged vegetables/fruits and whole bread*, and *others*. Similarly, Schneider (2008), classifies avoidable food waste by its prevention potential, in 4 categories that resemble Bernstad and Anderson’s stages: *original food*, *partly used food*, *leftovers* and *preparation*

residues, except for the latter which would be better suited within the non-avoidable and partly avoidable categories.

Several studies find it useful to place the amounts of waste within one of the categories mentioned above, providing a clearer picture of how different countries are disposing of foods. By classifying food waste by its potential to be avoided, it has been concluded that, in Switzerland, for example, 16% of the calories brought into the household become avoidable waste, and 5% possibly avoidable (Beretta et al., 2013). In the UK, 12% of food and drink entering home are avoidable waste, producing an equivalent of 17 million tons of CO₂ in greenhouse gas emissions (Quested et al., 2013). And in Sweden, 34% of the food waste is avoidable, inferring that minimization of this fraction of waste could result in a saving of greenhouse gas emissions of 800-1400 kg/tonne.

These classifications also allow authors to explore the motivations behind the food waste. Beretta et al. (2013), for example, ideate a list of reasons for the waste depending on their potential to be avoided. For avoidable food waste, the waste can originate because the customer bought too much food, cooked more than what was necessary, had leftover meals or stored foods for too long. For possibly avoidable, the reasons can be taste preferences or separation of inedible parts. Quested and Johnson subdivide avoidable waste into *cooked, prepared or served too much*, which includes accidents during preparation that render food inedible, *not used in time*, meaning spoilage or passed date, and *other*. Parizeau et al. found that the biggest amounts of avoidable waste came from spoiled foods, followed by passed expiration dates. Correctly identifying the causes of waste allows for the creation of prevention strategies. More of the reasons for waste and the solutions associated with each reason, will be described in the following sub-chapters.

2.2.2 Influential factors for food waste

The previous sub-chapter mentioned what consumers cite as “reasons” for their waste. However, consumers are generally not aware that much of what affects their waste production is related to events that occur long before the waste happens. As mentioned by Quested et al., an effective model for food prevention must include the context of the behaviors that cause the waste - a context that is often out of the consumer’s control.

As a starting point, it is safe to assume that the factors that govern food consumption will also exert an influence in how a person produces waste. According to Contento (2010), the factors affecting the way an individual eats, although hard to narrow down, can be simplified into three branches: *factors related to the food, factors relating to the individual and the external environment surrounding the individual*. Aspects like personal preference, perception of hunger and satiety, learned food patterns and social influence are found to have an impact in food consumption habits. The latter is specially emphasized in literature, such as in the study by DEFRA (2008). Our attitudes, personal identity and beliefs (or culture, as pointed out by Carlsson-Kanyama) will also affect food consumption choices, as well as our economical and information environment (e.g. media).

The studies that have focused on food waste concur on several of these aspects. For example, Schneider and Obersteiner (2007) mention that behaviors that lead to prevention of household food waste are governed by age, income and time spent at home. Below are some aspects that have a correlation with household waste rates:

Age - Quested et al. observed that in the UK, older people were better at making use of their food, presumably because of being raised in austerity or due to better food management education. Likewise, Canada’s youth seems to incur in poorer food management than their older counterparts (Chenhall, 2011).

Lifestyle - Several characteristics of the household’s lifestyle will have an impact in the rate of waste production.

The size of the household and the characteristics of inhabitants are among the factors that have a clear correlation with waste production (Koivupuro et al., 2012): The more inhabitants per house, less waste per capita, possibly due to bigger amounts in common package sizes and in recipes.

Work patterns and the routines depending on these will also have an effect. For example, a busier schedule might contribute to consumers making food choices supported on convenience (as ready-meals) or to forgetting items (Parizeau et al., 2015, Ganglbauer et al., 2013).

Another factor to consider is the household economy: It is found that the more money is spent on groceries, the more waste is produced (Parizeau et al., 2015). Britz et al. (2014) make the interesting observation that from an economical point of view, more comprehensive cooking practices that could lead to a reduction of waste would require additional time and energy. Implicitly, the consumer makes a comparison between the value of said time to the time that could be spent working or at leisurely activities. Therefore, to reduce waste, the economic value produced by the activities for waste prevention should be higher than that of other activities.

Culture and eating habits - Cultural beliefs and habits will have a direct influence in food waste. Personal preferences of food quality (which can often depend on the consumer's upbringing) will govern what parts of the food are eaten or what time passed in storage is acceptable for the consumption of an item (Britz et al., 2014, Halloran et al., 2014). Parizeau et al. (2015) indicated that people who threw food away depending on the time of storage produced more waste than those who used other parameters to determine edibility of food.

In the same way, common barriers for the effective prevention of food waste must be regarded. Considering that the first barrier is the very nature of foods, not all food losses will be preventable - foods are destined to spoil and that represents a challenge when managing prevention of waste (Buzby, 2014). An important obstacle for the reduction of food waste in the household are consumers' beliefs about the safety of perishable products and health (DEFRA, 2008). Often consumers have a misguided idea about what constitutes an edible product, and will throw items away that still retain consumption potential.

2.2.3 Household-centered prevention of food waste

The European Parliament identifies waste prevention as the priority step in solid waste management schemes (EU Commission, 2008). Given that as much as 60% of food waste is preventable (Quested et al., 2013), food waste prevention takes precedence rather than management of existing waste. Several types of interventions to help households reduce their waste have been implemented across Europe, among these the most common being social campaigns (Thönissen, 2010). Campaigns often aim to present to the public the information available on why food waste originates and the ways to avoid it. An example of this is the "Love Food Hate Waste" campaign, run by WRAP in collaboration with UK Government and other institutions. It aims to increase user's knowledge on how to reduce food waste by integrating simple steps into daily routine (WRAP). There is also "Stop Wasting Food" in Denmark (Stop Spild af Mad, 2015) and Save Food Initiative (Save Food Initiative, 2016) in Dusseldorf, Germany.

As prevention strategies for food waste are closely related to the underlying reasons for the wastage; they are naturally founded on research that characterizes the latter. An example of the sources used is the report by DEFRA (2008), which identifies opportunities to reduce food waste in reducing the price for compost bins, working on best before dates for products, strengthening food literacy, cooking with leftovers and helping the population relate food with GHG emissions. These, according to Quested et al. can be summarized in two branches: influencing consumers' behaviors and making changes to the products sold. Modifying expiration dates on products would classify as making changes to the products sold, while informing consumers on what the dates mean would constitute influencing their behavior. Prevention strategies can also be categorized by the stage in which the waste occur (Parizeau et al., 2015), comprised within planning, shopping, storage, preparation and consumption stages. No link between method of treatment for the waste and waste production was found in the literature.

As the present thesis will focus on consumer's experience, research on behavioral change is also considered. Griskevicius et al. (2012) affirms that to harness action from individuals it is more effective to work with, rather than against, their human tendencies. These tendencies are identified as "(1) propensity for self-interest, (2) motivation for relative rather than absolute status, (3) proclivity to unconsciously copy others, (4) predisposition to be shortsighted, and (5) proneness to disregard

impalpable concerns. These can influence how a strategy might be taken by the consumers. For example, the suggestion by Beretta et al. (2013) to be less delicate about food preferences as a means for reduction of waste could conflict with people's propensity for self-interest. Bernstad's (2014) statement that "clear tools must be provided to the user to harness action from them" aligns with the tendency to disregard impalpable concerns.

Below are presented the results of the literature review regarding actions that contribute to and/or help prevent the origination of food waste in households. Since technological initiatives tend to focus on one or some preventive actions, some solutions found in literature will be presented along the action it focuses on. To facilitate their understanding, the preventive actions have been structured in Parizeau et al.'s stage division:

Planning strategies:

Meal planning - Planning meals is named the intervention that would most help consumers reduce their waste in the study by Parizeau et al.; is considered "crucial" by Beretta et al.; and is included in the nine key behaviors for food waste reduction by WRAP (Quested et al., 2013).

Meal planning helps to estimate the items and amounts that are to be shopped, and consequently helps avoid leftovers. Quested et al. (2013) says that to make food planning possible, there needs to be proper communication between members of the household and available time to plan. The planning will also be influenced by the frequency and variability of food related routines, as shopping, cooking and eating.

Making shopping lists – Schneider (2008) and Quested et al. (2013) identify making shopping lists as a method of food waste prevention, for similar reasons as meal planning. In Canada, it was determined that most young adults were not partaking in weekly food preparation behaviors, including the preparation of a shopping list (Chenhall, 2011).

Checking food levels – Verifying what is inside the fridge or cupboard before shopping food helps prevent unnecessary purchases and forgotten items. The purchase of an item that was already part of the household's stock might increment the chance of it being wasted. (Quested et al., 2013, Graham-Rowe et al., 2014, Ganglbauer et al., 2012)

Shopping strategies:

Avoiding sales - Attractive deals in supermarkets can lead the consumer to buy items in a larger amount than they can consume, or to obtain items which end up not appealing to the consumer. Koivupuro et al. (2012) points out that the frequency in which people buy discounted products affects their waste production. Avoiding sales is also mentioned as a strategy for reduction of waste by Beretta et al. and IMechE. It is also mentioned by Ganglbauer et al. (2013) as "overbuying". The price of a product can influence how the consumer uses it. For example, a user might be more accepting of wasting a product that was cheap; and though animal products are more damaging to the environment, they are also wasted less often because they are considered expensive (Beretta et al., 2013).

Control over package sizes - Users tend to be attracted to large packages, expecting more value for the money spent. These packages, however, often lead to more waste (Halloran et al., 2014). Per Parizeau et al. (2015), resizing is one the interventions that consumers consider would help them the most to reduce their waste. Nonetheless, Beretta et al. (2013), place the responsibility on the consumer, by suggesting avoiding the temptation for large packages as a measure to avoid loss due to purchasing too much.

Date labels - Date stamps in products are often misinterpreted by consumers, leading to unnecessary avoidable waste. Better interpretation of food labels and efficient packaging are mentioned as important strategies by Aschemann-Witzel et al. (2015) and Halloran et al. (2014). Ideally, date labels would be redesigned to make them clearer, but the consumers should also be informed on the meaning of the different types of date labels e.g. best before dates, expiration dates, etc. Farr-Wharton et al. (2013) mention using sensory cues, as smell and taste, to evaluate the edibility of a product without relying entirely on dates. Nonetheless, the conflicting interest of preserving one's health often leads users to waste the items rather than risking sickness.

Some initiatives to tackle this matter have arisen: WRAP has included changes both in packaging and labelling within their campaigns (Quested et al., 2013). Development of plastic films for food packaging are promising, as packaging that allows the produce to breathe (Buzby, 2014) therefore extending the product's shelf life, and a type of low cost plastic packaging developed to test food for edibility instead of using date labels (TUE, 2013). Rouillard (2012) suggests a refrigerator that scans expiration dates upon placing of foods inside, and then informs the user through mail or phone when a food item nears said date.

Storing:

Correct storage maximizes foods' shelf lives, avoiding untimely spoilage or loss of quality that can lead to waste. Beretta et al. include optimizing storage conditions within their measures to avoid losses. Quested et al. refer specifically to storage of apples and carrots in the fridge, and storage of meat and cheese in appropriate packaging, although of course all foods can be affected by their method of storage. Some things that will influence correct storage are available space in the cupboard and fridge, correct knowledge of storage guidelines and the wish to encourage fruit consumption by making it more visible, which can in turn make it more prone to spoilage (Quested et al., 2013).

Storage time can also influence waste: either foods become spoiled after long storage times, or some people might decide to throw away foods after a certain storage time independently of the food's actual edibility (Beretta et al., 2013). This kind of issue can be resolved by cooking appropriate portions, and making smaller shopping trips, which shows the interrelation between various stages.

Effective use of refrigerators and freezers - is encompassed within storage recommendations, with the targeted food groups being dairy, meat, fruits and vegetables. Maximizing freezer usage is recommended as well, as many foods can be stored in the freezer to prolong their shelf life without significant loss of flavor and texture (Quested et al., 2013). Furthermore, the CO₂ emissions saved by avoiding the waste of food outweigh the additional emissions due to increase of energy related to freezer usage (Brown et al., 2014).

Some research has been made to increase visibility inside the fridge and avoid waste. In the study by Xie et al. (2013), radio frequency identification was used to locate foods inside the fridge and identify user behavior to improve food management by suggesting recipes. Farr-Wharton et al. (2012) suggest color coding refrigerator areas per type of food. By doing this, awareness of the available foods increases, therefore preventing waste associated to forgetfulness and expired products.

Preparation and consumption:

Observing portion sizes - Cooking portions larger than necessary can increase the amount of leftovers, and therefore, of waste. Schneider (2008) proposes using tabulated portion sizes for prevention of food waste. Quested et al. (2013) include specifically the portioning of rice and pasta, within the nine key behaviors for food waste reduction. Beretta et al. (2013) also mentions portioning as a mean to reduce waste caused by leftovers. Some tools that would

facilitate correct portioning are knowledge of correct eating amounts and owning measuring utensils (Quested et al., 2013).

Leftover management - Leftover management is identified as a key behavior to avoid waste by Quested et al. (2013). This includes proper storage of leftovers, reuse, and modification of already prepared meals to make them more attractive to consume again. Leftover management could also include sharing unwanted foods to prevent avoidable waste (Beretta et al., 2013). Ganglbauer et al. (2012) bring forth the concept of “visibility for cooperation”, referring to users having visibility of their and other’s food stocks in order to share leftovers and foods soon to expire. A technological initiative that tackles leftover management is Shareyourmeal (2012), a website that allows users to see what nearby households are cooking and partaking in sharing behaviors, therefore reducing food waste.

Food literacy - Food management or food literacy is desired (Aschemann-Witzel et al., 2015), given that food awareness influence waste production (Parizeau et al., 2015). A conflicting statement is that it is found that people who are considered “Food conscious”, as in using several parameters to decide whether food is still edible, produced more waste. However, Schneider (2008) says that education for creative uses of food, education about the money embedded in the wasted food and general awareness of food waste help prevent food waste. Beretta et al., (2013) also refer to consumer awareness as a prevention method, as well as the ability to adopt different methods of preparation as a way to tackle potentially avoidable waste. Another aspect of food literacy is being able to produce dishes with produce that is not at top quality, and to know how to peel vegetables in an optimal way to reduce unnecessary waste (Britz et al., 2014)

In Canada, it was determined that most adults were not skilled in freezing and canning foods, abilities that might hinder food waste (Chenhall, 2011). Brown et al. (2014), for example, mention the public’s uncertainty about how and which products can be kept longer through freezing, and demonstrates that the value of the food saved outweighs the energy used for freezing, making it a good alternative for food management at the household.

Wasting:

Visibility of waste - Social norms have an influence in food behaviors. This relates to visibility in the sense that, given that food waste is not usually subject to public scrutiny, the user is not encouraged to reduce their waste due to social pressure and shame (Quested et al., 2013). In some cases, food waste has reduced when waste separation schemes have been introduced, allegedly due to the new visibility (Quested and Johnson, 2009). Ganglbauer et al. (2012) examine what different types of visibility have to be achieved for the prevention of waste, as visibility for awareness achieved through food diaries, visibility for cooperation referring to social media, visibility of space through potential cameras in storage places as fridges and cupboards, among others.

Visibility of the food waste in itself raises consumer awareness, which can be achieved through a food diary or a separate food waste bin (Quested et al., 2013). The latter is done in some parts of Sweden because of food waste source separation. Some initiatives that have worked in the visibility of waste are Eco-Mate (Lim et al., 2015), a waste bin that measures the weight of food waste and provides feedback through a tablet. Also, there is BinCam (Thieme et al., 2012), which hopes to combine visibility and social media by installing a camera inside bins of young adults, then making the captured images of their food waste available to themselves and other users of the system.

2.2.4 Stakeholder-centered prevention of food waste

This sub-chapter will pertain to how different actors along the food chain, along with institutions that are not be traditionally considered as part of it, could have an impact on household food waste.

Beretta et al. (2013) define the food value chain as “the system of organizations, people, and activities involved in moving food from its producer, usually the farmer, to the consumer”. The actors involved in this can be part of the agricultural production, as farmers, horticultures and slaughterhouses; the postharvest handling, as dairies, manufacturers and distributors: grocery detail as supermarkets and shops, and the food service industry and hospitality sectors, as canteens and restaurants. The consumers and the waste handlers are also included in this system (Halloran et al., 2014, Graham-Rowe et al., 2014, Beretta et al., 2013).

From the food system perspective, some of the factors identified as causing the current amounts of food waste are unclear date labels, sales which encourage consumers to buy several items or bigger items, and the demand for visually pleasing foods, as well as defective systems and practices along the food chain (IMechE, 2013). Moll et al. (2005) pose that changes in the production of goods will change the indirect usage of energy in a household, and that changes in the household consumption will impact the production level. It is also easy to see how practices at the retailer level affect household behavior, or how consumer’s preferences will dictate producer’s actions. Consequently, solutions will often be centered at one stage of the food supply chain but will affect sectors either below or above them. Thus, for reduction of food waste at the household, activities at previous stages of production should be considered, as well as the positions held by outside institutions as governmental institutions, the media, etc.

Several sources stress that better communication between actors is important for reduction of food waste (Halloran et al., 2014). Coordination between stakeholders is also of importance because the postures held by different stakeholders might present a contracting message to the consumer, e.g. the wish to reduce food waste versus the wish for more food waste sorting for production of biogas (Bernstad, 2014). Schneider and Lebersorger (2011) studied the variety of barriers, as “marketing policies, economic development, legal restrictions and individual attitudes” that prevent proper functioning of food waste prevention measures. They conclude that measures implemented at a single level of the value chain may not have the expected effect and thus should target different levels simultaneously.

Below is a collection of stakeholders that might be useful in or affected by reduction of food waste. Their counterparts in Gothenburg could be contacted for further studies on reduction of food waste:

Governmental Institutions - Governmental policies evidently have a big impact on the regulation of food losses and it is common to find government-based projects in the literature that pertain the issue. An example of this is Fusions (Food Use for Social Innovation by Optimizing Waste Prevention Strategies), a project funded by the European Commission with 13 countries. Its aim is reducing food waste and losses, supporting the European Commission’s target of reducing food waste by 50% and leading to the development of a common set of guidelines for Food Waste policy (FUSIONS, 2016). Locally, the relevant institution is the Gothenburg Municipality. Reduction of food waste was included as an objective for the achievement of the environmental target “**Reduced waste volumes and increased resource utilization**” for 2020 by Gothenburg Municipality (Göteborg Stad, 2013).

Producers - Britz et al. (2014) mentions that if the economic aspect of the reduction of food waste is not considered, it could cause loss of competitiveness for agriculture. There are some examples of policies to reduce food waste at a producer level: In Italy, a law was passed to facilitate the process for farmers and businesses wishing to donate unsold food to charities, along with research on ways to package food that allow extending its shelf life (BBC News, 2016). Arla, the largest Scandinavian producer of dairy, has adopted a “zero waste” vision, helping consumers plan their purchases and creating packaging with the suitable amounts for consumers’ needs. Another example in Sweden is Lantmännen, an agricultural cooperative whose concept is to “create value from farmland resources in a responsible manner” (Lantmännen, 2015). While the cooperative mentions the implementation of waste of oats as

raw material for fuel, avoiding food waste or losses is not mentioned explicitly amongst their broad number of environmental key-issues.

Retailers - As retailers are the link between producers and consumers, important losses happen at this level. Some solutions have been ideated at the retailer level; the impact of which spans from preventing food losses at the production stage to the household level. In France, a regulation from 2015 dictates that supermarkets are to donate unwanted food to charity, as a part of a plan to reduce food waste by half by 2025 (Willsher, 2015). Walmart, one of the biggest retailers in the United States, will contribute to cutting down in food waste by requiring food suppliers to modify their expiration dates by making them less misleading. In 2016 they started selling visually unpleasing potatoes in an attempt to curb waste due to quality markers, and aim to extend their selection of “ugly” vegetables (Yiannas, 2016). In Sweden, big retailers that could be involved in waste reduction are ICA, Hemköp and Willys.

Packaging companies - As previously mentioned, packaging companies can influence household waste through the package’s sizes and expiration dates. Initiatives in the UK have included modifications to the way the food is packaged and labelled, along with price rises for packages deemed less effective (Quested et al., 2013). Halloran (Halloran et al., 2014) also poses that information should be shared with stakeholders about production of packages.

Waste Management Entities – Waste water and solid waste management are directly affected by the waste fractions produced by populations, while also exerting an influence in the kind of waste that is produced e.g. campaigns to encourage waste sorting. A relevant entity is the Kretslopp och Vatten (Recycling and Water) division of the Gothenburg Municipality, which manages the contracts that take care of the solid and water waste within the city. As of now, the companies hired by the Recycling and water division are Nordisk Återvinning Service AB, for retrieval of solid waste in West Gothenburg; Renova AB for waste retrieval in the remaining sectors of Gothenburg, and in charge of recycling stations and a plant for pre-treatment of food waste in Marieholm; and Gryaab for treatment of waste water, with extraction of energy and recovery of nutrients (Göteborgs Stad, 2013)

Consumer organizations and others - Sveriges konsumenter, or the Swedish Consumers’ Association works to “protect the interests of the Swedish consumers in regard to both publicly and privately produced goods and services”. One of their functions is to advocate for environmental sustainability, and food is currently one of their top priorities. Chalmers Students for Sustainability is a non-profit organization amongst Chalmers Student Union’s committees and associations, which works with projects and distributing information for sustainable practices. They often hold events focusing on food waste.

2.3 FoodWatch: a tool for studying food flows in the household

As a starting point, this sub-chapter briefly talks about household metabolism studies. Then, it presents the context in which the FoodWatch application originated, as well as the opportunities for improvement found by previous researchers. It also describes its functioning at the time of this study’s beginning, and introduces similar concepts found in literature.

2.3.1 Household metabolism studies and household waste studies.

Food flows in the household can be considered part of the household’s metabolism. Household metabolism is composed of the direct flows and indirect resources required to make household consumption possible (Noorman and Schoot Uiterkamp, 1998). Waste affects the indirect energy used, and is a product of existing consumption patterns. In the case of energy household metabolism, a final result would be the sum of all direct and indirect requirements of energy (Moll et al., 2005). Moll poses that “Quantification of the environmental load related to consumption is required to facilitate sustainable consumption”. Thus, to impact waste production, it is necessary to understand the household

dynamics instead of trying to implement new behaviors from the outside (Bulkeley and Gregson, 2009). Metabolism studies, therefore, provide a great opportunity to study household dynamics to create sustainable solutions.

Most household metabolism studies are focused on energy consumption, with few exceptions to be found. Amongst the exceptions is the study by Baker et al. (2007), analyzing the flow of C, N and P in households, including that embedded in food and its waste. Feng (2012) performed a pilot study for quantification of the metabolism in two households through gathering purchase receipts and collecting recyclable and organic waste, which presented several difficulties. Households' patterns of energy, water and food consumption were studied in the Czech Republic, taking into account their environmental impact (Prášilová et al., 2015). Moll et al. studied energy requirements in Northern European cities (including Swedish cities), concluding that all countries had high energy expenditures in the food category, most specially the highest requirement of indirect energy for all countries, next to transport and recreation. The studies made by Harder (2013, 2014), precursors to this thesis, aimed for a highly-disaggregated count of the energy, water and goods flows, including food, in a sample of households. The sub-chapter "**FoodWatch Background**" will expand on Harder's work.

Given the very nature of household metabolism, food flows will be often included in the studies although few studies have concentrated specifically on the food component of household metabolism. Nonetheless, from a non-metabolism perspective, several sources have studied household food waste. Many methods exist for collection of waste data, including food waste i.e. garbage trucks collecting the waste of a neighborhood (Dahlén and Lagerkvist, 2008). However, a standardized method for the collection of household specific waste data does not exist (Lebersorger and Schneider, 2011). In the research by Dahlén et al. (2007) municipal solid waste was collected and sorted from 1998 to 2004 in six municipalities in southern Sweden. Although focused on household waste, this study was also aggregated and obtained data by dividing volumes of waste obtained between the numbers of households studied. It was an objective of the study to analyze the differences in waste material flows.

Quested and Johnson (2009) denote three methods for quantification of food and drinks waste in households. First, there is the **compositional analysis** method, in which waste streams are analyzed, weighed and classified by researchers before reaching the waste collection management. An example in Sweden is the study by Bernstad and Andersson (2014). Another method is **diary keeping**, one dependent on the study participants, given that they are the ones to record the waste. This has, in the past, led to underestimation of waste of up to 40% (Quested and Johnson, 2009), and is said to lead to lower rates and inaccuracy of data collection. Some examples of diary-based waste data collection are the study performed by Sonesson et al. (2005), who studied the life-cycle environmental impact of food consumption in Swedish households; and a German study in which 200 households held an online diary (Europa, 2011). Diary keeping has also been used to quantify ecological footprint of all activities in the household, including food-related activities. Lastly, there is the **subtraction method**, in which waste is calculated by subtracting the consumption values from the purchase values and assuming the remaining is waste. Although several methods for collection of waste data exist, Gustavsson et al. (2011) identifies the need of data on food losses and waste "urgent".

Another aspect of household food waste studies that is not standardized is the delimitation of a household. Quested and Johnson, for example, draw the delimitation depending on the method of disposal of the waste, leaving out the food that is disposed out of home, as items consumed on the go e.g. snacks; but include home composting, food fed to animals and waste from foods that were originally brought home from catering. Harder (2014) differentiates between a household as a socio-economic entity and as a physical entity, where the first selects the flows based on the people independently of where flows happen, and the latter approaches flows independently of who produced them. He also recognizes the limitations of the physical approach, as services and flows that occur outside the household delimitation might carry important information (2013). Delimitation of a household will depend on the scope of every study, and can include or exclude many sources of flows. An example of the flows into a household is extracted from Quested and Johnson (2009) in Figure 1.

Independently of data collection method or delimitation, most studies that gather food waste data in aggregated way and do not consider the reasons behind the waste (Lim et al., 2014a). Studies that

include life cycle assessment (LCA) of the foods wasted are also to be considered, because they allow to summarize the impact of such wastes. The impact of waste can vary greatly depending on the type of food, the point in which it's lost, at what point of the chain and how is it managed after disposal (Beretta et al., 2013). LCA data will also carry its own delimitation of the steps included in the studies.

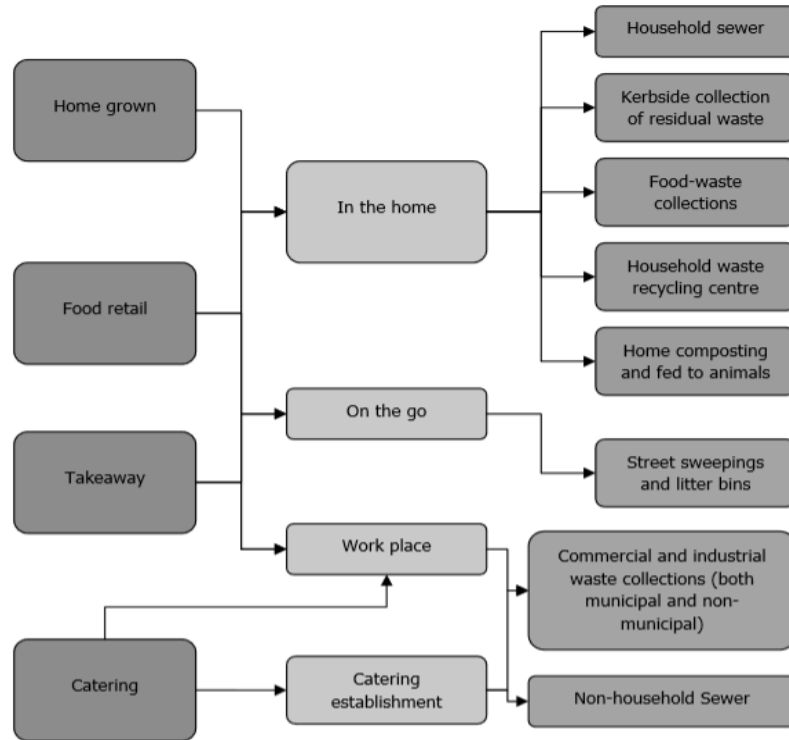


Figure 1 - Schematic of major flows of food and drink and associated waste routes (Quested and Johnson, 2009)

2.3.2 FoodWatch Background

In 2013, Harder studied two approaches to quantify the metabolism of individual households, aiming to obtain a higher level of disaggregation than in the literature available to date. His hypothesis was that only with such disaggregation would it be possible to reveal the causes for the differences between households' metabolism. The initial stage of the study collected data on water, electricity and goods flows.

Flows of goods were obtained by triangulating shopping receipt data with detailed analysis of solid waste. While this approach resulted in a constant stream of data, it was found that the triangulation process would not be practical for longer periods of time or larger samples of households. Depending on the retailer, the information on the receipts presented significant differences, which interfered with the systematization of receipt digitizing. Waste analysis, on the other hand, was difficult because of the nature of household metabolism itself: products can be either consumed and/or wasted immediately, or enter the household stock, which made it possible to miss information about a product entirely.

Although theoretically the triangulation approach required minimal involvement from the household; in practice, the users had to digitize receipts, separate recyclable waste in different fractions, divide organic waste per type, and regularly deliver their waste to the university. All in all, these steps could take up to one hour daily.

In response to these challenges, an online application for the quantification of food flows was developed. The rest of the flows considered in the first stage i.e. water, electricity and non-edible goods, were not considered for the second stage. The application, henceforth called "FoodWatch", allowed the

households to register the flows that occurred through formal pathways, i.e. bought at retailers and disposed through the municipal waste collection, utilizing a diary-based data collection method. Upon purchase, every item was marked with an identification sticker, to later be registered along with the product's barcode. If there was no barcode available, as commonly with fresh produce, the items were weighed on a scale and manually added into the application along with the sticker. FoodWatch's data base associated each product with one of 242 food groups in accordance to the COICOP and CP-2008 (Harder et al., 2014). For products with a barcode, items were automatically associated to a group, while for products without a barcode, the product groups were to be chosen manually. Once the purchases were part of the inventory, they could be removed entirely or by fractions; whether they were consumed, taken out of the household or wasted. For either case, the fraction to be registered was weighed.

This approach was simpler and less time consuming, and collected further details of the food-related activities in the household. While the use of FoodWatch seemed to require as much involvement from users as triangulation, it only took 5 minutes in average per session.

2.3.3 FoodWatch's current functioning

FoodWatch, as an online application or "app", can be accessed through any device with an internet connection.

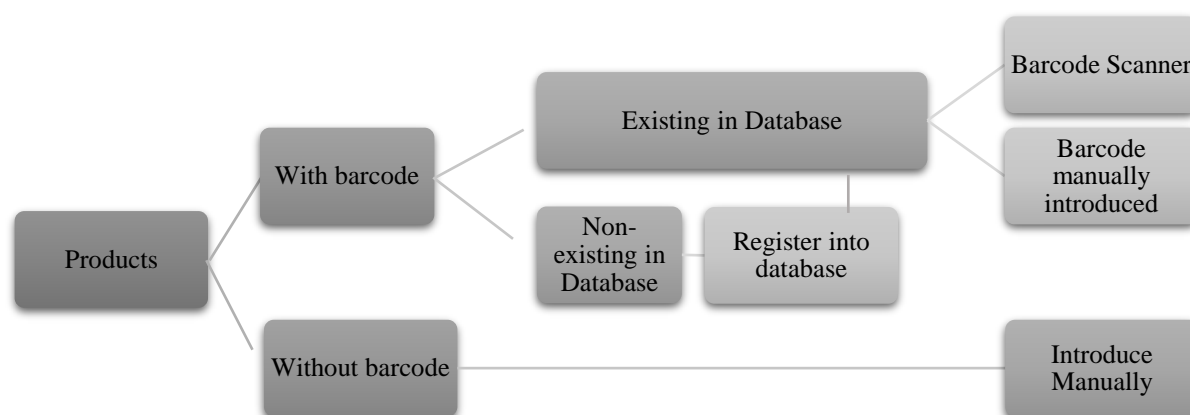


Figure 2 - Pathways for recording transactions in FoodWatch

As illustrated in Figure 2, there are several ways to record a food transaction depending on the type of product.

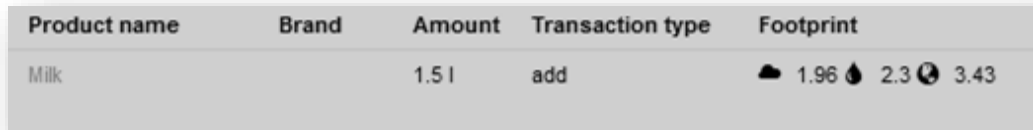
Packaged products can be registered by using a handheld scanner to read the product's barcode. The scanner can be paired with devices that enable a Bluetooth connection, e.g. tablets, smartphones and computers. Alternatively, the product's barcode can be inserted into the application by hand. For both cases, if the product exists within the database, it is saved in the User's Transactions section immediately. If unavailable within the database, the product can be added by providing its name, barcode and product group, and then registered to the transactions as usual.

Products without a barcode, generally unpackaged products such as fresh food or vegetables, are introduced within the app manually. When this option is chosen, a dropdown menu appears, where the user can choose a fitting product class. In this case, the product needs to be weighed, and the value introduced along with the product class. Values can be introduced in kilograms (kg) for solids and in liters (l) for liquids.

This process is valid for transactions of purchase or waste. Consequently, all transactions will be part of the inventory as one of these two options.

2.3.3.1 Environmental information

Products within the FoodWatch database are linked to life cycle analysis (LCA) data that present land, water and carbon footprints. In this way, the app can provide a quick overview of the impact a household's food consumption has on the environment (Knutsson, 2016). FoodWatch is particular in showing several kinds of footprint. The studies in Quested and Johnson's report (2009), for example, only present footprint of carbon emissions.






Product name	Brand	Amount	Transaction type	Footprint
Milk		1.5 l	add	 1.96  2.3  3.43

Figure 3 - Capture of product information in the FoodWatch application

The impact of each product is shown as in Figure 3. Carbon footprint appears in equivalent carbon dioxide emissions (eCO₂) and is represented by a cloud figure; water footprint in cubic meters (m³) and represented by a water drop figure; and land footprint in global hectares (gha), represented by a figure of a planet.

2.3.4 Improvement opportunities and potential applications

To simplify the use of FoodWatch, it was recommended to do further research on what sorts of data could be obtained from other sources, such as retailers and producers. Another idea suggested by Harder et al (2013) was studying the household practices that lead to food waste. Studying the causes of food waste aligns with Gothenburg's environmental targets, specifically the 11th target under the name of a "Good built environment". The reduction of food waste is considered a necessary measure for the milestone of reducing waste and increasing resources (Göteborg Stad, 2013).

Harder also mentions the potential applications of FoodWatch in living labs and user center research. For example, FoodWatch could be used within the HSB Living Lab after further development (Knutsson, 2016). The HSB Living Lab is an accommodation project conceived by Chalmers University of Technology, the HSB housing cooperative and Johanneberg Science Park, under the platform of the SusLab living labs project (Chalmers, 2015). The apartments in the living lab host technologies to reduce impact on the climate, with ongoing research in sustainable constructions and use of resources and energy (HSB, 2015).

Given that the subjects of the pilot test were researchers; it was also recommended to investigate whether common households would be willing to participate in a study that observed their consumption habits so closely. Once this is investigated, FoodWatch might be a suitable tool within the Johanneberg Factor 10 – Smart Sustainable District project (Knutsson, 2016). Many sustainable solutions, including resource management, are being tested in Johanneberg. These aim to reduce resource use by 90% without affecting economic and human growth (Chalmers, 2014).

At the time of Harder's licentiate publication, FoodWatch was being developed to include food footprints. Therefore, it was suggested to investigate the effect that this type of information would have on users. The availability of real-time environmental data suggested that FoodWatch's platform could allow for several types of intervention, amongst them "eco-feedback" (Harder, 2013, Knutsson, 2016). The concept of eco-feedback is expanded in the following sub-chapter, "**Persuasive technology**". By the start of this project, FoodWatch had a footprint database comprehensive enough to study intervention options.

2.3.5 Similar online applications

To further develop FoodWatch, it is useful to study what similar applications exist, and how they have worked on base of their objectives. Literature revealed that the concept of gathering shopping data from users and suggesting actions depending on the context has been studied, although not

extensively. In 2002, Berkeley University ideated a computer application which would register user purchases through receipt scanning and suggest nutritious foods in form of a shopping list (Mankoff et al., 2002). More recent examples have been found in the literature, such as EUPHORIA, EatChaFood and Love Food Hate Waste, although only the latter is available to the public. These have found it useful to integrate feedback into their methods, although not necessarily eco-feedback. Below is presented a summary of the characteristics of these applications:

EUPHORIA (Efficient food Use and food waste Prevention in Households through Increased Awareness) will be a mobile application used to reduce food waste by providing eco-feedback. The main intervention will be the recommendation of recipes that include ingredients at risk of wastage in several households, therefore allowing the users to gather and cook them into a single dish. It is devised as a social platform, and so users will be able to choose which flows will be visible for their social contacts, as well as see their friends' public flows.

Although EUPHORIA, just as FoodWatch, allows the user to track their purchases and waste, some dissimilarities stand out. Products are registered by selecting pictures of the food, therefore differences in brands are not captured (Lim et al., 2014b). Items to be consumed entirely will not necessarily be registered into the application, which means that it does not intend to quantify the household's metabolism. In the exploratory study, only foods which could be used for preparation of dishes were considered, therefore desserts and most drinks were excluded.

Also, it is not clear to what degree the collection of waste data is disaggregated. As a solution to the potential inconsistency of manual logging, it is planned to place a weight sensor below households' trash bins. This would be including unavoidable waste, and would replace weighing of items individually (Lim et al., 2014b).

The application emphasizes sustainable eating, e.g. suggesting seasonal ingredients and avoiding those with high eCO₂ emissions, but will not show a product's footprint information nor provide an approximation of the impact of the waste.

Akin to Harder's first stage of household metabolism study (2014), the EUPHORIA project will ask users to collect their receipts, although they will be used as a verification tool rather than as the main source of data. A most important difference between this application and FoodWatch is the social sharing format, which is identified as a challenge for user's privacy preferences.

EatChaFood (Farr-Wharton et al., 2013) is an app in development which intends to reduce household food waste. The app focuses solely on waste of food that has expired, leaving out all other aspects of food waste. EatChaFood cites *knowledge of what foods people have, knowledge of where they are placed, and food literacy* (i.e. food preparation, consumption, lifecycles) as contributing factors to food expiring before consumption; and accordingly set increasing user awareness of what food they have and where it is located, as well as notifications near an item's expiration date, as their strategies for expired food waste reduction.

The app works in combination with a camera inside the refrigerator, which could be used for automatic scanning of products or photo recognition. EatChaFood's creators also identify manual logging as an issue, which they plan to resolve by providing a clickable list of available foods. This might mean that the application will not make a distinction between specific brands, similarly to EUPHORIA. Another similarity will be the sharing of recipes using the ingredients available at the household. The app will not capture the household metabolism, as there will be no function to indicate when something has been wasted.

An advantage of EatChaFood is that it will provide information on how to use sensory cues to determine if the food is still safe to eat after the expiration date. The app also plans to involve social media, by allowing the list and pictures of available foods to be public.

The **Love Food Hate Waste** (WRAP) app helps users tackle behaviors that contribute to household food waste. The app provides a tracking function for food planning and shopping, help with cooking portions, recipes for use of available ingredients (as in both applications described previously) and suggestions for the use of leftovers. Encouragement for the reduction of waste has a social component in this application, as the user can win badges and share their accomplishments with other members.

The description of the app uses economy and environmental concern as incentives, the economy aspect being unique among similar applications. However, there is no explicit link to environmental impact during use of the application, and no other feedback than the badges is provided. Ingredients can be edited or deleted, therefore giving no count of how a product is used.

All of these applications track, to some degree, food flows in the household. They focus on reduction of food waste and utilize eco-feedback, both characteristics suggested as possible courses of action by Harder. Observing these applications characteristics allows to identify what alternatives haven't been studied and what aspects have been successful.

2.4 Persuasive Technology

This sub-chapter introduces the concept of persuasive technology, focusing on eco-feedback. Eco-feedback is defined and several methods are presented. Finally, the sub-chapter presents instances where eco-feedback has been used for food and/or waste studies.

Studies have been conducted on understanding the attitudes and behaviors of people to come up with strategies that endorse carbon savings. In general, things that encourage people to adopt behaviors are social norm, personal gratification, individual benefits and feeling part of something. Some of the things that hinder public participation are external factors as infrastructure, cost, time, work schedules, habit and skepticism (DEFRA, 2008). When talking about environmentally friendly behaviors, environmental concern is a strong predictor of adopting them (Mobley et al., 2009). Environmental concern is motivated by egoistic, altruistic and biospheric factors (Schultz, 2001), although there is no definitive theory on how environmental concern is born.

Something to consider when aiming to influence behavior is that information will generally not make any difference, unless it's accompanied by methods of facilitating the desired action (Bernstad, 2014, DEFRA, 2008). Brynjarsdottir et al. (2012) agree in that most articles expect to influence behaviors by raising awareness, but do not specify ways of reducing the resource consumption. Few articles have a delineated plan which bridges providing information with using it for behaviors changes. Both DEFRA (2008) and Bernstad (2014) say that studies should not only aim for a change of behavior, but also maintenance and reinforcement of these behaviors. Persuasive technology is seen as a tool to put environmental knowledge into action, and be able to maintain the newly adopted behaviors.

Persuasive technology is defined as "technology that is designed to change attitudes or behaviors of the users through persuasion and social influence, but not through coercion" (Fogg, 2002) often relying on interactive platforms. Foster and Lawson (2013) mention its promising potential due to the large amounts of people that are involved in online networks regularly, which makes them platforms to encourage positive behaviors.

As for any technique to promote behavioral change, it is vital to consider the incentive used. Shiraishi et al. (2009) cite the possibility of providing **individual, social, learning based** and **economic** incentives. Something to consider in persuasive technology is that a negative reaction can occur if the individual feels pressured to adopt a certain attitude or behavior (Brynjarsdottir et al., 2012). Persuasive technology can be potentially applied in any area of human behavior, but it has attracted attention for encouragement of environmentally beneficial behaviors, thus leading us to eco-feedback.

2.4.1 Eco-feedback

Eco feedback is considered a "strategy to increase awareness of resource use and encourage conservation" (Froehlich et al., 2010), which entails perceiving the activities of the household and

providing information about it through some display. Eco-feedback is based on the premise that general population is not aware of how their actions affect their environment, and have the power to change them through rational choice once made aware of the benefits (Strengers, 2011).

The type of message delivered in feedback varies between **descriptive norm messages**, which indicate values, e.g. kilowatts per hour spent in a household, in comparison to others, and an **injunctive norm message**, which evaluates the quality of an action, e.g. judging an amount of energy expenditure as bad. The latter example would be considered **aversive feedback**, which is usually seen as ineffective, but proves to be not necessarily bad (Foster and Lawson, 2013). Nilsson et al. (2014) classify interventions into **antecedence strategies**, as providing information, setting goals, predicting future behaviors, and **consequence strategies** which provide feedback and/or rewards. Midden and Ham (2013) report that, goal setting in specific, is very effective in encouraging environmental behavior changes.

To be considered is also the frequency of the feedback. Abrahamse et al. (2005) distinguish between **continuous feedback**, which shows the chosen values to the user at all times, and **periodical feedback**, finding that the latter is less effective. While feedback can be provided through any device that has a display, a common way to deliver continuous feedback is through in-home displays, or IHDs (Nilsson et al., 2014). Shiraishi et al. (2009) and Strengers (2008) stress that eco-feedback provided with immediacy motivates behavior change, while Nomura et al. (2011) conclude that feedback is most effective when consistent and reiterated.

Following a social psychology incentive, **nudging**, or the use of normative social pressure, can also be implemented in eco-feedback (Foster and Lawson, 2013). Many studies have been using competitive or comparative messages between households, based on research that states that comparison between social groups by judging the behavior of a household facilitates behavior change (Strengers, 2008). As an example, in the study by Foster and Lawson, 7 out of 8 households were influenced by social messaging about energy consumption. Strengers (2008) additionally states that eco-feedback should encourage more social interaction.

However, according to Quested et al. (2013), giving information to the user on how to change a behavior will rarely be effective if not combined with more engaging strategies. Abrahamse et al. (2005) and Hunter et al. (2006) agree that only informing will not promote behavior change, specifically in the case of energy and footprint reduction. Something to consider is the message in which the feedback relies to harness action (Bernstad, 2014). By its very definition, eco-feedback appeals to the user's environmental concern, but it's been studied that the ability of a person to connect to a message will depend on their values, and the very reasons that cause the "undesirable behavior". For example, if the person is wasting food because of health reasons, a message relating to environmental impact might not be effective. Strengers agrees that eco-feedback is only likely to appeal to people with environmental concern. Quested et al. (2013) identify guilt, economy and health as motives that might be more effective, at least in regards to food waste reduction. In this way, the consumer might be more motivated by the reduction in their food expenses rather than the reduction of their carbon footprint. In the case of energy studies using IHDs, while the information motivated curiosity in users, the barriers were in the difficulty to change habits and in bridging between the behaviors and the consumption values (Nilsson et al., 2014). Another common barrier is the user's difficulty in understanding the values provided in the eco-feedback, and not knowing how to use this information to change their behavior. Similarly, the user might understand the values but frame them into the behaviors that they assume will be helpful, which might not be so (Strengers, 2011).

Some difficulties found in persuasive technology and brought forth by Strengers (2008), who recognizes the difficulty of influencing normative behaviors, i.e. those that are too ingrained to easily change through information. She mentions that our practices are more dependent on social and cultural patterns, habit, available technologies and institutional rules than on reasoning, and thus recommends that eco-feedback systems be designed focusing on every day practices. She also points out that the individual should not be treated as a separate being from its socio-technical context, as the information about consumption could show the user their cultural and social dynamics.

Brynjarsdottir et al. (2012) found that most of studies from 2009 to 2011 involving persuasive technology to provoke sustainable behaviors were about energy consumption, followed by water

consumption. Some examples are the studies by Foster and Lawson (2013), which studied cases to reduce energy consumption, and Erickson et al. (2012) where eco-feedback and social influencing was tried for water use. Outside Gothenburg, a study was performed providing eco feedback to households about their electricity consumption (Nilsson et al., 2014). A project called One Tonne Life (2014) was conducted in Stockholm, providing a single family with an energy smart house, efficient house equipment and electric car, as well as providing advice from experts for their reduction of energy usage in daily life. An appliance called Energy Watch showed their daily energy usage and suggested activities that could change their behavior for reduction of waste, reaching a reduction of their emissions by 75%.

2.4.1.1 Eco-feedback applied to food issues

Few articles about eco-feedback pertain the reduction of food related CO₂ emissions, much less about waste. Nonetheless, research is just catching up with the idea that eco-feedback might be useful to influence food management as well. Shoppers are increasingly interested in obtaining information about the products they buy and the consequences of buying those products, many expressing that they don't know where to find information about the environmental impact of their food choices (IGD, 2007). Clear et al. (2013) identified eco-feedback as a good strategy for the reduction of embedded energy into food after evaluating the foods cooked and practices of university students.

Amongst the studies that implement eco-feedback in food related issues are the following. A study evaluating the impact of feedback on food waste separation and recycling in a street-based comparison to the neighborhood's average had positive results (Nomura et al., 2011). Shiraishi et al. (2009) focused on reduction of CO₂ emissions by targeting various behaviors within the household, including to "avoid leaving leftovers from food". In the study by Wood and Newborough (2003) the decrease of energy used during cooking is evaluated when providing eco-feedback. The intervention was more effective than just providing information before the study. The study also asserts that eco-feedback should be regular. Kalnikaite et al. (2011) uses a display clipped on shopping carts, showing information about the scanned products' origin (food miles, or how many miles has the item traveled to arrive at the supermarket) and whether the product is organic or not. Social norms were also included, as the device displayed how the present shopping cart compared to the average. Use of the device gave a significantly positive effect.

In regards to food waste (Lim et al., 2014a) has made a pilot test with an augmented trash bin that provides feedback, including social feedback, about wasted foods, resulting in promising findings. The bin can receive input on type of food and state at which it was disposed (bad, possibly bad, etc.), allowing some level of disaggregation. The study also stresses how little research there is on eco-feedback's impact on food-related behaviors pro reduction of food waste. Nomura et al. (2011) also studied the effects of social feedback on recycling of food waste, though not on its production. Koivupuro et al. (2012) found that people who considered they had high potential of reducing their waste were generally the ones producing more waste.

3. Methods

This chapter describes the methodology followed for the completion of the project.

The present project is meant to have quantitative elements resulting from the use of the app, and qualitative research coming from the users' experiences. Parting from that, the project was carried out in several steps, starting by a literature review. The information gathered in the literature review served as a base for the elaboration of a comprehensive conceptual model and for the identification of the stakeholders that could be relevant to the project. The conceptual model aided in the identification of the necessary changes in the app to achieve the desired objectives. After the modification of the app, a pilot test was carried out, where voluntary individuals used the application for five to thirteen weeks. The final step consisted in processing and analyzing the data obtained from the pilot test, to produce the finalizing remarks.

Figure 4 shows the progression of the actions taken during the project.

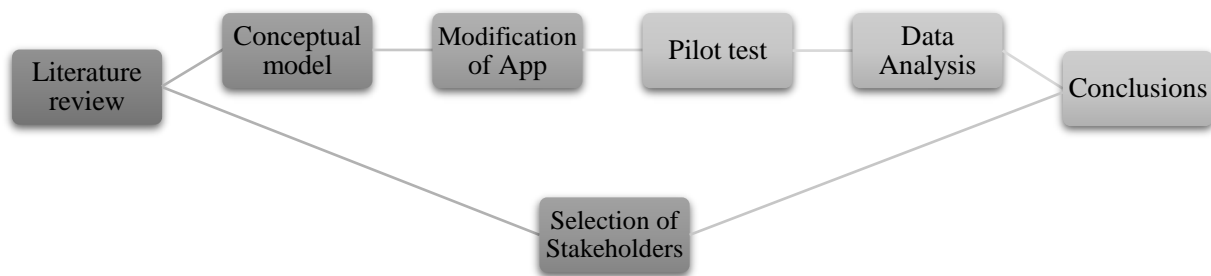


Figure 4 - Overview of methodology for the project

A description of the main stages will be presented in the following sub-chapters.

3.1 Literature Review

As a commencing step to this project, a literature review was conducted. Opportunities of development for the application FoodWatch pointed out the possibility to implement eco-feedback. After analyzing options for the reduction of food-borne greenhouse gas emissions, the focus of the literature review was to gather information on the surrounding factors of food waste: its reasons, consequences and actors, as well as strategies for its prevention. Although some information about food waste at all stages of the food chain was gathered, more attention was put into the aspects surrounding household food waste. Some information about general household waste was also gathered. Literature on persuasive technology was also studied to determine the characteristics of the interventions to be implemented.

Due to the character of the subject and the number of articles available, most of the information was had a global perspective, with a slight focus on countries within the European Union and Northern Europe.

The literature review also helped select the relevant stakeholders, based on their influence in each stage of the food system. After identifying which were the stakeholders' relevant to food waste on a general level, some of their counterparts in Sweden and/or Gothenburg were identified.

The main sources for relevant articles, reports and book excerpts were the Science Direct website, the Chalmers Library search function and the Google Scholar search engine.

The findings from the literature review were presented in the previous chapter.

3.2 Formulation of conceptual model

Parting from key concepts identified during the literature review, a conceptual model which describes the processes of household food management was elaborated. A visual flow diagram representing these processes is shown in Figure 5. The stages in food management follow the model of Parizeau et al. (2015). Each stage is characterized differently, and carries certain actions or factors that can affect waste production positively or negatively. These are tied back to findings in the literature review, largely based in the articles by Beretta et al. (2013) and Quested et al. (2013). They are presented in Table 1.

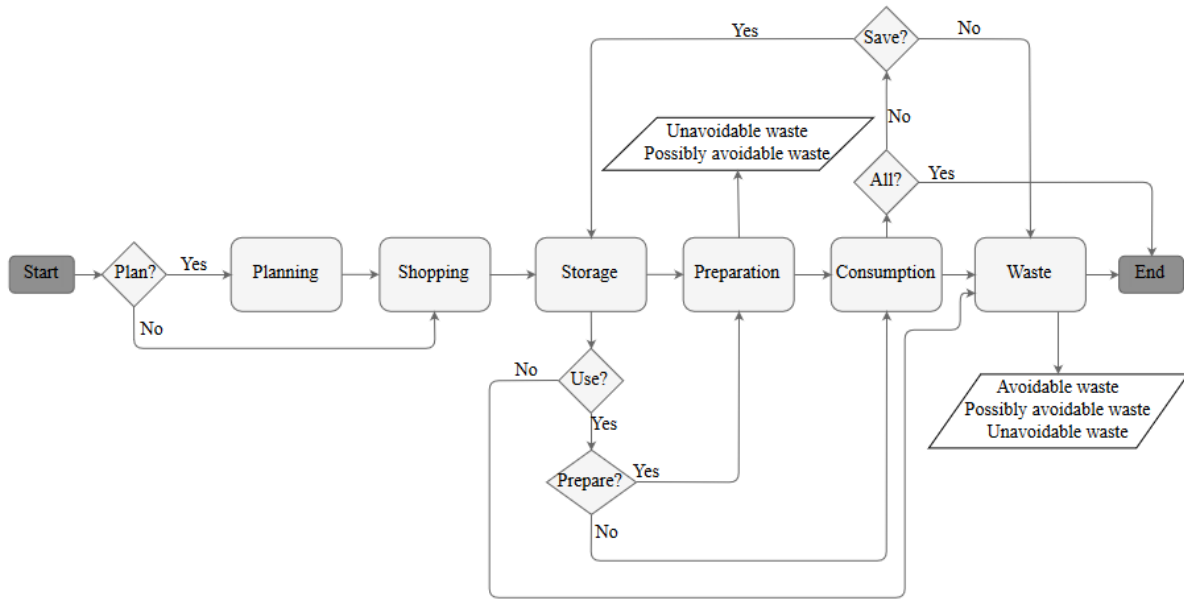


Figure 5 - Flow diagram of food behaviors in the household

Additionally, further characterization of waste is presented in Figure 6. Given that the project will focus on reduction of avoidable and possibly avoidable waste, the state and reason for waste adapt to this. The state of the waste is a simplified version of the concepts proposed by Bernstad and Andersson (2014). Reasons for waste are collected from diverse sources.

Table 1 - Detail of actions and factors involved in every stage in flow diagram of food behaviors

Stage	Type	Actions and factors that affect waste
Planning		<ul style="list-style-type: none"> - Checking levels of food before shopping - Planning meals - Making shopping lists
Shopping	-	<ul style="list-style-type: none"> - Sizes of packages (standard or bulk) - Buying in discount or sales
Storage	<ul style="list-style-type: none"> - Unrefrigerated (cupboard, countertop) - Refrigerated - Frozen 	<ul style="list-style-type: none"> - Visibility of products - Available space for storage - Time of storage - Correct storage per food type
Preparation	<ul style="list-style-type: none"> - Cutting and/or peeling - Cooking 	<ul style="list-style-type: none"> - Portion sizes - Use of recipes - Use of measuring implements
Consumption	<ul style="list-style-type: none"> - Fully - Partially 	<ul style="list-style-type: none"> - Leftover management - Understanding of date labels
Waste	<ul style="list-style-type: none"> - Avoidable - Possibly avoidable - Unavoidable 	<ul style="list-style-type: none"> - Visibility of waste

Edibility of waste	Type of waste	State in which product is wasted	Reason for waste
<ul style="list-style-type: none"> •Edible •Inedible 	<ul style="list-style-type: none"> •Avoidable waste •Possibly avoidable waste 	<ul style="list-style-type: none"> •Unopened package •Opened package •Half eaten food •Prepared food 	<ul style="list-style-type: none"> •Large package •Forgotten item •Not tasty item •Spoiled item •Expired item •Wrong storage

Figure 6 - Characterization of waste

Through this, potentially any wasted item could be defined. As an example, a full package of strawberries left on the countertop until spoiled would be passing from the **Storage** to the **Waste** steps in the flow diagram; it would be classified as **inedible** and **avoidable waste**; disposed at the **unopened** state; and the reason for waste would be **spoilage** and **wrong storage**.

3.3 Modification of the App

To make the app more user friendly, some practical modifications were performed. Among these, the introduction of items by using their barcode was made more accessible than before, and a virtual keyboard was added for text input.

The rest of the modifications were related to the study objectives, and thus conceived to address notions from the conceptual model. The proposed changes pertained the ability of the app to collect numerical and qualitative information related to the transactions, as well as the introduction of feedback interventions. These were presented to Dr. Jesper Knutsson, who elaborated the coding necessary for implementation into the online application. The changes implemented are presented below:

3.3.1 Purchase sessions

The first change done to the app was the introduction of the “session” concept. In this way, when a product is introduced, a timer is set within the app. All products introduced within 30 minutes of the first product will constitute a session, similarly to a trip to the grocery shop. This facilitates keeping track of the order in which products enter the household and being able to relate them to behaviors previous and after shopping.

When a product is related to an existing session, the message in the following image appears on the screen:

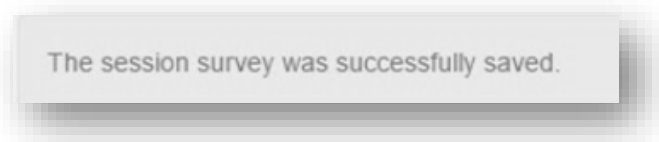


Figure 7 - Saved session message

3.3.2 Purchase metadata

An important factor relating to the production of waste in the household is the routine preceding the trip to the grocery shop. As stated in the literature review, the creation of a list, the habit of checking what is already in the cupboard and fridge and the planning of weekly meals present a high correlation with the eventual wasting patterns. To observe the planning habits of the users, a brief survey at the beginning

of each shopping session was introduced. When a session begins, the user is presented with the questions depicted in Figure 8.

Did you go shopping? Please answer a few questions below.

[Skip this step](#)

Before shopping, did you...

- ☐ ...do nothing, just unplanned shopping?
- ☐ ...plan your meals before shopping?
- ☐ ...check levels of food in cupboards and fridge before shopping?
- ☐ ...make a shopping list?
- ☐ Other, please specify below

[Submit](#)

Figure 8 - Questions associated with shopping session

This way, when a product is wasted and can be tracked down to a purchase session, it can be seen whether its purchase was preceded by a planning behavior.

3.3.3 Waste metadata

To simplify the introduction of waste into the app, the wasting function follows the same pattern as that of the introduction of a purchase. Figure 9 shows how a product can be “Added” or “Removed”, whether by registering it with the barcode reader or by choosing a manual option for produce without a barcode.

[Add](#) [Remove](#) [Check](#)

[Submit](#)

[Remove Product without barcode?](#)

[Help on this section](#)

Figure 9 - Adding and removing product screen

To address the factors surrounding the waste of a product, the questionnaire shown in Figure 10 was presented to the user upon product removal.

- **How much of the wasted item was edible?** This can be presented in terms of mass.
- **“Was it avoidable?”**, with the available options being Yes, No, Possibly and Not Sure, following the model of Quested and Johnson (2009) and Beretta et al. (2013).
- **“Reason for waste”** The available answers are large package, forgotten item, displeasing taste, spoilage, expiration date and wrong storage. These have been selected as possible answers by evaluating various sources of literature, amongst the paper by Parizeau et al., (2015).

- **“Character of waste”**, which pointed out the stage at which the food was upon wastage. From Bernstad and Andersson’s (2014) classification.

The data obtained can be used for research, as well as provide a base for future feedback provided to the user. Upon completion of the questionnaire, the resulting transaction can be seen by the user in the app. The image presented to the user resembles that in Figure 11.

The product was successfully removed.

Please detail the waste

Wasted product *Banan 0.4 kg*

Select (estimated) amount that was edible 0.4 kg

Was it avoidable? ☐ Yes ☐ No ☐ Possibly ☐ Not sure

Reason for waste ☐ Large package ☒ Forgot about it ☐ Was not tasty ☐ Got spoilt ☐ Passed date of expiry ☐ Stored wrong way

Select character of waste ☐ Unopened packaging ☐ Opened packaging ☐ Half eaten food ☐ Prepared food

Was this the last of this product you had at home? ☒ Yes ☐ No

Submit

Figure 10 - Questions associated with registering waste

3.3.4 Perception of product stock

Keeping track of the food flows in an accurate way was one of the most important aspects for the result of this project. The waste of a product can occur on stages, or entirely in one occasion, and to convey that aspect of the food flows, the question **“Was this the last of this product you had at home?”** was also included in the wasting metadata questions. If the wasted item is marked as fully consumed i.e. Yes is selected upon the previous question, the application generates an automatic transaction that indicates the difference between purchase amount and waste amount. Said transaction can, in certain cases, be used as a proxy for the amount consumed. This automatic transaction is visible both to the administrators as data, and as a transaction in the user inventory, similar to **Error! Reference source not found..** Said transaction type will be referred to as **“balance transaction”** hereby.

3.3.5 Feedback functions

Two ways of providing eco-feedback were chosen for the project. While in the first stage it was already possible to see the environmental impact of a product’s through the symbols for water, land and CO₂ footprint (a continuous descriptive type feedback), it was however not easy to keep track of such figures.

That is why, for the second stage were introduced graphs with the footprint weekly fluctuations for each participant’s respective household. One graph presents general footprint information, while the second presents exclusively avoidable waste related footprint. When the user pressed the “View report” option, a screen like the one shown in Figure 13 appeared. This type of feedback is considered an antecedence strategy, with a periodical descriptive message.

<div> <div>View shopping sessions</div> <div>Transactions</div> <div>View report</div> </div>							
<div> <div>For help on this section, please scroll down to the bottom of the page.</div> </div>							
<div>User transactions</div> <div>1</div>							
	Product name	Brand	Amount	Transaction type	Footprint	Timestamp	
	Banan		0.2	avoidable waste	-0.16 -0.13 -0.2 100%	2016-06-09 00:58:11	
	Banan		-0.4	avoidable waste	0.31 0.26 0.4 100%	2016-06-09 00:56:20	

Figure 11 - Waste transaction shown in user inventory

	Admin test	Apelsin	1 l	add	1.4 1.02 1.1	2015-09-30 23:53:01	
	FieldTrial HH 1	Hard Cheese	0.05 kg	balance		2015-09-27 08:45:23	
	FieldTrial HH 1	Hard Cheese	-0.05 kg	avoidable waste	0.62 0.24 0.57 100%	2015-09-27 08:45:10	

Figure 12 - Balancing transaction

The other feedback intervention attempted to tackle specific user habits. A series of advices were introduced into the app, and were related to various food groups identified as critical during the literature review and the interviews. In this way, whenever a user would register a transaction of a specific food group, a relevant advice for the prevention of its waste would appear. Spontaneous advice was also implemented. This kind of advice would pop-up in the higher portion of the screen during application use, but unrelated with the registration of transactions.

Each advice belonged to one type of four: Neutral or general, Diet, Storage and Waste, according to the corresponding parts in the conceptual model. It is to be considered that “waste” or “storage” advice did not necessarily correspond to waste or add transactions. This means that storage advice could be received during a waste transaction, and vice versa. A complete list of the available advices is presented in Appendix 1.

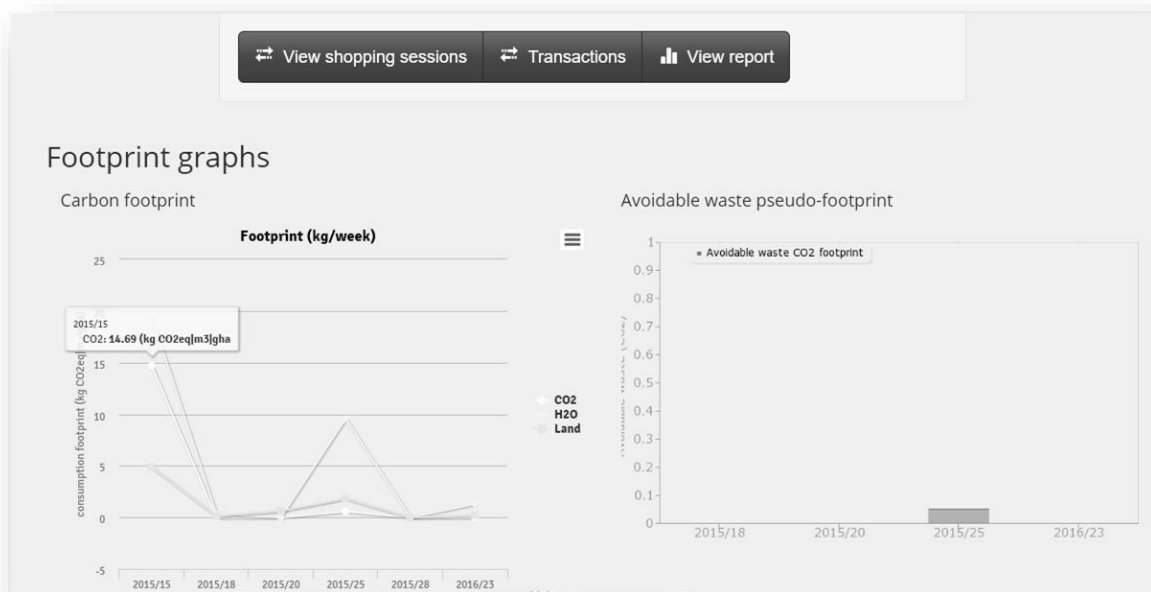


Figure 13 - Graphs showing weekly total and waste-exclusive footprints

3.4 Pilot test

A pilot test with the modified version of the application was conducted to obtain a picture of the user's food flows and associated routines; both before and after implementing interventions, and to identify any areas of possible improvement. The pilot test was initiated in July of 2015 and continued until October of the same year.

The study was devised to have two main stages, each with a different purpose. It followed a diary self-reporting and interviewing structure, identified in the literature as one of the most robust data collection methods (Hunter et al., 2006). The participants underwent an initial interview, after which they proceeded to use the app in its first stage. Then followed the second stage, which was characterized by the implementation of feedback functions within the app. The stages were continuous, and although the users were warned that the app would suffer some changes, they were not notified exactly when this would happen. Afterwards, the users participated in a final interview that marked the completion of the second stage, and consequently, of the study.

The progression of these stages is shown in Figure 14.

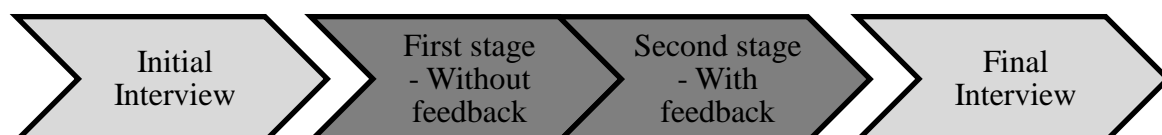


Figure 14 - Stages of the field trial

A more detailed description of each stage, along with the selection criteria for the participants and the boundaries of the project are presented below.

3.4.1 Households selection

The study was designed for households with one or two inhabitants. Consequently, two single households and two households with two people were recruited. Participants entered the pilot test on a voluntary basis, responding to an announcement published in social media. All participants live within Gothenburg municipality, are students at Chalmers University of Technology and are between 25 and 35 years of age.

During the literature review, it was identified that the more inhabitants there are in a household, the less waste is produced per capita (Parizeau et al., 2015). Additionally, package sizes and recipes with several portions have been pointed as factors that influence waste production in households, given that package and recipe sizes are conceived for more than one consumer, making households with less inhabitants vulnerable to a higher production of waste per capita. Considering the propensity of smaller households to produce more waste per capita, households with one or two inhabitants were chosen as the target for the investigation. An additional factor is to avoid situations in which the recipient of the feedback is not the person in charge of consumption decisions, as exemplified by Strengers (2011).

3.4.2 Interviews to participants

Two questionnaires were created for the trial test, one for an initial interview and another for a final interview. The questionnaires were semi-structured, following the guidelines of Merriam (2014). Their format intended to cover the main points in the conceptual model, but allowed to elaborate in any other interesting points that were brought on by the participants. A basic goal of the interviews was to obtain a picture of the participant's consumption and wastage habits broader than what the app data could allow, as well as address the research question of "How can FoodWatch capture household's food metabolism and related routines?".

Both questionnaires were presented verbally and in person to the participants. Each participant was interviewed individually in a place of their choosing. Interviews were recorded, each averaging 35 minutes of duration. The responses were later documented with the aid of a transcribing website. The aspects tackled by each interview aspects are presented below:

Initial Interview - The first questionnaire was presented to the participants at the beginning of the field trial. Consequently, the questions had an exploratory character. The first section investigated general information about the user's living characteristics, such as daily routine and household inhabitants. Then, the focus lied on what factors influenced the participant's food choices, as well as behaviors relating to the stages of food planning, shopping, storage, consumption and waste. The last section briefly explored the participant's attitude towards food in an environmental context. The responses from the users raised some follow-up questions to be included in the final interviews, and aided the process of selection for the advice included in the feedback functions.

The model of the initial questionnaire is presented in Appendix 3. Important aspects of the initial interviews are summarized in the "**Results**" chapter, while the full transcriptions can be found in Appendix 5.

Final Interview - A second interview was conducted after the end of the trial. The questions intended to assess if any of the behaviors expressed in the first interview had changed, and whether the users attributed such changes to the use of the app and/or to any external factors. Moreover, the questionnaire aimed to identify the effect of these changes, if any. Apart from considering pre-existent behaviors, the interview also investigated the perceived efficacy of the app in encouraging the adoption of waste-preventing actions, as well as in increasing knowledge of the environmental impact of food waste.

Participants were encouraged to recount their experience in detail and to provide constructive criticism. The questionnaire referred to the app in itself, but also to the instruments used by the participants, in order to identify any source of error due to malfunction. The information obtained in the interview was compared to the data obtained through use of the app, as well as taken as a base to suggest future courses of action in the "**Conclusions**" chapter.

The model of the final questionnaire is presented in Appendix 4. A summary of the final interviews is presented at the Results chapter, while the full transcriptions can be found in Appendix 5.

3.4.3 App utilization

A first individual meeting was set up with each participant, where they received the equipment necessary to carry out pilot test. Instructions for the study were given verbally, before having practical examples of each action to be executed on the app. The users also received a printed version of the study protocol (See Appendix 2), which included their anonymous account into the FoodWatch website, instructions on how to operate the app, basic troubleshooting of the equipment, a list of what foods were included in the study and a brief description of the types of waste. Some time was given to the user to read the instructions and clarify any doubts. On this meeting, they also partook in the initial interview.

During the study, participants were to record their consumption and waste food flows, following the diary keeping method for waste studies. From this point, it was paramount to have regular communication with the participants, paying special attention to reports of malfunction of the equipment or confusion over procedures. A log of interactions with the participants is presented in Appendix 6.

The equipment provided to the participants, as well as a detailed description of each stage, are presented below.

3.4.3.1 Equipment

All participants were provided with the necessary equipment to complete the tasks required in the study. The instruments provided were the following:

One generic handheld wireless barcode reader. The reader was used to register both purchase and waste of food items that had a barcode.

One tablet, Samsung Galaxy 4 model, in which they were to access the online application. The barcode reader was connected to the tablet via Bluetooth.

One standard kitchen scale, used to measure the weight of purchased food items without barcode, as well as the weight of all wasted foods.

3.4.3.2 First stage (No feedback)

The first stage of the trial was aimed at gathering baseline information of food purchases and wasting habits in each household. Moreover, it served the purpose of allowing participants to become acquainted all procedures, eliminating source of error due to incorrect handling of the app or the equipment.

In this stage, the users were expected to introduce all the food transactions that occurred in the household, within the boundaries defined in the study (see sub-chapter “**Boundaries**” below). The user was also asked for information regarding actions taken before purchases, and elements surrounding the wasting of a product.

Given the purpose of this stage, the app did not include any feedback functions during the first period. However, it did present the ecological information corresponding to the items introduced as purchase or waste. The information was shown in the form of icons which symbolized water footprint, land use and equivalent CO₂ emissions; and next to each icon was presented its corresponding value for the food amount that was introduced. This stage lasted 10 weeks, between the months of June and September.

The data obtained from the app was compared to the verbal responses in the first questionnaire, and later to the data obtained at the second stage. These values will be summarized in the “**Results**” chapter, and presented in their entirety in Appendix 7.

3.4.3.3 Second stage (Feedback)

The purpose of this stage was to obtain data that showed whether providing the user with both information about and means to modify their wastage practices would exert any influence on them.

Consequently, the defining characteristic of the second stage was the introduction of the feedback functions described in the **“Modification of the App”** sub-chapter. For this step, users continued to record their food transactions as usual while receiving both chosen methods of intervention. This means there was no change in the actions required from the user.

The data obtained from the app was compared to the data from the previous stage and to the verbal responses in the second questionnaire. A summary of these values will be shown in the **“Results”** chapter, and the full figures in Appendix 7.

3.4.4 Boundaries of the pilot test

Given that this study was limited to waste production in households; the boundaries of the study were mainly related to what constituted a household system and the scope of the foods to be introduced in the app.

The defining parameter to decide whether a food product was part of the household system was its source. Household consumption covered foods that enter the household after purchase in a retailer or were originated in the household itself by personal farming. These foods were considered part the household system independently of whether they are consumed and/or wasted inside the household. For example, an apple that was taken home from the supermarket, and was then taken to work as a snack, was still part of the system. In the case of food that is prepared home, and consumed or disposed outside the household, the participant was encouraged to measure it and register it nonetheless. Under the same criteria, foods that entered the household as leftovers from restaurants or catering were not considered within the study, similarly to the delimitation by Quesada and Johnson (2009), see **Error! Reference source not found.**Figure 15.

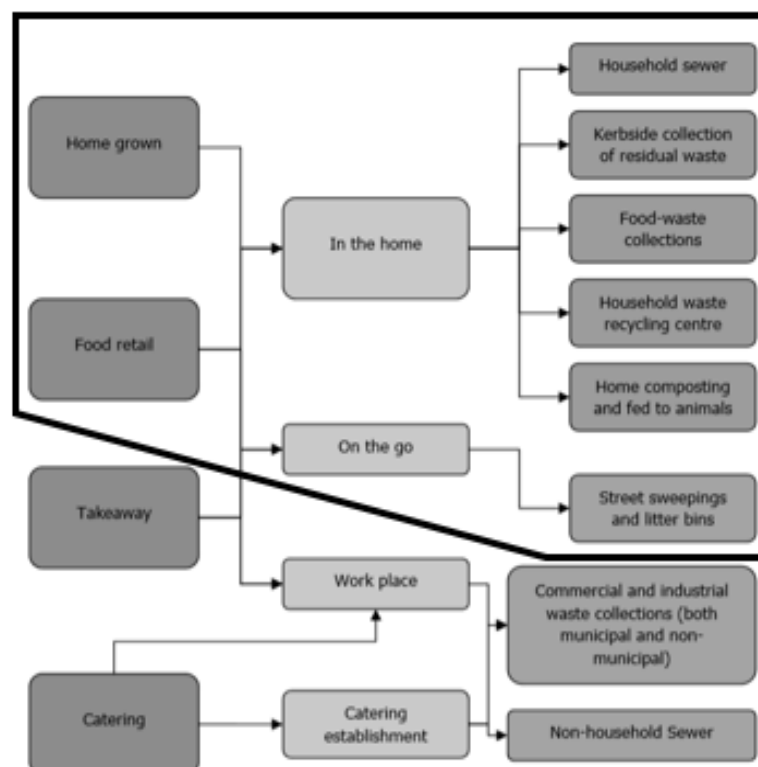


Figure 15 - Flows of food and drinks within range of study, based on schematic by Quesada and Johnson (2009). Selected flows enclosed in black line.

Given that this project aimed at reducing the avoidable and partly avoidable shares of waste in households, the participants did not have to account for non-avoidable waste. Possibly avoidable waste, though included in the scope, is considered to a lesser degree. This is because much of it is subscribed to factors deeply tied to consumer's identity, and thus difficult to influence.

Ready-to-eat frozen meals were not considered in the study, given that they do not currently exist within the database of FoodWatch. Their introduction to the database by users would be too complex, due to the variety of ingredients in these foods.

Prepared meals that contain several ingredients mixed, as in curries, or soups, proved to be difficult to quantify. To register waste of these kinds of meals, the participant was instructed to provide a rough estimate of the two main ingredients in the dish, or to only register it as waste of the main ingredient (i.e. meat in a curry).

In the food classification made for the study by Quested and Johnson, there were certain items that represented less than 5% of the waste produced in a household: salt, sugar, dried herbs, spices and powder sauces. These did not have enough confidence around the estimate produced. Due to the difficulty in estimating the amounts used in cooked and wasted meals, and to their lower significance in the household waste, the quantification of these was omitted in the study.

Oils and fats were also excluded under the same reasons. Other kinds of oils, such as those drained from tins of fish, olives, etc., (Quested and Johnson, 2009) were considered as non-avoidable waste and therefore were excluded from the study.

These boundaries were presented to the participants in the user protocol (Appendix 2).

4. Results

This section will present the results collected from the interviews and from the use of the application. The small number of households and relatively short duration of the study allowed for a detailed view of the highly-disaggregated data. Nonetheless, there are numerous divisions of the data, according to household, method through which the data was obtained, character of the data and phase of the study. To draw upon this, the results will first be presented individually, i.e. household by household, and then comparatively. For each household, the results will start with a basic profile of each participant, then the data will follow the structure of the conceptual model, and will finalize by a comparison between stages one and two in the study. Each of these sub-sections will include the main findings from the pilot test, when available, and will be complemented by experiences expressed by the users in the interviews. A last division of this chapter presents a summary of inputs about the application use and the experiment design.

Some factors to consider regarding the presentation of the results are stated below:

Sample - Only results from Households #1, #2 and #3 will be presented, as Household #4 withdrew from the study at an early stage, providing no information of use. The term "Household" followed by its respective number will also be used to refer to the corresponding participant/s.

Sessions - Sessions that only have purchase transactions, or both purchase and waste transactions, are referred to by their corresponding number. Sessions in which only waste has been registered are not counted automatically in the application, but to simplify presentation of results they will be referred to by a prefix "WHH", followed by the number of household, and then their auxiliary session number. For example, "WHH314" would refer to the 14th instance in which Household #3 has registered only waste.

Transactions - All transactions of liquids are assumed to have a density of 1 kg/l. Thus, to simplify presentation of results, transactions of liquids will be grouped with transactions of

solid foods and are assigned their corresponding mass. Nonetheless, transactions will retain their original unit in the Appendix 7.

Only transactions introduced by the user, i.e. transaction and waste, are presented below unless specified.

The following section will present a summary of all data obtained. The interview transcriptions are shown entirely in Appendix 5 while the transactions data is presented in Appendix 7.

4.1 Household #1

The main participant of household #1 was a 33-year-old female Iranian student. She shared her apartment with a partner for two weeks every month. At the time of the study, she had a summer job. None of the inhabitants had any food restrictions, but they limited their intake of salt and oil and said that they consumed a lot of meat, fish and dairy products except for cheese. One of the participant's main driving forces in food habits was preserving her health: many of her food choices were based on what she had learnt that was "good for her body", and several times she expressed worry about becoming ill because of spoiled food. Another important factor was ease of preparation, as she didn't cook often.

During the study, household #1 registered 165 transactions, being an active participant from July 16th 2015 to October 4th 2015 (12 weeks), with an interruption of data collection from the 20th of August to the 9th of September (3 weeks), see Figure 31, Page 65. Thirty of the transactions were identified as defective (see Discussion – Shortcomings of data collection) and nine meant for balancing, resulting in a total of 126 valid transactions and 9 weeks of data collection. This is presented in a day per day basis in Figure 16.

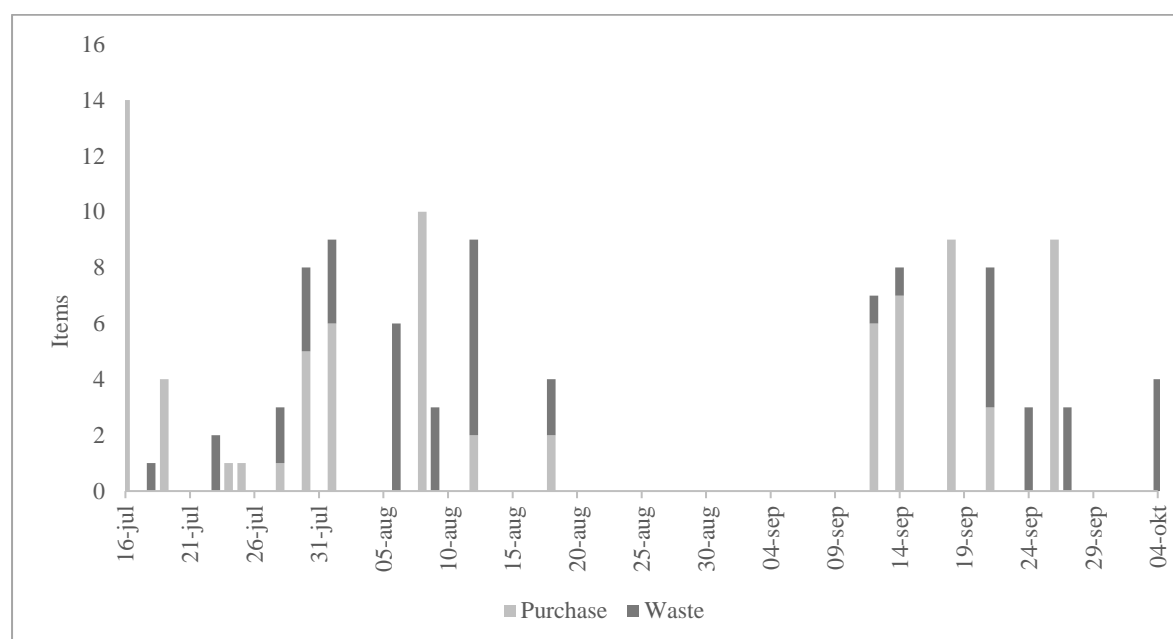


Figure 16 - Transactions in Household #1. Red line symbolizes beginning of Phase 2.

According to the final interview, the participant maintained her usual routine throughout most of the pilot test in spite of being busier at university. Her routine was only disrupted in the weeks when she had visitors at home, which are assumed to be the weeks in which no transactions were registered. Eating preferences remained the same, although her partner started prioritizing fresh foods.

4.1.1 Planning

The participant does not check her levels of food before shopping nor plans meals in advance. Nonetheless, her partner does the latter to help her when she's busy. The participant does not write a

shopping list either, but does check the supermarket website prior to shopping to have an idea of what to buy.

During the study, the user registered 15 valid purchase sessions (see Table 2). In average, it took her 2:41 minutes to answer the planning questionnaire at the beginning of a session. Sixty percent of the sessions were preceded by at least one of the behaviors, which means that 65 products, or 81%, were bought following some planning action.

Although an unplanned purchase indicates that the user did not partake in any of the recommended behaviors, the user selected this option in addition to “checked food levels” in sessions 36. Another notable result is seen in session 60, where the participant indicated that she had planned her meals, unlike stated in the interviews. Upon inspection of the items in this session, this did not seem an instance in which her partner was home, thus it is assumed that she selected this option. Besides this, no change was perceived in the planning routines.

According to the final interview, the partner continued checking levels of food and making shopping lists, contrary to the main participant. The data does not support this, as the frequency and content of the shopping sessions does not indicate presence of the partner for all sessions in which a planning action was taken.

Table 2 - Planning behaviors of Household #1

Session	Date	Items registered	Unplanned shopping	Planned meals	Checked food levels	Made shopping list	Any
32	2015-07-16	14			•	•	•
36	2015-07-19	4	•		•		•
39	2015-07-24	1	•				
40	2015-07-25	1	•				
43	2015-07-28	1	•				
47	2015-07-30	5				•	•
48	2015-08-01	6				•	•
52	2015-08-08	10				•	•
55	2015-08-12	2			•		•
56	2015-08-18	2	•				
60	2015-09-12	6		•			•
62	2015-09-14	7	•				
64	2015-09-18	9			•		•
68	2015-09-21	3	•				
71	2015-09-26	9				•	•
Total			7	1	4	5	9
Percentage of sessions			47%	7%	27%	33%	60%

4.1.2 Shopping

The user stated that she usually shops in “Hemköp”, a supermarket at a 5-minute walking distance from her apartment, and sometimes at Lidl, located several tram stations away. When her partner stays at the household, their purchase is meant to last around ten days. Otherwise, she makes small purchases every two or three days. They do not buy in bulk, and only buy meat in discount if they plan to use it quickly. Milk is bought in several small packages rather than one large package, to have a stock when a carton has passed the expiration date. Her budget when alone is around 450 kr for two weeks, and unknown when her partner stays.

During the study, eighty of the valid transactions corresponded to purchase of items. The number of products per session can be seen in Table 2. Purchase frequency coincides with what was stated in the interviews when discounting gaps in the data collection.

The number of items purchased per product group can be seen in Figure 17. The most purchased product group, “Fruit Juice”, was often bought in several units (two to three cartons per session). The amounts can be considered bulk purchases, as seen in session 32 in Table 3, where the user bought 4.75 liters of juice. Yoghurt, although not bought as often as Fruit Juice, was also purchased in large amounts, as in session 62, in Table 4.

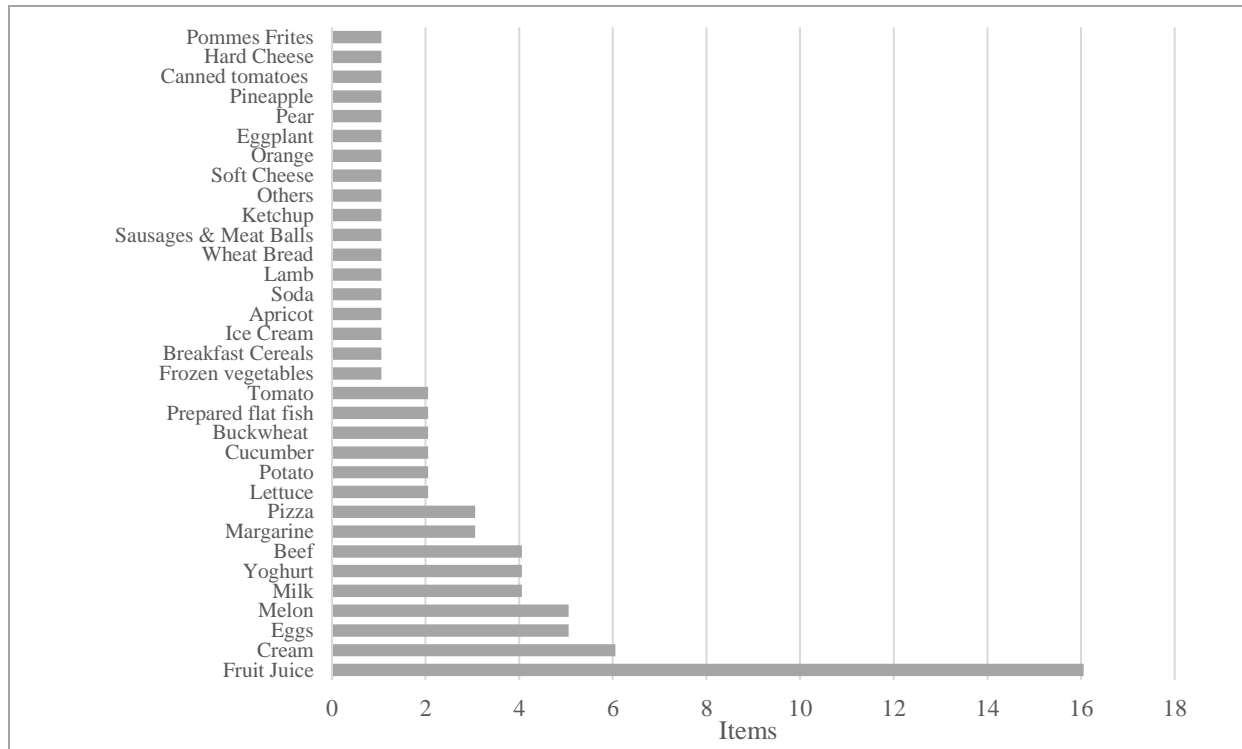


Figure 17 - Items per product group in Household #1

As stated in the interviews, milk was also bought in several packages in one occasion, although at other times only one item was purchased.

In the final interview, the participant said that her frequency and place of shopping remained the same, except when she had visitors. During this time, food was consumed mostly outside. Additionally, the participant stopped buying frozen meals and replaced the habit for eating out, which reflects in the data as well.

Table 3 - Extract from Session 32, Household #1

Timestamp	Product name	Amount	Transaction type
2015-07-16 17:42	Fruit Juice	2.00 l	add
2015-07-16 17:42	Orange Juice	2.00 l	add
2015-07-16 17:45	Fruit Juice	0.75 l	add

Table 4 - Extract from Session 62, Household #1

Timestamp	Product name	Amount	Transaction type
2015-09-14 17:00	Original skogsbär (Yoghurt)	1.00 kg	add
2015-09-14 17:00	Original skogsbär (Yoghurt)	1.00 kg	add
2015-09-14 17:01	Original skogsbär (Yoghurt)	1.00 kg	add

4.1.3 Storage

Household 1's kitchen has plenty of dry storage space and is equipped with two fridges. This provides good visibility, except directly after a big purchase when the user's partner is home.

Meat is usually kept in the freezer, unless it is planned to be used soon. They freeze bread to prolong its shelf life, and sometimes freeze vegetables too. Cheese and dairy are kept in the fridge inside a bag, as well as most vegetables. Leftovers are not kept often, except for sauces which are seldom placed in the refrigerator for a short time. Fruits are kept outside. She does not feel secure in her knowledge about guidelines for proper storage of foods, but feels that her partner is. The participant affirmed that these habits remained the same throughout the study.

During the study, it was possible to account for purchased items that were storage sensitive, see Table 5.

Table 5 - Units purchased by Household #1 per food category

Food Category	Items Purchased
Fruit	11
Cold-stored Beverages	16
Vegetable	8
Meat and/or Fish	8
Dairy	16
Eggs	5
Dry	4

Given that the application does not permit registering waste specifically from a product that has been previously registered as a purchase, the relation between purchased and wasted products was established empirically, according to the last similar product registered. For the products in which this was accomplished, the storage time was calculated to the days between purchase and waste (see Table 6). Observe that the table does not include all waste transactions.

Table 6 - Extract of Household #1 waste transactions

Waste date	Days since purchase	Product name	Purchase Amount	Waste Amount	Waste type	Reason for waste	Last of item
07-23	4.3	Lettuce	0.65 kg	-0.25 kg	Avoidable	Large package	Yes
07-28	4.4	Watermelon	2.45 kg	-0.65 kg	Avoidable	Spoiled	Yes
07-30	0.0	Lamb	2.00 kg	-0.15 kg	Avoidable	Large package	No
07-30	14.1	Pizza	0.50 kg	-0.20 kg	Avoidable	Large package	Yes
08-06	7.0	Lettuce	0.55 kg	-0.25 kg	Avoidable	Large package	Yes
08-06	21.2	Beef	0.50 kg	-0.20 kg	Avoidable	Large package	No
08-09	1.2	Fresh flat fish	0.5 kg	-0.10 kg	Avoidable	Large package	No
08-09	21.1	Cucumber	0.55 kg	-0.05 kg	Avoidable	Large package	No
08-12	27.9	Milk	1.50 l	-1.20 l	Avoidable	Wrong storage	Yes
08-12	11.4	Potato	1.55 kg	-0.30 kg	Avoidable	Wrong storage	Yes
08-18	30.4	Cucumber	0.55 kg	-0.20 kg	Avoidable	Wrong storage	Yes
09-12	35.4	Standard milk	1.50 l	-1.50 l	Avoidable	Expired	Yes
09-21	2.5	Eggs	0.30 kg	-0.05 l	Avoidable	Not tasty	No
09-21	2.5	Cream	0.25 l	-0.15 l	Avoidable	Not tasty	No
09-27	0.7	Hard cheese	0.5 kg	-0.05 kg	Possibly avoidable	Wrong storage	Yes

10-04	64.0	Potato	1.55 kg	-0.05 kg	Avoidable	Wrong storage	No
-------	------	--------	---------	----------	-----------	---------------	----

4.1.4 Preparation and consumption

Per the first interview, the participant only prepares simple breakfast and dinners, as oatmeal, and has lunch at the university restaurant. This is accompanied with weekly baking. When her partner stays in the apartment, he takes charge of the cooking and prepares more elaborate dishes, including lunch. Her partner does not use measuring implements, and she only uses them for baking. He does not use recipes either, but the rare times she cooks she uses them. She affirms that they don't usually have leftovers because she prefers that her partner does not cook amounts larger than necessary.

From the data, it was possible to identify some products that required preparation. Meats and fishes can be assumed as prepared, see Figure 17. No waste was registered as “prepared meal”, but many of the “half eaten food waste” were items which needed preparation, such as chicken, fish and frozen vegetables (see Appendix 7). Some of the waste suggested preparation of a cake, as with sugar, flour eggs cream and butter (see session 68 in Appendix 7). Twenty-seven of the wasted items (against 18) were marked as last of product, which indicates full consumption and waste.

In the final interview, the participant said that their consumption habits remained the same during the study, except when there were visitors. She also mentioned that she stopped using measuring implements for baking.

4.1.5 Wasting

Several of the participant's motivations for wasting were captured during the first interview. Given her worries about food poisoning, the participant throws away foods immediately after they pass the best-buy date. This is not the case for her partner, who uses visual and olfactory cues to decide if the food is still edible. Package sizes also influence her waste, although she tries to be aware of this when shopping. The items that she buys in discount are used immediately or placed in the freezer, so she does not consider that discounts affect her waste. According to her, most wasted items are half-used, never reaching the point of spoilage. Unexpected situations that she thinks can affect her waste are unplanned traveling and unplanned eating out.

As for attitudes towards wasting, the participant considers herself very aware of her waste production, and avoids it as much as possible due to ethical and cultural reasons. She stated that coming from a country where food is not always readily available make her wary of mispending resources. She does not feel that she can prevent her current waste rate, because she doesn't cook much and still produces leftovers. The household does not have a separation system for organic waste, therefore food is thrown in the combustible bin.

During the application use, forty-six transactions corresponded to wasted items, one of which did not have qualitative data (reason for waste, etc.). Therefore, the summary of qualitative data presented below will only refer to forty-five of the registered transactions.

The valid transactions totaled 11.95 kg of waste. The household wasted items from all food types, e.g. fruits, vegetables, grains, meat and dairy. Sixteen items were not related to a registered purchase transaction; therefore, it is not possible to determine what percentage of the purchased items had gone to waste. Fifty-six purchased articles had an EAN number and therefore probably a date label. Only two of these were wasted due to passed expiration date.

Disaggregated data permitted to see the relation between type, state, and reasons for waste. For example, four of the transactions were labeled as “possibly avoidable” (not tasty watermelon, and wrongly stored muesli, bread and hard cheese that had been partially eaten), and one as “not sure” (an open package of milk that passed its expiration date). Twenty-seven, or more than half of the waste registered, corresponded to the last of the product. Average edibility ratio was 0.85, which means that most of what was wasted was still edible.

The character of waste transactions can be seen in Figure 18, and their interrelations in

Figure 19 19. Notably, the only product that was wasted due to the participant “forgetting it” (an opened package of yogurt) had to be removed from the data due to error.

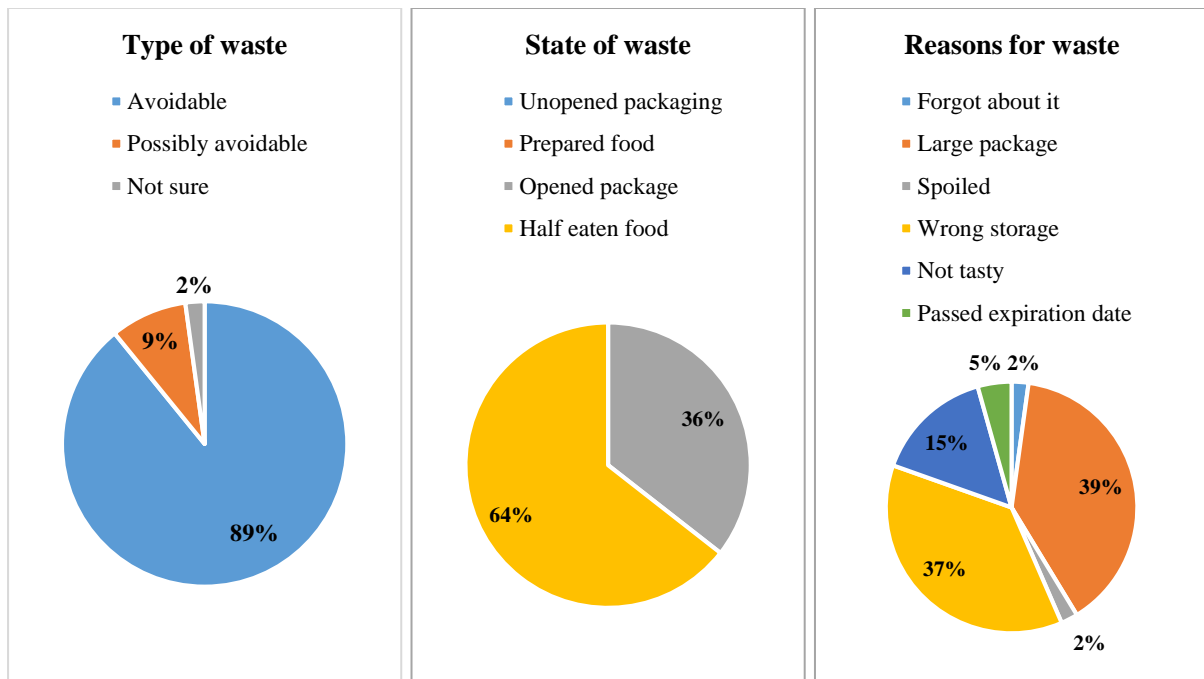


Figure 18 - Character of Waste for Household #1

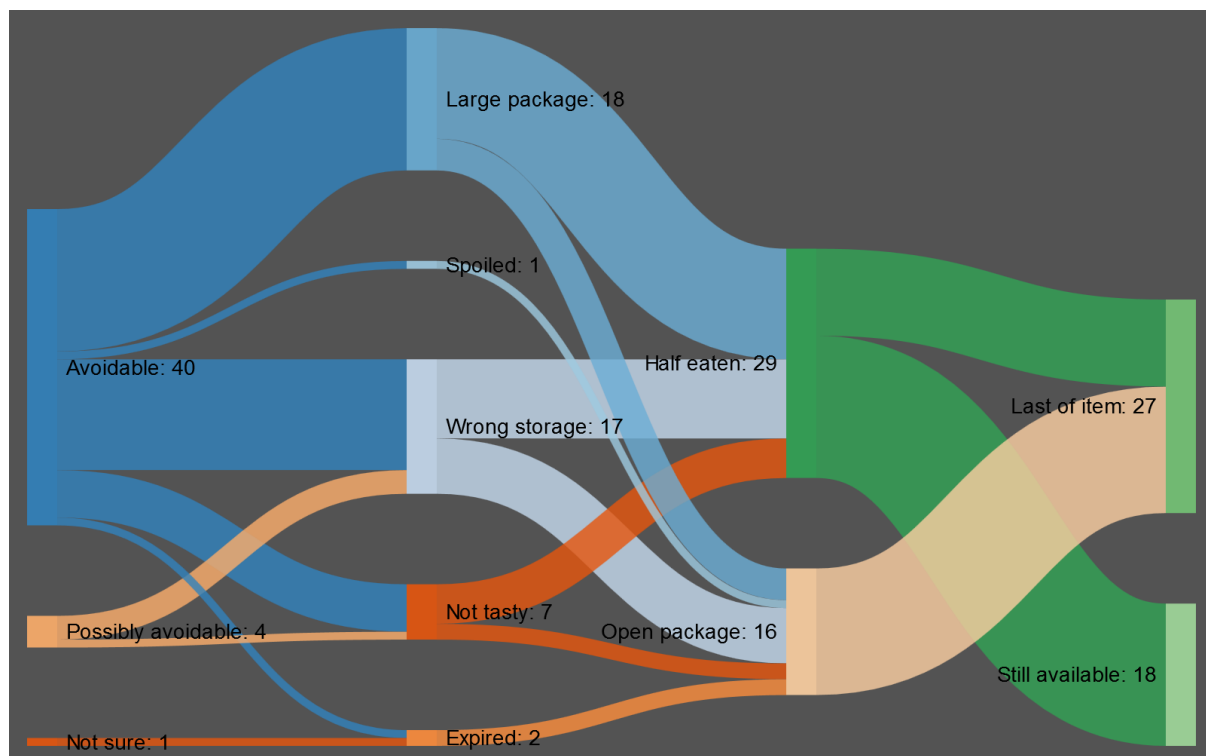


Figure 19 - Sankey diagram showing relations between type, reason, stage and stock of waste for Household #1

According to the final interview, the participant perceived a difference in the spoilage rate with the season changes, although she is not sure if it was because of the climate or due to differences in her consumption patterns. She realized that she often wastes opened packages, in addition to and half-used which she had mentioned in the first interview. She is not sure if there was a change in her wastage patterns, and thinks that it would be easier to perceive it if there were more inhabitants in the household.

4.1.6 Environmental impact and attitudes

The participant is an Infrastructure and Environmental Engineering master student; therefore, she has previous knowledge in environmental matters. She associates food waste to wasted energy, and buys ecological food whenever the price allows her to, although mainly because of health reasons. Other than that, she does not feel that she has enough knowledge about sustainable food consumption.

A total of 242.44 kg eCO₂ emissions, 116.21 m³ of water footprint and 421.80 gha were accounted during the pilot test, of which 11%, 19% and 12% respectively corresponded to food wasted. GHG emissions along the study duration are seen in Figure 20. Products with the highest levels of emissions, both purchased and wasted, can be seen in Table 7 and Table 8 respectively.

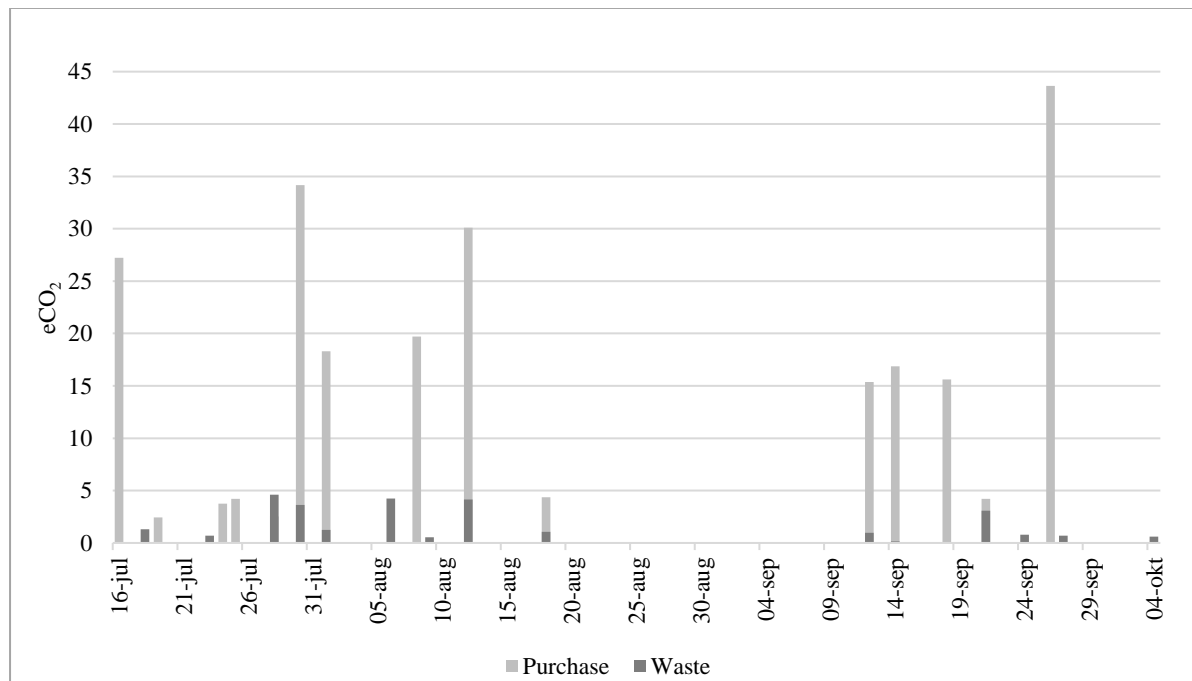


Figure 20 - Footprint of purchase and waste transactions per day in Household #1

Table 7 - Purchase transactions with highest carbon emissions in Household #1

Session	Product name	Amount	eCO ₂
47	Lamb	2.00 kg	30.81
55	Beef	1.50 kg	29.49
71	Beef	1.00 kg	19.66
48	Sausages & Meat Balls	0.80 kg	10.00
32	Beef	0.50 kg	9.83
60	Beef	0.50 kg	9.83
64	Fish	1.00 kg	7.40
71	Hard Cheese	0.50 kg	6.24

71	Pommes Frites	2.00 kg	6.20
40	Ice Cream	2.00 l	4.20

Table 8 - Waste transactions with highest carbon emissions in Household #1

Session	Product name	Amount	eCO ₂
WHH13	Beef	-0.20 kg	3.93
43	Butter	-0.35 kg	3.61
47	Lamb	-0.15 kg	2.31
55	Milk	-1.20 kg	1.57
68	Butter	-0.15 kg	1.55
WHH11	Whipping cream 36%	-0.25 kg	1.32
47	Pizza	-0.20 kg	1.24
43	Watermelon	-0.65 kg	0.99
60	Milk	-1.50 kg	0.98
55	Alcoholic beverages	-0.9 kg	0.91

According to the last interview, her knowledge and attitude towards environment remained the same. Nonetheless, she affirmed that she checked the inventory out of curiosity, and found the footprint information attached to every product interesting.

4.1.7 Feedback effects

Nineteen of the valid transactions occurred after eco-feedback was implemented, of which ten corresponded to waste. The participant wasted 1.59 kg/week of food during the first stage and 0.43 during the second phase. Per this, the weekly rate of waste mass declined. The waste in the first phase was composed of fruit and vegetables, as well as some dairy and meat, while the waste on the second stage was mostly of animal products with some dried foods and little vegetables. Although the first phase had more waste from vegetable sources, it also included beef and lamb, both high emitters, while second stage didn't include these. The footprint per week of the waste also declined in the second phase, as shown in Table 9. However, the short duration of the second stage and faults in registration must be considered. Although weekly purchase masses also declined by more than half, the percentage of waste in relation to purchase masses declined from 13% in the first phase to 5% in the second phase.

Table 9 – Average of weekly transactions per phase in Household #1

	Purchase				Waste			
	Mass (kg)	eCO ₂	Water footprint (m ³)	Land footprint (gha)	Mass (kg)	eCO ₂	Water footprint (m ³)	Land footprint (gha)
Phase 1	8.92	28.40	13.31	51.80	1.59	3.67	3.00	6.38
Phase 2	4.39	21.82	11.51	29.59	0.43	1.04	0.54	2.24

The user received five advices during the second stage, three of those corresponding to waste advice and the rest to storage advice (see Table 10). The products targeted in the advices were mainly of animal products. All advices can be seen in Appendix 1.

The participant stopped her participation in the study ten days after the first advice, therefore it is hard to judge whether the advices caused any change in the user's habits. This is corroborated by the second interview, where she stated that she found the advice "nice", but that she did not receive many since she wasn't using the application as often as before during stage two. She also did not perceive that the feedback encouraged her to adopt any of the recommended behaviors.

Table 10 - Advices received by Household #1

Date received	Session	Feedback type	Advice ID	Product	Transaction type
09-24	WHH15	Waste	4	Chicken	Waste
09-26	71	Storage	8	Eggs	Purchase
09-26	71	Storage	17	Milk	Purchase
10-04	WHH17	Waste	16	Potato	Waste
10-04	WHH17	Waste	6	Milk	Waste

4.2 Household #2

The participant of household #2 was a 25-year-old female Chinese student living in a student apartment. Her food habits are highly variable, depending on how busy she is with her studies. She consumes meat almost every day, and eats out four to five times per week, including lunch at the university restaurant. Her choices are mainly driven by personal preference and culture, as well as nutrition and product appearance.

During the study, household #2 registered 116 transactions, being an active participant of the study from July 16th 2015 to October 14th 2015 (13 weeks), with an interruption of data collection between the 27th of August to the 9th of September and from the 1st of October to the 7th of October (3 weeks) see Figure 31, Page 65. None of the transactions were identified as defective, and three were identified as balancing transactions, therefore resulting in a total of 113 valid transactions and 9 weeks of data collection. This can be seen in a day per day basis in Figure 21.

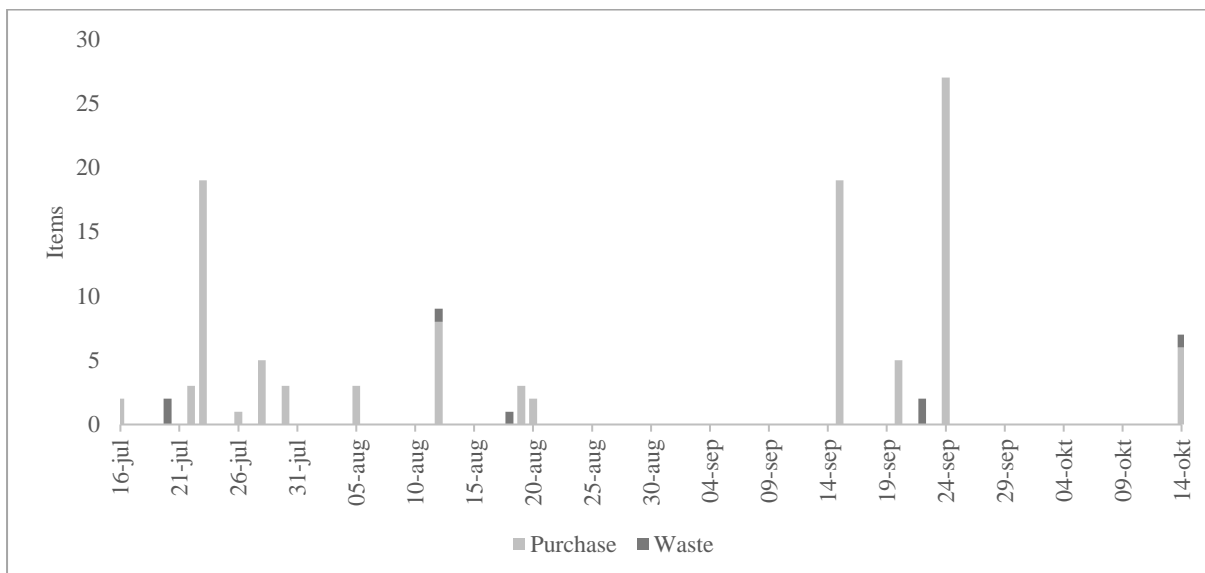


Figure 21 - Transactions in Household #2. Red line symbolizes beginning of Phase 2.

During the last interview, she expressed that her routine and preferences remained almost the same, although she cooked less often at busy times and started consuming more vegetarian food when outside.

4.2.1 Planning

The participant does not feel the need to check the cupboard because she is aware of its contents, but does check the fridge before shopping. She sometimes does shopping lists, and does not plan meals to any degree other than deciding at what time she will have them.

In the study, the user registered 15 valid purchase sessions. In average, the user took 1:11 min to answer the planning questionnaire at the beginning of a session.

Like Household #1, the user marked two of the “unplanned purchases” with some other planning behavior, causing a contradiction. Additionally, for the sessions in which “Other behavior” was marked, it was not possible to access information on what this other behavior was. This can be seen in Table 11.

Table 11 - Planning behaviors of Household #2

Session	Date	Items registered	Unplanned shopping	Planned meals	Checked food levels	Made shopping list	Other	Any
33	07-16	2		•		•		•
37	07-22	3	•					
38	07-23	19		•	•	•		•
42	07-26	1		•	•			•
44	07-28	5				•		•
45	07-30	3	•				•	•
50	08-05	1		•			•	•
51	08-05	2		•			•	•
54	08-12	8	•	•				•
57	08-19	3		•		•	•	•
58	08-20	2		•				•
63	09-15	19			•			•
67	09-20	5	•					
70	09-24	27		•	•	•		•
73	10-14	6		•	•	•		•
Total			4	10	5	6	4	13
Percentage of sessions			27%	67%	33%	40%	27%	87%

The combination in which the planning actions occurred varied, though all options appeared throughout the study period. Remarkably, the two final sessions are the only ones in which the participant partook in all three planning behaviors.

The data mostly coincides with what was stated in the interviews, although it is not clear whether the participant planned their meals in the sense intended by the study. In the last interview, the participant said that she started making shopping list when she didn't want to forget an item, but that otherwise her planning habits remained the same.

4.2.2 Shopping

The participant buys at several large supermarket chains (ICA, Hemköp, Willys) as well as in an Asian supermarket, all at varying distances. Groceries are bought in small amounts when her stock of food is finished, approximately two or three times per week. A main concern for the participant is the size of food packages. In her opinion, the Swedish sizes for bread and meat constitute bulk when compared to products in China, which caused a lot of waste for her upon moving to the country. The participant only buys in discount if she considers the items to be of good quality, and does not know her average expenditure in food.

During the study, hundred and six of the valid transactions corresponded to purchase of items. The number of products per session can be seen in Table 11. Purchases, in average, occurred every 6 days. When discounting gaps in the data collection, this coincides with what was stated in the interviews. The number of items purchased per product group can be seen in Figure 22.

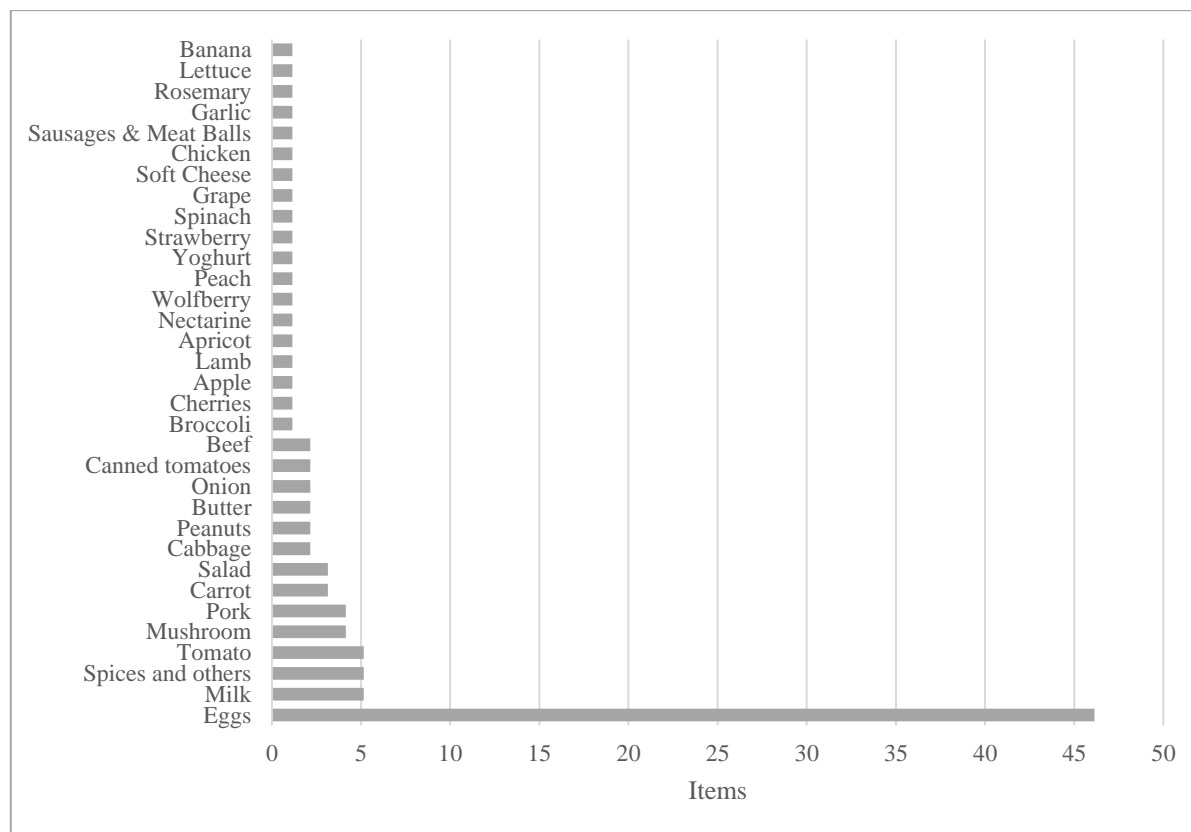


Figure 22 - Items per product group in Household #2

Although bread was identified as an important waste in the interview, no bread was registered as a purchase during the study. It must also be noted that eggs appeared in such a large amount because the user, due to error, registered each egg individually instead of registering a complete carton. When accounted in cartons of 15 eggs, the number of packages bought was four, therefore bought less often than Milk and Tomatoes.

As stated in the interviews, purchases were not made in bulk amounts nor in packages larger than average, except for one instance in which the participant bought a total of 3 liters of milk, see Table 12.

Table 12 - Extract from Session 67, Household #2

Timestamp	Product name	Amount	Transaction type
09-20 12:00	Milk	1.50 l	add
09-20 12:01	Milk	1.50 l	add

The only purchased item that weighed over one kilogram was a cabbage, near the end of the study (see session 73 in Appendix 7).

Towards the end of the study, the participant shopped more often in Hemköp, and felt an increase in her shopping frequency. She also stopped buying large packages to avoid producing waste and having to register it into the app.

4.2.3 Storage

The participant uses the communal kitchen at her building, therefore the refrigerator and cupboard space are shared. This represents a limitation for her storage needs. She stores most items in the refrigerator, including leftovers. Bread and dry foods are kept in the cupboards, and the freezer is used to extend the shelf life of meat, fish, bread and self-baked goods. Although the space is limited, the participant does not perceive that a lack of visibility affects her waste. She feels that she is aware of some, not all, guidelines for proper storage.

During the study, storage sensitive items were accounted per categories, see Table 13.

Table 13 - Units purchased by Household #2 per food category

Food Category	Items Purchased
Fruit	14
Vegetable	18
Meat	9
Dairy	9
Eggs	46
Dry	2

Storage times were calculated by the same method as for Household #1, see Table 14. From this, it is possible to conclude that some products were stored until spoiled, and kept even past this point, as for the cabbage and onion on the 22nd of September.

Table 14 - Extract of Household #2 waste transactions

Waste date	Days since purchase	Product name	Purchase Amount	Waste Amount	Reason for waste	Character of Waste	Last of item
07-20	3.6	Cabbage	0.5 kg	-0.10 kg	Not tasty	Opened package	No
07-20	3.6	Mushroom	0.5 kg	-0.05 kg	Not tasty	Opened package	Yes
08-12	7.0	Nectarine	1 kg	-0.35 kg	-	-	-
08-18	6.1	Tomato	0.25 kg	-0.10 kg	Forgot about it	Opened package	Yes
09-22	68.0	Cabbage	0.5 kg	-0.10 kg	Spoiled	Opened package	No
09-22	34.3	Onion	0.4 kg	-0.05 kg	Spoiled	Opened package	Yes
10-14	24.4	Chicken	1.4 kg	-0.45 kg	Forgot about it	Half eaten food	Yes

During the final interview, the participant expressed that she now places meat in the freezer if she buys a portion larger than necessary for one meal. She also learned some new guidelines for storage, as not putting onions or celery in the refrigerator, and instead placing the bread inside the refrigerator when it's close to expiring.

4.2.4 Preparation and consumption

Participant #2 cooks in bulk, intending meals to last for one to three days. For this, certain fresh ingredients are avoided, and all leftovers are eaten except if they last more than week. She does not use measuring implements because the Swedish measuring units are larger than in China, and only uses recipes for cooking dishes that are not Chinese.

The application does not allow to explicitly indicate preparation or consumption of a product. However, from the data obtained it is possible to infer information for any of these actions for some products. For example, meats and fishes can be assumed as prepared, see Figure 22. No waste was registered as prepared meal, but one of the items marked as “Half eaten” was chicken. Four of the wasted items were marked as “Last of product”, which indicates full consumption and/or waste. Additionally, the “possibly avoidable” waste of cabbage and mushrooms due to bad taste might refer to preparation residues.

In the final interview, the participant said that she is cooking less when busy, and that she started using measuring implements for baking. She considers that she is producing less leftovers because of trying to eat everything and cooking appropriate amounts for the chosen number of days.

4.2.5 Wasting

In the initial interview, it was identified that the participant follows expiration dates strictly, except with butter. She feels that foods often spoil due to her forgetfulness, and does not think that food prices have any effect on her waste. She most commonly wastes bread and meat due to the package sizes; and sprouted potatoes and other vegetable parts which are not acceptable to eat in her culture. Sensory qualities also influence her waste, as she disposes items whose appearance, feel or smell are perceived as unpleasant, independently of their edibility. She considers that some packages’ shapes and sizes also make it difficult to avoid waste and believes to waste items at all stages of usage.

The participant feels guilty if she wastes food because of a passed expiration date, but not when it’s due to spoilage, as she considers it is impossible to maintain nutritional balance while avoiding all waste. The participant shares food with neighbors to avoid wasting, and sorts all her waste.

During the pilot test, seven transactions corresponded to wasted items. One of those was an incomplete transaction, meaning that amounts were included, but no additional data describing the waste was recorded. Therefore, the numerical data presented below corresponds to seven transactions, but the qualitative data only refers to six waste transactions.

A total of 1.20 kg was wasted, including no liquids. All waste was of vegetables and fruits, except for one instance of wasted meat. All wasted products could be traced back to a purchased item. Seventy-one of the purchased articles had an EAN number and therefore probably a date label, none of which were wasted.

Disaggregated data permitted to see the relation between type, state, and reasons for waste. For example, the possibly avoidable waste of cabbage and mushrooms that were not tasty suggest a preparation residue i.e. cutting parts of the vegetables, while the waste of a forgotten half eaten chicken indicates that this was a leftover. All the waste corresponded to last of item except for the two waste transactions of cabbage. Average edibility ratio was 0.17, which means that most of the waste was not apt for consumption by the time of wastage.

The character of waste transactions can be seen in Figure 23 and their interrelations in Figure 24. Notably, no instance of waste is related to expiration date, contrary to what the user expressed in the first interview.

According to the final interview, the participant continued to guide her waste by expiration dates, but became more flexible with bread and eggs. Vegetables and eggs now last longer for her, after following the tips in the app. She thinks that her reasons for wasting have changed due to less leftover production during the experiment, and that she is wasting less in unopened and cooked states. This can also be seen in the data. However, she expressed that if leftovers last too long she still throws them away independently of edibility. She avoided wasting food more than usual during the experiment, mainly to not register additional transactions into the app, but thinks the change will be longstanding. She also continues to separate her waste.

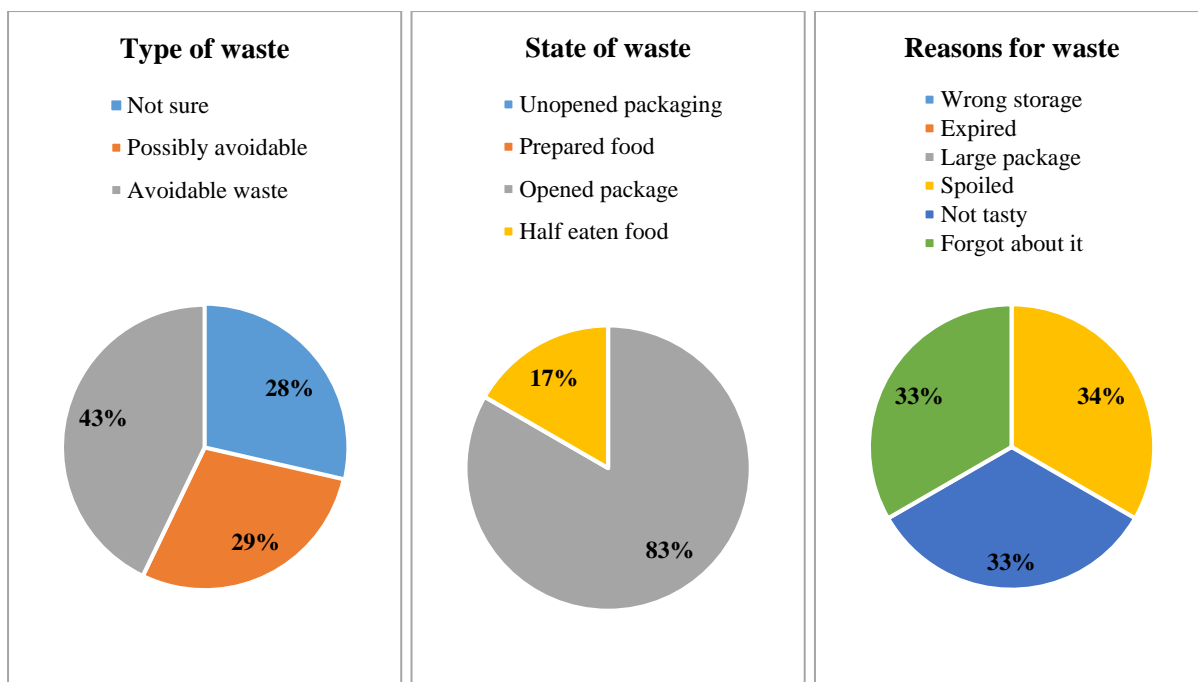


Figure 23 - Character of Waste for Household #2

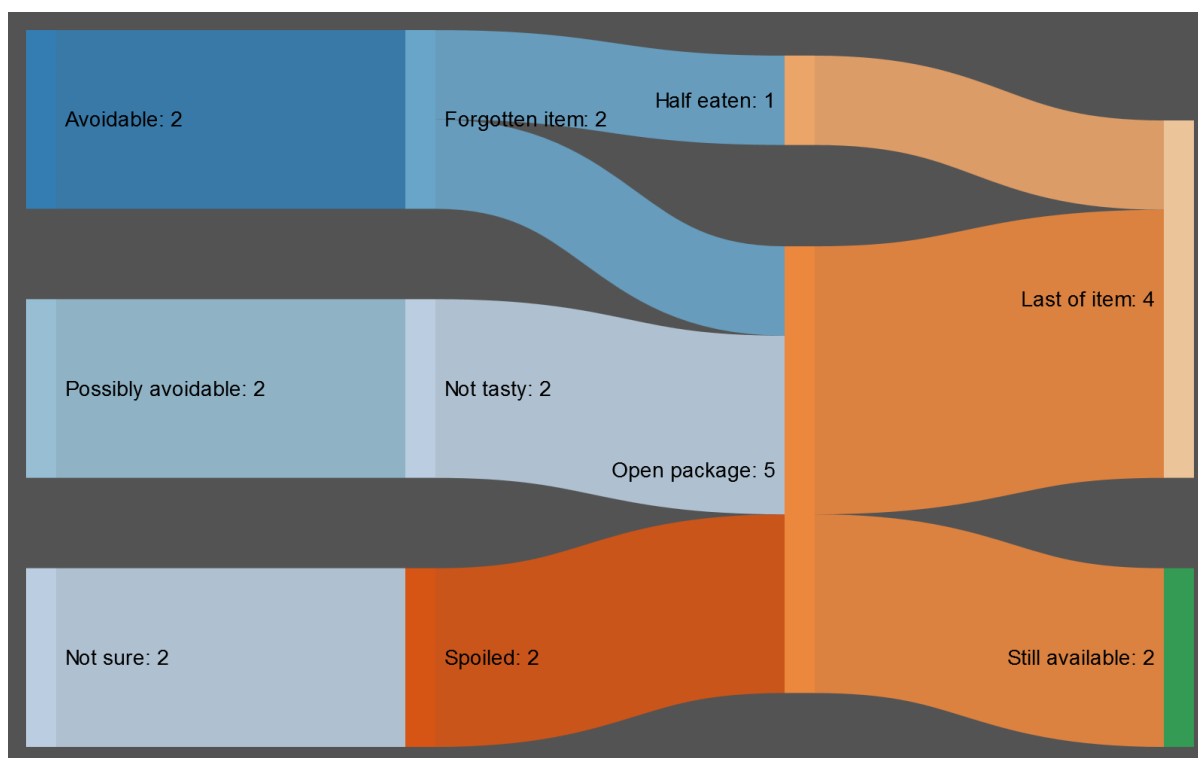


Figure 24 - Sankey diagram showing relations between type, reason, stage and stock of waste for Household #2

4.2.6 Environmental impact and attitudes

The participant had taken a master level course in waste management; therefore she possesses knowledge about the relationship between waste and environment. However, she does not feel confident

in her knowledge about sustainable food consumption, except for items marked as ecological. She finds the topic of food related GHG emissions interesting.

A total of 101.65 kg eCO₂ emissions, 70.54 m³ of water footprint and 184.77 gha were accounted for, of which 2%, 3% and 3% respectively corresponded to waste. GHG emissions along the study duration are seen in Figure 25. Products with the highest levels of emissions, both purchased and wasted, can be seen in Table 15 and Table 16 respectively.

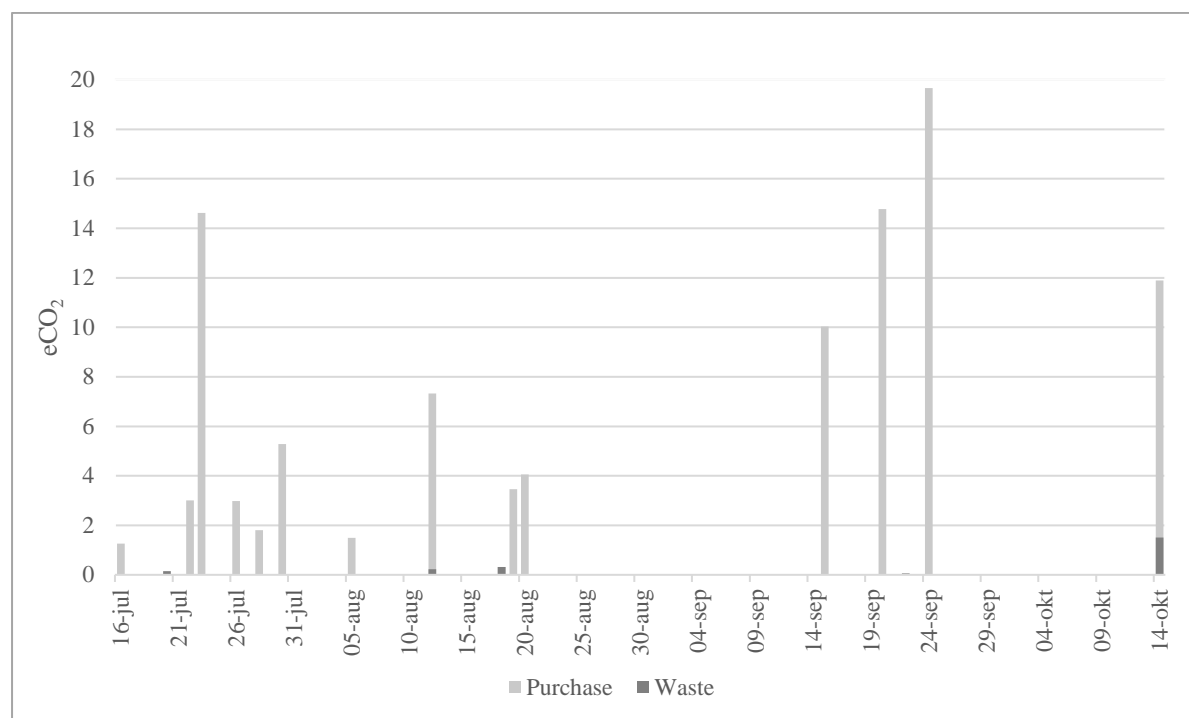


Figure 25 - Footprint of purchase and waste transactions per day in Household #2

According to the last interview, her knowledge and attitude towards environment remained the same. She checked the inventory a few times, but did not use the information; and found the environmental impact of foods easy to understand and unexpected, although she did not see the graph.

Table 15 - Purchase transactions with highest carbon emissions in Household #2

Session	Product name	Amount	eCO ₂
70	Beef	0.50 kg	9.83
73	Beef	0.40 kg	7.86
38	Lamb	0.50 kg	7.70
67	Chicken	1.40 kg	4.70
54	Yogurt	1.00 kg	3.90
67	Sausages & Meat Balls	0.30 kg	3.75
58	Tomato	1.00 kg	3.20
57	Eggs	0.80 kg	3.00
38	Pork	0.50 kg	2.98
42	Pork	0.50 kg	2.98

Table 16 - Waste transactions according to carbon emissions in Household #2

Session	Product name	Amount	eCO ₂
73	Chicken	-0.45 kg	1.51
WHH22	Tomato	-0.10 kg	0.32
54	Nectarine	-0.35 kg	0.23
WHH21	Mushroom	-0.05 kg	0.11
WHH21	Cabbage	-0.10 kg	0.04
WHH23	Cabbage	-0.10 kg	0.04
WHH23	Onion	-0.05 kg	0.02

4.2.7 Feedback effects

Thirty-five of the valid transactions occurred after eco-feedback was implemented, of which two corresponded to waste. The participant wasted 0.19 kg/week of food during the first stage and 0.70 kg/week during the second phase, indicating that the weekly rate of waste mass grew. In the same way, the waste in the first phase was exclusively of fruit and vegetables, while the waste on the second stage was only of chicken. Therefore, this makes the average weekly footprint much higher as well, see Table 17. Consider that both weekly average masses of purchase and waste increased, but the percentage of waste compared to the purchased amounts still grew from phase to phase: from 1% in the first phase to 4% in the second phase.

Table 17 - Average of weekly transactions per phase in Household #2

	Purchase				Waste			
	Mass (kg)	eCO ₂	Water footprint (m ³)	Land footprint (gha)	Mass (kg)	eCO ₂	Water footprint (m ³)	Land footprint (gha)
Phase 1	3.13	8.76	5.52	15.64	0.09	0.10	0.04	0.06
Phase 2	4.25	15.78	13.21	29.82	0.23	0.76	0.81	2.16

The user received nineteen advices during the second stage, see Table 18. Two of those corresponding to waste advice, two to diet and the rest to storage advice. Observe that most advices happened within one single session. A list of all the advices can be seen in Appendix 1.

The advices emerged upon registration of chicken, eggs, and beef, all animal products and therefore high emitters. Two advices emerged upon registration of spices, but given that its food type was outside the scope of the study they will not be considered.

The participant remained in the study for twenty days after the first received advice, although data collection was interrupted during this time. Thus, it is hard to judge whether the advices caused any change in the user's habits. During the final interview, the user expressed that she liked the tips and used one related to eggs. Nonetheless, she does not think that the app influenced her planning behaviors.

Table 18 - Advices received by Household #2

Date received	Session	Feedback type	Advice ID	Product	Transaction type
09-24	70	Storage	8	Eggs	Purchase
09-24	70	Storage	21	Eggs	Purchase
09-24	70	Storage	8	Eggs	Purchase
09-24	70	Storage	8	Eggs	Purchase
09-24	70	Storage	8	Eggs	Purchase
09-24	70	Storage	21	Eggs	Purchase
09-24	70	Storage	8	Eggs	Purchase
09-24	70	Storage	21	Eggs	Purchase
09-24	70	Storage	21	Eggs	Purchase
09-24	70	Storage	21	Eggs	Purchase
09-24	70	Storage	21	Eggs	Purchase
09-24	70	Storage	21	Eggs	Purchase
09-24	70	Storage	21	Eggs	Purchase
09-24	70	Storage	21	Eggs	Purchase
09-24	70	Diet	7	Muskotnöt Malen	Purchase
09-24	70	Storage	8	Eggs	Purchase
09-24	70	Diet	7	Oregano	Purchase
10-14	73	Waste	23	Beef	Purchase
10-14	73	Waste	4	Chicken	Waste

4.3 Household #3

The participant of Household #3 was a male 27-year-old Swedish student of Somali descent, living alone at a student housing. He studies at a master level, although at the beginning of the study was also working full time. He does not consume pork for religious reasons, and is cutting back on meat due to environmental motivations. Price is a big factor in his food purchases, as is place of production because of his trust in the Swedish food system. When the price allows, he buys ecological products, and prefers to eat out rather than buying “convenient” foods.

During the study, household #3 registered 56 transactions, being an active participant from July 17th 2015 to August 8th 2015 (5 weeks), with an interruption of data collection between the 23th and the 29th of July (1 week) see Figure 31, Page 65. Two of the transactions were identified as defective (see Discussion – Shortcomings of data collection) and therefore removed from the data, resulting in a total of 54 valid transactions and 4 weeks of data collection. Masses per day can be seen in Figure 26. Observe that dates are not continuous.

According to the final interview, the participant’s living situation remained the same. His eating habits progressed towards more consumption of corn, beans and mushrooms, and less animal protein, and more of his choices are driven by environmental concern.

4.3.1 Planning

The participant partakes in several planning actions: he checks the levels of food before purchasing, makes a mental shopping list and only purchases after deciding what his meals will be. He decides the dishes he will cook depending on what he feels like eating and how much time he has available.

During the study, the user registered 4 valid purchase sessions (see

Table 19). In average, the user took 4:12 min to answer the planning questionnaire at the beginning of a session. Observe that he user indicated that they had planned the meals twice, being this the only behavior taken. Fifty percent of the sessions were preceded by a key behavior, which means that 27 of the products, or 55%, were bought following some planning action. The last session did not include any metadata, though it is unclear whether this was a choice taken by the user or an error by the application.

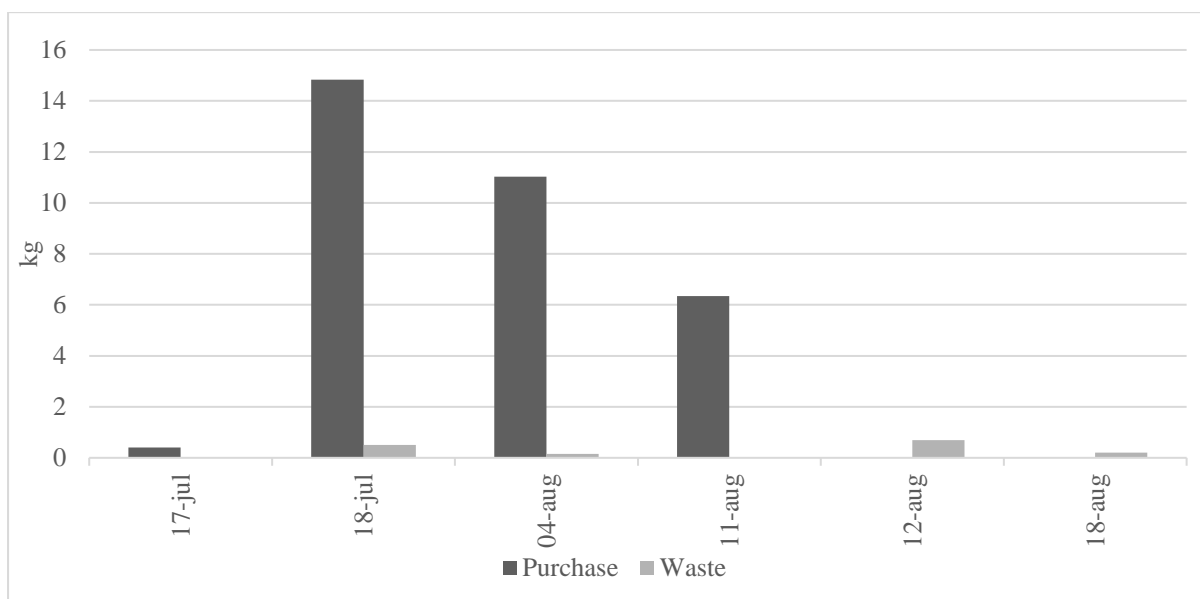


Figure 26 - Masses in purchase and waste transactions in Household #3

Table 19 - Planning behaviors of Household #3

Session	Date	Items registered	Unplanned shopping	Planned meals	Checked food levels	Made shopping list	Other	Any
34	07-17	1		•				•
35	07-18	26		•				•
49	08-04	14	•					
53	08-11	8						
Total			1	2	0	0	0	2
Percentage of sessions			25%	50%	0%	0%	0%	50%

This shows that the participant incurred in planning activities by the beginning of the study, which changed during the last weeks. Nonetheless, the data collection time was too short to identify a pattern. Most of the data coincides with what was stated in the interviews, except that he did check his levels of food before any of the purchases. In the last interview, the participant expressed that he did not perceive any change in his planning behaviors.

4.3.2 Shopping

For household #3, shopping occurs in nearby supermarkets as Willys Hemma Eklandagatan and Utlandagatan, and in Ica Maxi Möndalsvägen. He only buys before cooking, namely two or three times/week according to his schedule. The only item he buys in larger amounts is coffee; he only buys in discount if it's something that he knows he will use, and sometimes buys ready-to-eat meals to warm at the university, but not for home consumption. His food budget is 1500-2500 kr monthly, excluding expenses from eating out. He did not pay attention to food package sizes, but upon questioning he reflected that he would like bigger packages for some dry foods.

During the study, forty-nine of the valid transactions corresponded to purchase of items. Purchases, in average, happened every 8.5 days; contrary to what was stated in the interviews. The number of items purchased per product group can be seen in Figure 27. Some non-perishable items, as pasta and beans, were bought in large amounts, see Table 20.

Table 20 - Extract from Session 53, Household #3

Timestamp	Product name	Amount	Transaction type
08-11 16:55	Spaghetti	1.00 kg	add
08-11 16:55	Spaghetti	1.00 kg	add
08-11 16:55	Canned tomatoes	1.20 kg	add
08-11 16:56	Beans	0.42 kg	add
08-11 16:56	Beans	0.42 kg	add

In the final interview, the participant confirmed that he shopped in same places, except for one purchase at an Arabic supermarket, with a slight reduction in his budget. He identifies that some products get wasted because of sizing, and thus feels more of a need for differently sized packages. Nonetheless, he continues to buy the same sizes.

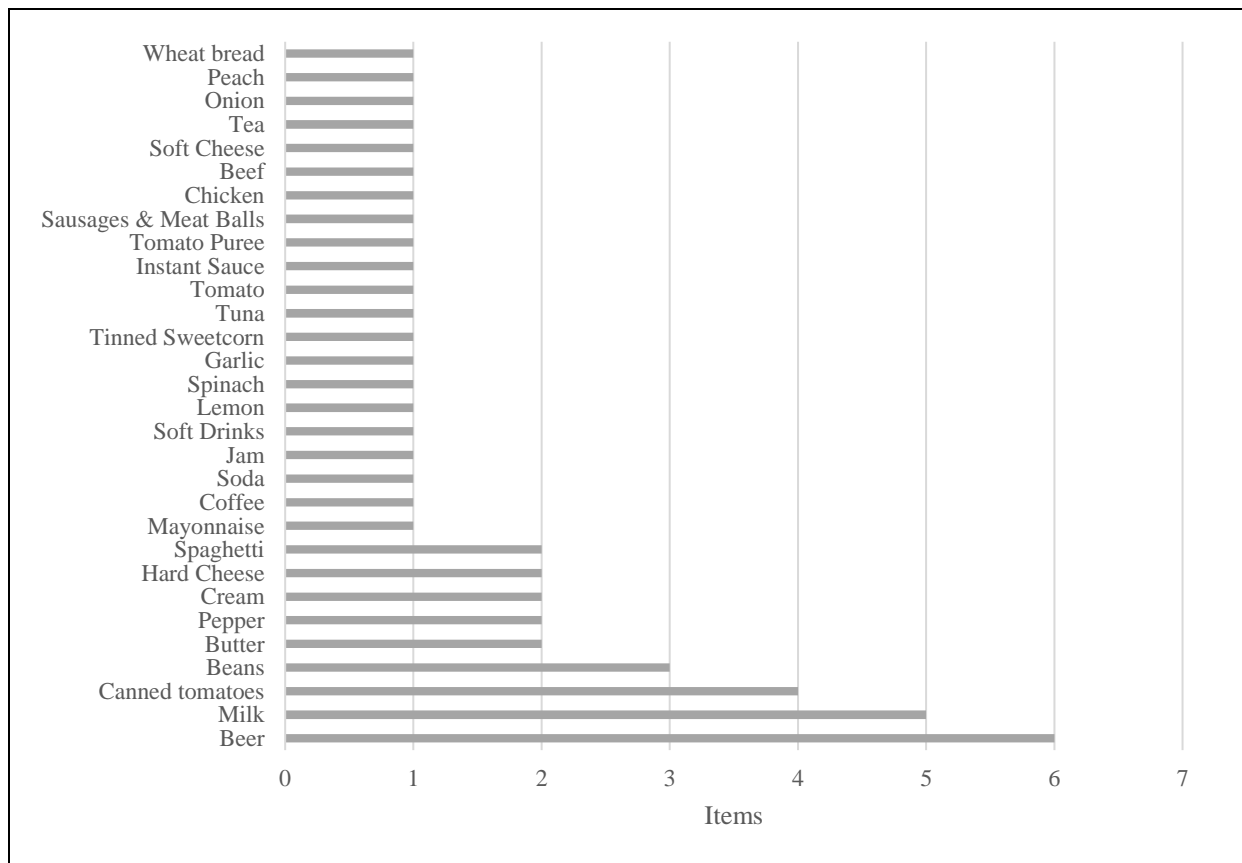


Figure 27 - Items per product group in Household #3

4.3.3 Storage

Household 3's student apartment has a kitchenette, which is a big constraint for his storage needs and limits visibility due to the placement of the small refrigerator.

He keeps the meat in the freezer, as well as half of the bread and boxes with bulk-prepared meals when they don't fit in the refrigerator. He does not freeze vegetables because due to changes in the texture. Dairy, cheese, vegetables and food boxes are kept in the refrigerator. The rare times that he

buys fruit, they are stored outside. He is confident of his knowledge of storage guidelines. The participant affirmed that these habits remained the same throughout the study.

During the study, storage sensitive items were accounted per categories, see Table 21.

Table 21 - Units purchased by Household #3 per food category

Food Category	Items Purchased
Fruit	3
Vegetable	5
Meat	3
Dairy	12
Dry	3

Storage times were calculated the same as for Households #1 and #2, see Table 22. Observe that the table does not include all waste transactions.

Table 22 - Extract of Household #3 waste transactions

Waste date	Days since purchase	Product name	Purchase Amount	Waste Amount	Reason for Waste	Character of Waste	Last of item
07-18	0.0	Canned tomatoes	0.50 kg	-0.50 kg	Spoiled	Open package	Yes
08-04	17.1	Lemon	0.25 kg	-0.15 kg	Forgotten item	Half eaten food	Yes
08-12	-	Rice	-	-0.70 kg	Wrong storage	Prepared food	No
08-18	7.3	Peach	1.00 kg	-0.10 kg	Spoiled	Open package	No
08-18	14.3	Hard Cheese	0.10 kg	-0.10 kg	Spoiled	Open package	Yes

From this it is possible to assume, for example, that the canned tomatoes bought on the 18th of July were spoiled upon shopping.

4.3.4 Preparation and consumption

Participant #3 eats out approximately five times per month, and cooks once or twice per week, preparing food boxes for the following days. The portions and measures are decided by eye except when cooking rice. He has memorized his most commonly used recipes, therefore is not influenced by set portion amounts in standard recipes. The participant doesn't usually have leftovers, as he tries to eat all the contents of his food boxes. Though, when there are leftovers, he doesn't consume them in order not to refreeze and reheat.

The application does not allow to explicitly indicate preparation or consumption of a product. However, from the data obtained it is possible to infer information for any of these actions for some products. For example, meats and fishes can be assumed as prepared, see Figure 27. One transaction of waste (see session WHH31 in Appendix 7) was registered as prepared meal and the reason was wrong storage, which suggested this belonged to one of his food boxes from bulk cooking. A little over half of the wasted items were marked as last of product, which indicates full consumption and waste.

In the final interview, the participant said that his consumption of food, and therefore frequency of preparation, varied a lot; though he was not sure why. He transitioned to using measuring implements when baking, which happened more often during the study.

4.3.5 Wasting

Participant #3's main expressed reasons for wasting are lack of visibility, package sizes (for yoghurt, milk and cream) and time spent working. The times that he's not home affect the spoilage rate of products, and therefore his waste. He believes that the stages at which he wastes the most are opened and partially used, and that he has only wasted unopened products in instances he has bought the wrong product. The participant thinks that he can prevent most of his waste except for yogurt, which he attributes to the size of the package. In regards to expiry of products, the only products with date labels that are often purchased by him are bread and dairy. For those, he always checks the date and picks the product with longest shelf life. He tries to finish these as fast as possible, but otherwise utilizes sensory cues instead of expiration date to decide whether a product is still edible.

The participant has strongly negative attitude towards unnecessary waste, due to the way he was raised. He recycles but does not separate food waste because of lack of storage space; although he believes he would be more conscious of his waste if he sorted it.

During the application use, five of the valid transactions corresponded to wasted items. A total of 1.55 kg were wasted, with no liquids being introduced as waste. Some fruits and vegetables were wasted, as well as a small amount of dairy. Forty-two purchased articles had an EAN number and therefore probably a date label. Only three of these were wasted, none related to its expiration date.

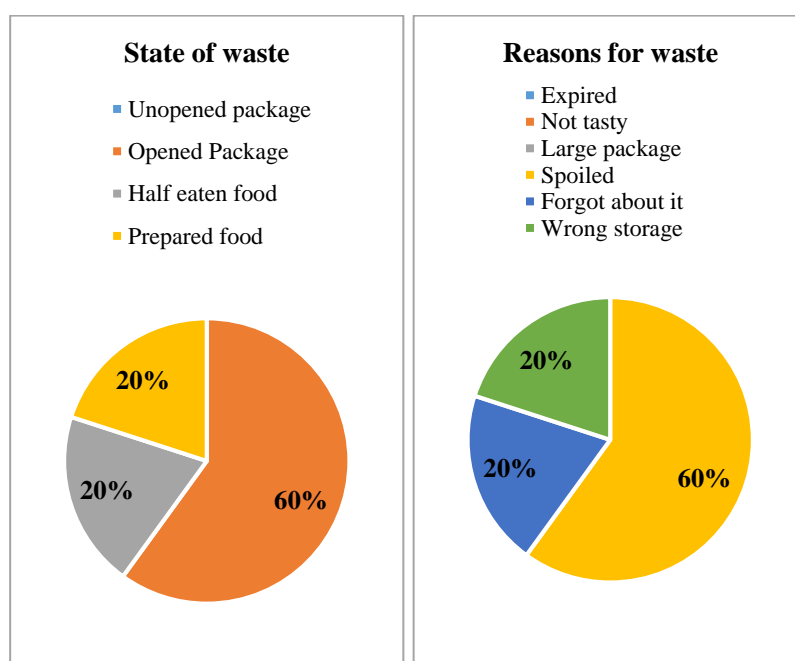


Figure 28 - Character of Waste for Household #3

All the waste was classified as avoidable. The character of waste transactions can be seen in Figure 28 and their interrelation in Figure 30. Three items were marked as last of the item. Average edibility ratio was 0.72, meaning that most of the waste was still edible.

During the final interview, the participant expressed that most of his wasting habits remained the same, although he became aware that some of his waste is due to the size of products.

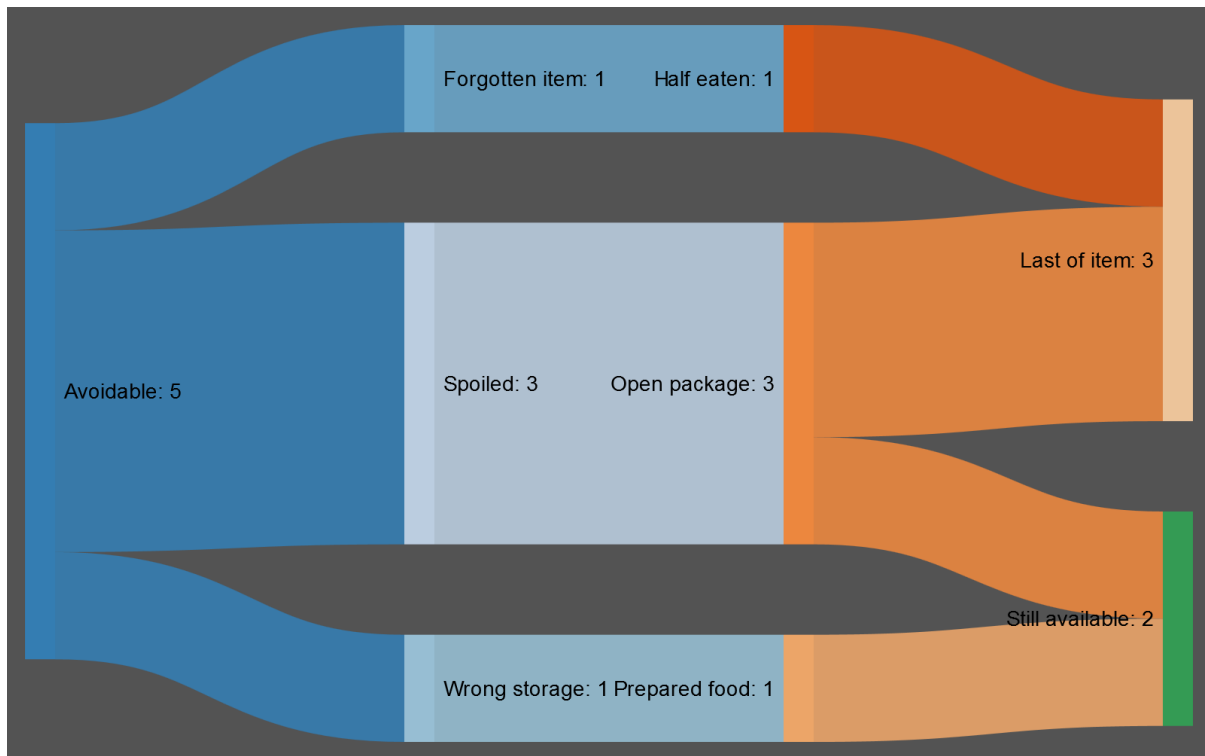


Figure 29 - Sankey diagram showing relations between type, reason, stage and stock of waste for Household #3

4.3.6 Environmental impact and attitudes

The participant studies Infrastructure and Environmental Engineering at Chalmers, therefore has knowledge of environmental matters. He is aware of how his food choices affect the environment and knows the benefits of reducing food waste. Several of his actions are pointed towards sustainable consumption, as reducing his meat intake and buying locally when economy allows.

A total of 119.60 kg eCO₂ emissions, 108.89 m³ of water footprint and 208.10 gha were accounted during the pilot test, of which 3%, 2% and 2% respectively corresponded to waste. Below is shown a summary of the masses and footprints produced per week.

Table 23 - Weekly masses and footprints in Household #3

Week	Purchase				Waste			
	Mass (kg)	eCO ₂	Water footprint (m ³)	Land footprint (gha)	Mass (kg)	eCO ₂	Water footprint (m ³)	Land footprint (gha)
1	15.23	35.83	33.80	47.82	0.50	0.14	0.01	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	11.03	74.74	69.17	153.01	0.15	0.08	0.07	0.15
4	6.34	9.03	5.92	7.27	0.70	2.56	1.66	2.21
5	0.00	0.00	0.00	0.00	0.20	1.19	0.53	1.10

Carbon footprint per day in eCO₂ are shown in Figure 30. Note that some values are too small to be seen under the graph's scale, and that only dates in which transactions were submitted are shown in the graph. Although emissions related to waste increase towards the end of the study, the amount is

negligible. Products with the highest levels of emissions, both purchased and wasted, can be seen in Table 24 and Table 25 respectively.

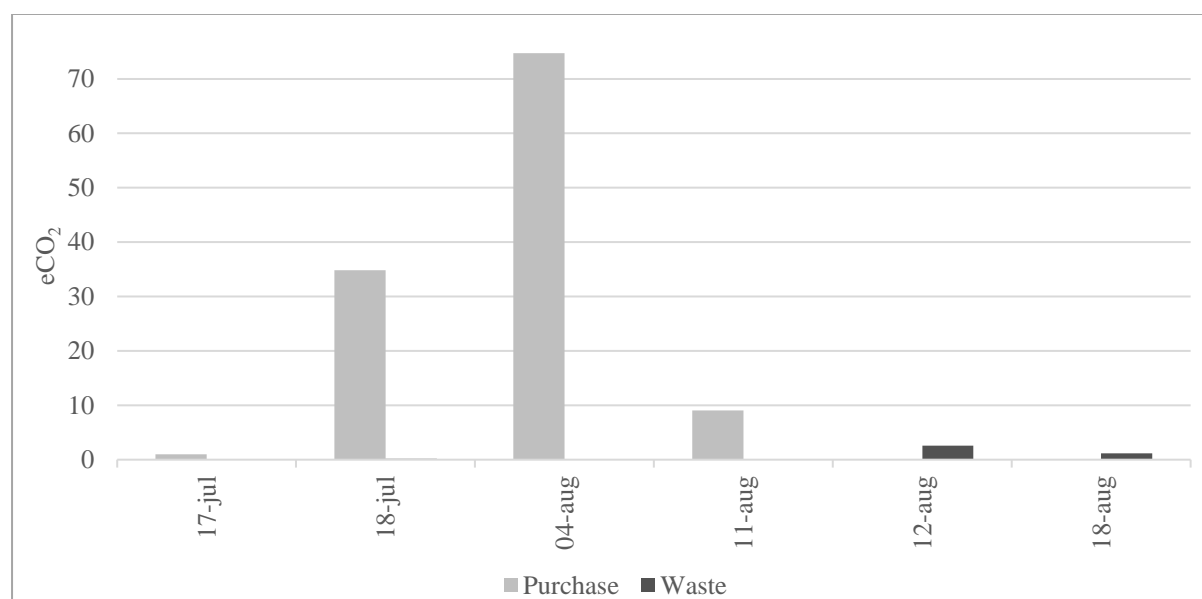


Figure 30 - Footprint of purchase and waste transactions per day in Household #3

According to the last interview, his knowledge and attitude towards environment remained the same. During his use of the application, the impact graph was not available, and although he accessed the inventory to verify whether products registered, and to copy other products' barcodes, he did not pay attention to the footprint values of transactions.

Table 24 - Purchase transactions with highest carbon emissions in Household #3

Session	Product name	Amount	eCO ₂
49	Beef	2.15 kg	42.26
35	Butter	0.75 kg	7.73
49	Butter	0.75 kg	7.73
49	Sausages & Meat Balls	0.45 kg	5.63
35	Coffee	0.50 kg	4.05
53	Canned Tomatoes	1.20 kg	3.43
49	Chicken	0.90 kg	3.02
35	Tomato Puree	0.80 kg	2.56
49	Soft Cheese	0.20 kg	2.50
35	Jam	0.75 kg	2.25
49	Hard Cheese	0.18 kg	2.25

Table 25 – Waste transactions with highest carbon emissions in Household #3

Session	Product name	Amount	eCO ₂
WHH31	Rice	-0.70 kg	2.56
WHH33	Hard Cheese	-0.10 kg	1.12
35	Canned tomatoes	-0.50 kg	0.14
49	Lemon	-0.15 kg	0.08
WHH32	Peach	-0.10 kg	0.07

4.3.7 Feedback effects

Household #3 registered their last transaction on August 18th. Given that the eco-feedback was implemented from September 24th, this participant did not receive any of the advices and the impact of the intervention on their wasting habits could not be observed.

4.4 Results from aggregated data

During the study, 293 transactions were registered, of which fifty-eight corresponded to waste. The study lasted thirteen weeks, though the dates of data collection varied between households. Figure 31 shows the weeks in which households participated in the study.

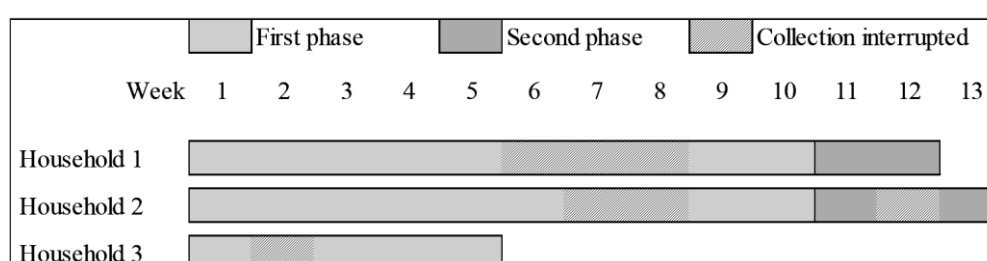


Figure 31 - Comparison of households' length (in weeks) of active participation in the study

A complete collection of the data obtained during the study is presented in Appendix 7. The following observations were made upon combination of all the participants' data:

Planning - All participants partook in planning activities in more than half of their purchasing sessions, leading to a 76% percent of purchase sessions being planned in some way. Across households, the recommended planning behaviors were almost equally popular. Gathering information on planning behaviours allowed to estimate how many of the waste transactions came from products from purchasing sessions that were planned, as the example for Household #2 present in Figure 32.

Shopping - The product type most purchased per unit was dairy, closely followed by vegetables. Fruits were the fourth product type the most bought, ahead of meat.

Preparation and Consumption – Attending to the research question of “How can FoodWatch capture household's food metabolism and related routines?“, the app allowed to follow the stock of individual items, as shown in Table 26. The automatic balancing transactions allowed to observe the consumption for items that were marked as “last of item” when wasted. In the table below, the bookkeeping transaction is marked as “consumed”. This nearly captured the metabolism of certain products, except in cases where it was possible to have unavoidable waste, for which the balancing

value would then be merely an approximation. The meta-data permits the observation of how a product has been used during its shelf life, i.e. to see routines behind this metabolism, see Table 26. However, due to missing data, in many product's cases the consumption figure was not reliable.

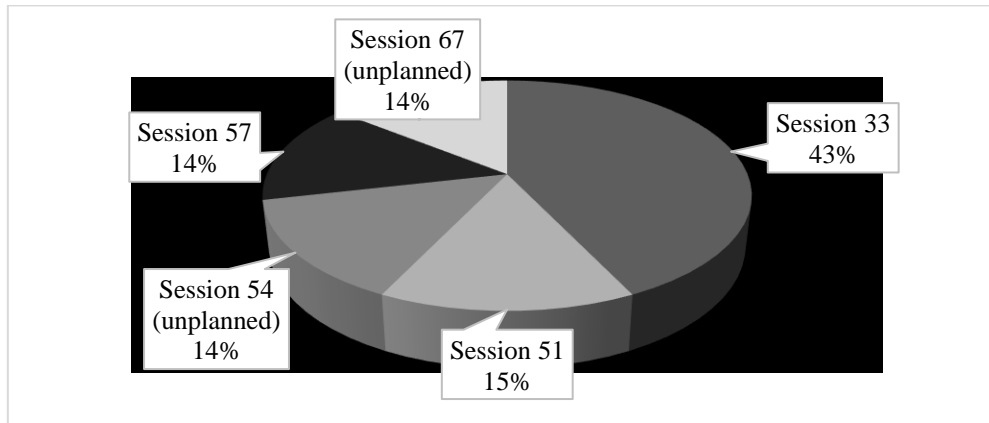


Figure 32 - Items wasted per shopping session in Household #2

Table 26 - Muesli stock in Household #1, with preceding behaviors and characterization of waste

Planned meals	Checked food levels	Made shopping list	Date	Transaction type	Amount	Stock	Last of item	Waste type	Reason	State	Advice
No	No	No	07-19	Add	0.20 kg	0.20 kg					
			08-06	Waste	-0.10 kg	0.10 kg	No	Avoidable	Large package	Half eaten	No
Yes	No	No	09-12	Add	0.55 kg	0.65 kg					
			09-27	Waste	-0.05 kg	0.60 kg	Yes	Possibly avoidable	Wrong storage	Half eaten	Yes
			09-27	Consumed	-0.6 kg						

Wasting - A hundred and thirty-seven kilograms of food were purchased, of which 10% was wasted, a value lower than that seen in literature. This translated to 463.69 eCO₂, equalling 7% of purchase footprint. In general, more vegetables and fruits were wasted than animal products, which correlates with Beretta et al.'s (2013) statement that fresh products waste fraction tends to higher than other kinds of products in households.

Environmental impact and attitudes – All participants had higher level education in Environmental Sciences and/or Engineering.

Comparison between stages - Only two of the participants used the application during stage two, receiving a significantly different amount of advices. The waste fractions changed in different ways in phase two, but none of the households had more than two weeks of participation during this phase. Additionally, many setbacks were experienced during data collection. Consequently, it is not feasible to stablish consensus on what was the effect of the eco-feedback.

4.5 About FoodWatch and experiment design

This section presents the answers from participants to interview questions regarding the experiment design and functioning of the app.

4.5.1 Household #1

Equipment used during study - The barcode reader presented many issues for the user. It turned on and off repeatedly, and marked several items as unknown, both with national and international products. It also stopped working for more than week, time during which the user had to register items as products without barcode

Study design and application use – The user felt that she fully understood the protocol. Nonetheless, she found several difficulties with the registration method within the app, as identifying whether products had been registered or not and estimating the percentages of waste. With the latter, though, she became confident by check-proofing with the scale. She wonders how much the packages' weight affected the measures, and also expressed confusion about distinguishing between avoidable and non-avoidable waste.

For a certain period, none of the products she tried to register worked. One instance in which she contacted the researchers was about pasta waste, which recorded with a weight equal to 0 (see Appendix 6). Also, she sometimes bought products that weren't in the database, and did not register them because she couldn't find the product group amongst the options.

The user expressed that she would not use the application outside the test trial because she feels that she is already careful about waste.

Suggestions and final thoughts – The user would like more messages from the app that evaluate how participants eat and waste, and to receive more tips. She considers the app should be aimed at larger households. An unexpected effect for her was that she became curious about her waste amounts because the inventory allowed her to see the transactions, preventing her from forgetting them.

4.5.2 Household #2

Equipment used during study – The participant found that tablet lagged and the sensitivity of the screen was poor.

Study design and application use – The participant fully understood the protocol, and thought that the questions within the app were relevant, although there were some which she felt did not apply to her. The user found the database options limited: Items such as figs, a type of mushrooms, chicken hearts, some Chinese foods and minced meat (both beef and mixed) were not found by her within the product groups, so she could not introduce them to the app database.

Moreover, the participant experienced difficulties with registering transactions and new items: She was confused about registering the flour portion of baked items, and experienced an issue with eggs which forced her to register them one by one. It was also difficult for her to identify when a waste was avoidable or not due to cultural differences. She was not sure whether certain small amounts of waste counted, and found it hard to estimate waste percentages.

She thinks the app is not user friendly and is better suited for research. Because of this, she thinks she would not obtain any benefits nor fun from using the application in daily life.

Suggestions and final thoughts – Households #2 suggested using the application to educate people about the importance of waste separation, and to quantify the effect of food choices. She also suggested linking the application with social media and allowing users to compare their waste, similarly to step-counting mobile applications.

4.5.3 Household #3

Equipment used during study - Sometimes it was difficult for the user to distinguish whether the barcode reader was working due to a lag with the application. On one instance, the barcode did not allow him to register transactions so he had to introduce the barcode manually.

Study design and application use - The participant experienced no difficulties with the protocol or with the questions in the application. He had some trouble distinguishing between avoidable and non-avoidable waste, which he attributed to cultural differences. He felt confident with his estimated waste percentages.

He did experience some issues when registering transactions and new products. Sometimes, products that he had previously registered (cooking oil and possibly milk) stopped working properly. At other times, the app didn't recognize a string of products and wouldn't add them to the database either. Some products from the Arabic store he frequents weren't in the database, and it didn't work when he tried to introduce them to the database. Others, as processed meats for sandwiches (turkey, beef, chicken), he couldn't register because he had already thrown away the packages. He was unsure of how the application would differentiate between products that were wasted and products that were fully consumed. Also, had doubts about how to register waste of cooked meals and brewed coffee.

The participant thought the application was nice, and liked the idea of keeping statistics of his food habits. He would use the application in daily life if it were easier to use and available on smart phones.

Suggestions and final thoughts - Although the user does not feel it would help him personally, he thinks it would be useful for other people to show a more accessible quantification of waste in the app. He also suggested making the app mobile and enabling barcode reading through cellphone or tablet cameras instead of using the handheld reader.

Some ideas that the user had to make the application more user friendly were being able to register waste through the purchase history instead of scanning the product again, being able to mark "Refill" for products that have been purchased before, and allowing transactions to be edited instead of having to erase and re-register them. These occurred to him due to experiences with the application, as forgetfully throwing away packages before registering waste and using the wrong mass unit for transactions. He would also like an option for "average waste" in his profile to be able to select that instead of introducing the waste manually if the average coincided with the actual waste, and being able to see a general overview of his transactions.

Household #3 thought it was nice to keep a log of his transactions and would like to do it more if it were easier. The participant did not feel that they learnt new things, changed any habits or perceived any change otherwise during the experiment.

5. Discussion

The results from the pilot test and interviews are discussed below, following the format of the research questions. Other aspects of the data that were found interesting are also discussed.

5.1 Food waste reduction as the target for eco-feedback

Reduction of food waste was identified as one of the possible applications of FoodWatch by Harder (2013), and argued as a necessary matter for reduction of greenhouse gas emissions related to food consumption in the Literature Review. Nonetheless, it is possible that reduction of food waste on a large scale carries certain rebound effects that are not addressed by FoodWatch.

One possibility is that reduction of food waste could imply a reduction in purchase of food items, which could in turn reduce prices for items and increase their demand in other areas (Alcott, 2008), therefore altering economy patterns. Also, less food waste could affect the amount of time that the composting bags are left in the household garbage bin, affecting the quality of the waste to produce biogas, and/or change in the composition of waste streams composting (A. Bernstad, 2011). Considering these, other alternatives for reduction of food-related greenhouse gas emissions could have been studied.

It is also to be considered whether merely attempting to modify user's habits could have a significant impact, without tackling as well the factors that are not governed by consumers i.e. making changes to the products sold (DEFRA, 2008, Quested et al., 2013). This is supported by the fact that both Household #2 and 3 mentioned that packages' shapes and sizes make it difficult to avoid waste, yet in the case of the latter he continued to buy same sizes. The present study attempts to compensate for this matter by including a section about possible stakeholders' involvement in the literature review.

Nonetheless, research (DEFRA, 2008, Quested et al., 2013) points out that many of the measures to reduce food waste do rely on the consumer's attitude, as helping the population relate food with GHG emissions, which FoodWatch can be said to do. Besides, sources also point out that compared with other strategies for the reduction of food-related footprint, as lowering consumption of calories or animal products, reduction of food waste is expected to have the highest reduction of footprint and higher chance to be accepted and implemented by the population, adding to the fact that food waste reduction, specifically, has rarely been the target of eco-feedback.

5.2 Implications of the experiment design in collection of waste data

This section presents some reflections about the chosen aspects of the study design:

Sample - The present study processes the highly-disaggregated data of three households. While this enhances the analysis of the type of data obtained, the small sample might not accurately represent the trend within the targeted population.

The participants entered the study as volunteers, which might signify that they already had an interest in the environmental impact of food or in reducing their food waste. Therefore, it is not clear whether the app would hold the same effect for people who are not interested in neither, and supports the idea of including people who are not environmentally motivated in future studies. In the same way, it should be considered whether the difficulty experienced in finding participants represent a general unwillingness of the population of partaking in waste reduction measures, challenging what's stated in literature.

Diary-based data collection - Several studies before have concluded that self-reporting leads to substantial underestimation of food waste in households (Beretta et al., 2013, Martindale, 2010, Quested and Johnson, 2009), losing up to 40% of data when compared with a flow stream analysis (Quested et al., 2011). It is possible then, that the data introduced by the users carries a significant degree of error (Parizeau et al., 2015). Although this and other studies integrate the use of scales to ensure measuring accuracy, the self-reporting might still lead to inaccurate final amounts of waste. An example of this is the case of Household #2, who expressed insecurity regarding whether certain small amounts of waste counted. This suggests that these amounts were not registered, which brings forth questions of what amounts the users consider worth registering. Another example of inaccuracies even while using the scale would be the difference in weight due to packaging of products, as brought to attention by Household #1. While this is disregarded as insignificant, it could accumulate over time.

Nonetheless, other waste-data collection methods would not allow for the level of data disaggregation that this study is characterized for; and including compositional analysis as an additional verification step, as in Harder's study, would imply an additional effort by the participants and researchers that would be deemed unnecessary to verify the hypothesis.

Given that many of the user's involvement diminished over time, it can be questioned whether this method would ensure that users reliably and consistently provide data in subsequent trials. Lim and

Yalvaç (2014) considered this as well, and planned to address it by combining the strategies of a shopping list, eco-feedback, social visibility and most importantly, periodic reminders. FoodWatch already integrates eco-feedback, and could benefit from the concept of reminders.

As for other aspects that could have deterred users from registering information, the participants expressed confusion on how to register some types of waste into the application and some discomfort with the protocol. Households 1 and 2 mentioned that initially, the estimations of percentage of waste were hard to understand, while households 2 and 3 expressed doubt on how to register waste of brewed coffee, flour in cakes due to weight changes, and distribution of ingredients in cooked meals. The latter is of special interest, as diary-based data collection also affected user's ability to register waste resulting from dishes that included many ingredients- such as soups, curries, etc. These are difficult to estimate compositionally, and therefore might have led to inaccuracies. In subsequent version of the application, the study would benefit from expanding the protocol on registration of prepared meals. An option would be to allow the addition of prepared dishes, as the ones proposed by Carlsson-Kanyama (1998).

A positive aspect of this collection method is that the users' process of analyzing waste before inputting transactions in the app make the participants more aware of their actions, providing increased visibility and awareness of their waste. It can be argued that self-reporting helps preventing waste by working with human tendencies: Griskevicius et al. (2012) affirm that it is more effective to consider people's "predisposition to be shortsighted, and proneness to disregard impalpable concerns". Household #1 expressed that FoodWatch prevented to a certain degree the "out of sight, out of mind" situation with food waste, and helped her realizing that she wasted food for more reasons than she originally thought (see sub-chapter Results – Household #1 – Wasting). This fits in with the concept of providing improved visibility as per Ganglbauer et al. (2012). Besides, the diary approach of the application of resulted in a short time required to register transactions. While the **"Results"** chapter shows the average time that it took for users to answer the questions related to purchase sessions, in Harder's study, processing of organic waste through shopping receipts and analysis of waste took approximately 30 min per day (Harder et al., 2014). Thus, even with additional steps in the submission of data to FoodWatch, the time that it takes to be used can be considered advantageous.

Household delimitation - Something to consider is how much relevant data can be overlooked depending on the boundaries established for the study. The study by Harder (2013) is only considering formal flows, i.e. those that are purchased at the supermarket and are disposed through municipal waste collection systems, and the current study follows similar guidelines, if only slightly more broad, considering that often students do not eat at home and bring food outside instead. This brings forth the question of how much data is being left out, as food that is received as a gift or brought as leftovers from restaurants or catering, or food that is given as a gift for other people (as mentioned by Household #2). Not following a carefully delimited household introduces bias, because important flows might be unknowingly missed. A way to tackle this would be to include more comprehensive questions relative to the household's food flow sources in subsequent studies.

Study length - Given the short duration of the study, there is a possibility that the kind of foods that are consumed follow a seasonal pattern and that some seasonal associated waste is present (Quested and Johnson, 2009). Therefore, the results may not be extrapolated to what the wasting behavior would be year-round. This effect is generally seen on fresh produce, which is coincidentally what tends to be more wasted, both in literature (Beretta et al., 2013) and in the current study. Nonetheless, as the current is a pilot test, it can be argued that it presents the waste data necessary to allow for reflection and suggestions for a subsequent study. Further experiments might find it useful to extend the duration or make comparison studies in two different seasons.

Also, the short duration of the second phase in comparison to the first stage makes it difficult to establish a comparison between wasting patterns, especially since in single household's instances of purchases or waste might be more spaced out. Furthermore, the time lapse between the end of the pilot test participation and the final interview possibly affected the quality of the answers of the participants regarding their experience in the study.

While many of the method's limitations refer to the precision of the data obtained, the degree of precision desired must rely on the intended use of the application. Accuracy might not be of vital importance if the application is a method for public use, aimed towards the eco-feedback part. If it is used, however, as a tool for waste studies, more work shall be done in establishing boundaries and ensuring reliability of user provided data.

5.3 Shortcomings of data collection through FoodWatch

To assess whether eco-feedback achieved the desired result in reduction of waste and its footprint, it is necessary to have reliable data of the flow variations during the study. However, during the study were identified several factors independent of the study design that affected the collection of data. Some of the problems were mentioned during informal communication with the participants (see Appendix 6) and in the final interview, while some of the data errors were identified through inspection of the gathered data. All the identified factors are presented below:

5.3.1 Equipment related

The barcode reader did not function for Household #1 from August 5th to 12th, possibly because of errors in the connection with the tablet. The participant had to introduce products that had a barcode as products without a barcode. This might explain why some of the wasted products within this time frame have a product name that is different from the purchased product from which the waste might have originated. For example, the participant purchased "prepared flat fish" but wasted "fresh flat fish". The malfunction did not affect footprint data retrieved, given that the differing products belonged to the same product group, and therefore had the same footprint in the database. Nonetheless, malfunctioning of the equipment, as well as the added step required to register transactions manually, might have deterred participants from engaging with the app. Additionally, errors like this could have implications for the data analysis further down the road: since the calculation of storage times for products is currently done manually, differing product names resulting from different methods of registering make the calculation more complicated. If a method for automatic calculation of storage times is introduced, this kind of situation would lead to loss of data.

Even on the assumption that the barcode reader will work appropriately, its involvement in the registering of waste transactions should be reevaluated. Household #3, for example, mentioned that having to use the barcode reader a second time to register waste was problematic, because he usually threw away wrapping and packages after purchase. The user did not register some products due to that, which were animal products and therefore significant to footprint data. The inconvenience also points back to his dubitative answer when asked whether he would use the application long term.

Nonetheless, the use of a barcode reader is undoubtedly an improvement for self-reporting, in contrast to recording products solely by writing or through search in a display list. Shiraishi et al. (2009) mention that manual self-reporting is on the way to become obsolete and thus other reporting methods should be found. Hunter et al. (2006) corroborate that diary based collection is time consuming and could be complemented with other techniques to make it easier for the user. No other study found in the literature involves the use of a barcode reader, presenting an advantage for FoodWatch's use of it.

Another situation which led to loss of data was malfunctioning of the recorder during the final interview. Two of the interviews were affected, and while some of the information lost was retrieved, some sections of the interviews could not be recovered.

5.3.2 Application related

Submissions of purchases, waste and new products to the database suffered malfunctions at various times during the field trial. At some occasions, it was not possible to introduce any type of transaction into the system. Household #1's transactions failed to save repeatedly on July 24th, while for Household #3 the same happened on August 4th. On the latter, some products could be added and some not, as was the case for products "Cooking oil" and "Salami". It is possible that there are some inaccuracies in the calculation of storage time of products, since some products were lost during the period that data was not collected.

A similar case occurred when Household #1 and #2 attempted to introduce new products within the database for further use, which was not accomplished, leading to loss of data. While it is unreasonable to aim for the inclusion of all existent products to the application database, it is a given that constant work must be done in expanding the catalogue of products. To tackle the difference of products offered by different retailers (as considered by Household #1), the integration of stakeholders is an option to consider.

In various cases, the submissions went through but presented errors upon inspection. In Household #1, eighteen transactions of both purchase and waste had a null amount. The participant did not report these errors, except for the case of fresh pasta on the 25th of July. Although the error for this product was fixed shortly after, the participant did not attempt to submit the waste again. The same happened for Household #3 in two transactions of waste. Ten of the amounts for transactions in Household #1 were subsequently found in the data set for purchase sessions, therefore they were re-added. The rest were removed from the data set, given that it was not possible to extract amount or footprint information from these data points.

Seventeen waste transactions in Household #1 presented mirrored transactions, unrelated to book-keeping transactions. This means that immediately after each one of these, a waste with the same amounts but opposite sign was registered. The mirrored transactions were removed from the final set, leaving the original as a valid data point. Similarly, one waste transaction registered with an opposite sign. For this, the sign was corrected.

Nine transactions in Household #1 presented incongruent units, such as an amount of “Cauliflower” measured in liters. Upon inspection, it was determined that these were not user mistakes. For these, the equivalence of units was 1:1, so the unit was simply replaced in the final data and the footprint values remained the same.

Transactions which lacked some of the standard data were also found. One transaction did not include footprint in it, despite the footprint of this kind of product being in the application’s database. For the data evaluation, the footprint was added manually. Also, one waste transaction in Household #1 and one in Household #2 did not include information about the waste’s characteristics, such as reason of waste, type of waste, etc. These were considered in the analysis which required numerical data, but not for the qualitative ones.

In some cases, the number of products that appear in the transactions data does not match the number of times that they appear in the sessions data, e.g. only two “Original skogsbär” in session 62 HH1 while three in transactions data, only one “standard mjölk” included in session 52 HH1 but two in data, only one “normalsaltat matfettblandning 75%” in session 64 HH1 but two in data, and one “Apelsin” in session 68 HH1 and two in data. The same happens with two units of milks in transactions data while there is one in metadata for session 67 in HH2. For all cases, the higher number of units was taken as the valid data.

Ultimately, there were often defective or invalid data during the study. While it was easy (though very time consuming) to identify the errors within the relatively small amount of transactions gathered, this might not be possible in a larger scale study and would lead to inaccurate results.

5.3.3 User-related factors

Household #2 had interrupted data submission because of forgotten account information (August 25th to September 7th) and lost tablet password (October 10th to October 14th). The same case presented for Household #1, where no data was registered for 3 weeks due to personal reasons. Most remarkable is the case of Household #3, which suspended their participation of the study before the phase 2 started, and therefore had no exposure to eco-feedback. This is also something that affected the calculation of storage time of products. Additionally, the differences in collection times make it difficult to draw comparisons between households.

For Household #1, the main user's partner did not participate in the interview, so information about his habits was only gathered through what the participant expressed. That means there might be some inaccuracies in the qualitative information gathered for the household.

Apart from explicitly missing data, it is helpful to question how user's understanding of the application's inquiries affected the data that was received. For example, for Household #1, in one of the purchase sessions marked as "unplanned", the user indicated that they checked the food levels. The same occurred in Household #2 for two of those "unplanned purchases", where the user indicated that they partook in various planning behaviors. The contradiction might indicate a mistake by the users, but most likely it indicates that the question was not clear to her. It is recommendable to modify the question wording, or configure that specific questions such that it's not possible to choose a behavior when "unplanned purchase" has been selected.

Also, in the case of Households #2 and #3, cultural differences made it difficult for the users to differentiate between avoidable and partially avoidable waste. Household #1 also experienced confusion over what constituted avoidable and non-avoidable waste, although it is not certain that this was related to cultural differences. It is presumed that this affected the data minimally, since inspection of the waste characteristics sometimes helped identify to which category the transaction belonged. Furthermore, it could be argued that the degree of analysis that the user had to undergo before registering waste might increase their awareness and therefore diminish partially avoidable waste, even if they are not sure to which type the waste belongs. Nonetheless, in follow-up studies it might be useful to further clarify the difference between types of waste. Questions that are easier to understand by the user will positively affect the quality of the data received.

Similarly, other questions in the application should be evaluated to avoid overlapping or confusion, for example, the reasons available for a waste transaction.

5.3.4 Others

Five of the purchase sessions (45, 50, 51, 57, and 65) in Household #2 had been marked as being preceded by "Other" planning behaviors. However, no information was attached to this. It is not clear whether this was an application error or if the question was intentionally not answered by the user. Session 53 does not have any meta-data. It is unclear whether this is an error or not. In the same way, some session IDs appeared in the "Sessions metadata" but not in the "Session Transactions data". For some it was possible to triangulate with the normal transactions data (sessions 34 and 50), but the rest were eliminated (sessions 65 and 46).

Another interesting case is that of Household #2, where eggs appeared in such a large amount because the user registered each egg individually as opposed to registering a complete carton. While the user did not recollect why it was difficult for her to register a complete carton, one must consider that difficulty in registering such a commonplace product might cause the user to lose interest in utilizing the application.

5.4 Perception of household metabolism and surrounding habits

One of the research questions of the study pertained exploring how FoodWatch could capture household's food metabolism and the routines behind this metabolism. Tying back to the conceptual model, ideally information should be obtainable in each step of the flow diagram, namely the planning, purchasing, storage, preparation and/or consumption and wasting stages, and potentially the existing loops between these stages.

The quantitative and qualitative data derived from the planning, purchasing and wasting stages was successfully obtained, as shown for every user in the "**Results**" chapter. Changes in these stages' patterns should also be possible to perceive. As an example, user #1 mentioned during the final interview that her partner became more interested in fresh products, which means that her transactions would have shifted towards more products without a barcode, as are generally fresh vegetables, or

could also be perceived in an increase of the items placed under fruits and vegetables category. While no such thing was noticed in the retrieved data, it can be argued that it's possible to perceive.

On the other hand, obtaining data for the storage and preparation and/or consumption stages other than that from the interviews proved to be difficult, if not unfeasible. A manual way was devised to identify the length of a product's storage: although the app did not have an automatic mechanism to track from which items the waste came from, the wasted items were traced back to purchased items empirically. This allowed for comparison between storage time and life span of product. Nonetheless, the manual tracing allows for plenty of error, as in the time periods in which no products were registered. Products missed during these times could provoke incorrect tracing and therefore faulty storage time data. App modifications in this regard, such as allowing users to choose from what product the waste came from (similar to the tag system in Harder's study), would permit proper calculation of storage times, comparison between these values and ideal storage times, and open the possibility for storage feedback directly related to the products in the user's stock i.e. telling the user that their milk could be soon to spoil. The latter would help with waste of fresh products, although not of that coming from cooked products, which can have a shorter time span for storage in the case of leftovers.

This brings us to obtaining data in the stages of preparation and consumption. When waste from a product is registered, in many cases it can be assumed that an instance of consumption has occurred. Adding the question of "Is this the last of product" when registering waste opened the possibility observing in the data which products have undergone full consumption and/or waste. Given that participants were instructed to record all their existent products upon beginning of the trial, it can be assumed that the products that were never marked as last of item were, either fully consumed without waste, or are still in stock. However, items which weren't registered as waste can't be tracked for consumption. This makes data lack in various cases, such as when an item is consumed fully without producing any waste. This concern was expressed by user #3 in the first interview, as he was unsure of how the application would differentiate between products that were wasted and products that were fully consumed. In any case, working to tackle the shortcomings of data collection would make it easier to calculate the product stock accurately thus obtaining more precise information of the consumption stage. While Harder's study allowed for registration of consumption within FoodWatch, the utility of such a function should be compared to the effort that it would require from the user to register every instance of preparation and consumption.

In the case of preparation happens the same as with consumption, such that no information of preparation is obtained other than that coming from transactions of waste. Processes as cooking can only be inferred from the type of product, as meat or rice, a transaction of waste and triangulation with the type of waste it has been classified as. Nonetheless, it is debatable whether such a detailed level of information is necessary for effective feedback design, which is ultimately the objective of this thesis.

Another way in which the metabolism cannot be perceived completely is that the only avoidable and possibly avoidable waste can be perceived, therefore the figures corresponding to non-avoidable waste are lost. These should ideally be part of the calculations in order to obtain the full picture of household metabolism. While this makes the application in its current state not entirely suitable for perceiving all food flows in the household, it is still necessary to ponder how necessary is this to implement any subsequent modifications in the application.

As for the knowledge, attitudes and socio-cultural pressure influencing the food-related habits, much of this was obtained from the interviews. Food literacy was perceived through the interviews as well. For example, food literacy in users could be gauged, as for Household #1 who expressed not feeling secure in her knowledge about preparation of food, about storage times, about spoilage signs, contrary

to Household #3 who felt a lot of confidence in these. This could, in a future, help customize the feedback to suit levels of knowledge, thus helping maintain interest of the user.

Attitudes, which as stated before are not necessarily congruent with actions, are perceived both through the interviews and the application. In the interviews, Household #1 mentioned that many of her food choices were based on what she had learnt that was healthy. The actions that span from this are possibly normative as defined by Strengers (2011), and probably unnegotiable in spite of receiving information that states otherwise. For Household #3, some of his food choices are motivated by environmental concern. These attitudes reflect in the data in areas as reasons for wasting and character of waste, e.g. Household #1 will waste more “half eaten foods” due to wrong storage or large package, while Household #3 wastes more foods that have reached point of spoilage, meaning he has waited until the last possible moment.

It is also possible, to some degree, to capture cultural differences in the data. Such is the case with Household #2, where one of the waste transactions was classified as “possibly avoidable” and “not tasty” corresponding to cabbage and mushrooms. It can be inferred that the user referred to certain parts of the vegetables that for her are not ideal for consumption, considering that the user remarked in an interview that some vegetable parts that were not accepted to eat in her culture.

5.4.1 Comparison of qualitative and quantitative results

Attempting to perceive household metabolism and its surrounding habits by obtaining qualitative and quantitative data allowed for comparison between the two types. This comparison revealed certain discrepancies between what was captured by use of the application and what was said in interviews. Some of the users’ perceptions did not correlate with actual habits or waste production despite stated interest in reducing amounts of waste. For example, Household #1 said in the last interview that she would not use the application outside the test trial because she feels that she is already careful enough about waste. Nonetheless, she wastes more than the other participants, rarely partakes in actions to prevent waste and rarely uses leftovers, as well as doesn’t eat anything after its marked “best-by” date. This means that the user perceives herself to be doing all possible within her values, but also indicates a lack of food literacy. It is expected that a lack of food literacy correlates with higher waste productions rates (Chenhall, 2011).

Also, it is said in the final interview that her partner continued checking levels of food and making shopping lists, none of which the participant adopted. The data does not support this, as the frequency and content of the shopping sessions does not indicate presence of the partner for all sessions in which a planning action was taken. This might mean that she is not aware of the frequency with which she partakes in these actions. This could also be explained by changes in the visiting pattern of her partner, but this was not mentioned during the last interview.

In the case of Household #2, in the interview the participants states that she felt that she produced less waste but the data shows otherwise in terms of weight and footprint. On the other hand, she did not come up with any thoughts about how the study influenced her, but it is stated that the user allowed the study to influence her by adopting tips, being encouraged to modify her storage practices and to try reducing her leftover and waste productions, as well as buying smaller packages to produce less waste. Both aspects can mean that she misjudged the impact the study had in her habits.

For Household #3, most of the data coincides with what was stated in the interviews, although there is no register that he checked his levels of food before any of the purchases, which he said in the interview was a strong habit. Purchases, in average, happened in a different frequency than that stated in the interviews. This might mean that the user had a busier schedule during the study, that there were many faults with registering, or that his perception about how often purchase happens was wrong. Nonetheless, the user did demonstrate carefulness in his habits from before purchase to the wasting moment, combined with high environmental awareness in the interviews. This supports that environmental concern is a strong predictor of environmentally friendly habits (Mobley et al., 2009).

Many of the points above could be attributed to confusion from the user, or errors in the data collection. On the other hand, these could support a disconnection between actions, perception and intention in the users, specially so in users #2 and #3; this confirming what is stated by Parizeau et al. (2015) and Quested et al. (2013). It could also point to Strengers's mentioned disconnection between the data provided and the perceived non-negotiability of the desired actions (2011), despite the expressed "effort" in reducing waste.

5.5 Use of disaggregated data for Eco-Feedback

A question that this research wished to broach is in what ways the data obtained by FoodWatch can be used to create interventions. The most remarkable about the data in FoodWatch compared to previous studies is its level of disaggregation at several stages, and the presence of some footprint information for most, if not all, products. Summarizing charts and advices based on user's actions were also presented, although not all users remained in the study long enough to receive them.

5.5.1 Displaying the footprint of transactions

Often consumers don't associate food consumption to climate change (Halloran et al., 2014), but see it more as a societal problem (Parizeau et al., 2015), and so using the environmental argument without first making the link between environment and the desired action tends to be ineffective (Quested et al., 2013). In this way, if wanting to use eco-feedback, a relation to the environmental argument must exist or must be created within the same app. Hunter et al. (2006) mentions anecdotal evidence that environmental footprint values shown through diary collection methods has the potential to raise awareness of consumers. A positive side of showing footprint values next to each item added to the transactions is that the user can immediately see how their consumption affects the environment. It can be argued that showing the footprint of each single transaction helps form the link of food to climate change, which is confirmed by users: In Household #1, interest was raised about the footprint and Household #2 found the environmental impact of foods unexpected. An advantage of FoodWatch, in comparison with other eco-feedback systems, is that the footprint is shown next to every item instead of shown as an aggregate result, which can point the user towards favorable behaviors e.g. reducing waste of a high emitter. Nonetheless, one must keep in mind that providing information will usually not be sufficient (Bernstad, 2014), which is why the advice interventions were used as a complement to footprint information.

A downside of the way in which the footprint was shown is that, although the impacts appeared immediately, they were only visible when the user accessed the inventory, which doesn't provide the immediacy recommended by the literature. A solution to this might be showing pop-up messages when a transaction carries a high footprint, therefore providing an injunctive norm message, as per Foster and Lawson (2013).

Th other type of intervention involving footprint values was the display of weekly values in a graph. This also appeared once the user accessed their transactions, which resulted in low visibility. It is recommended to place the graph in a more visible place or making it pop-up as well.

Also, the desired accuracy of footprint values must be pondered. For example, cooking and storage energy in the household are not included in the calculations, nor are origin or production method. Therefore, the resulting values for footprint should be discretionary. Similarly, some products do not have some of the footprint information in the database, which shows as a water and/or land footprint equal to 0. This means that their true footprint is not quantified. While it would be valuable to obtain accurate footprints in these two regards, it must be considered that the aims of the project limits to reduction of carbon footprint, not to exactly quantify it.

5.5.2 Advice interventions

During the study, it is seen that the disaggregation in waste data helps identify the aspects of households' consumption that could be targeted in interventions. For example, "Wrong storage" was the second main reason for waste in Household #1, while 40% of the advice received by Household one was of the "Storage type". While this was not based on any preconceived parameter, as the feedback type appeared randomly and only depending on food type, the data allows us to see whether the feedback targets the necessities of a given user, and could be used in future versions to adapt feedback to other parameters,

such as the ones present in “reason for waste”, or the most common characteristics of waste as displayed in Figures 19, 24 and 30. In Household #1, milk was the second product most bought per unit, while the participant pointed out that milk was one of her “problem” products in the interviews. Although few advices were shown to the user, two out of the five corresponded to Milk, being this the only product which received more than one advice. Similarly, for Household #2 eggs were the most bought item, and they were the item with most advices (some of which the user adopted). While it is evident that products that are most commonly used will have a greater probability to receive advice, this shows the advantage of having the advice linked to product registration: constant purchase can indicate frequent consumption or frequent waste.

Also, many of the advices received by the users were aimed at animal products, which are generally resource intensive. This brings forth the possibility of fine-tuning eco-feedback to aim at products with high footprint values.

As mentioned in the previous section, with a minor modification as allowing the user to point out from which purchase came the waste, the disaggregated data on storage times could allow for comparison between storage time and life span of product, and lead to more precise feedback related to storage times. The possibility of accessing expiration dates directly from the packaging or producing companies has been considered, although it could be counterproductive to follow those strictly, considering that products might still be edible after expiration time. This would benefit consumers as that in Household #1, who had “forgot about it” as one her main reasons for wasting food (see Figure 18).

The interruptions in data collection might have also limited the effect of the advices. This reinforces the importance of implementing reminders to use the application, or advices that pop-up independently of participants’ submission of transactions.

5.5.3 Adoption of new habits

Another thing to consider is how the feedback influenced user’s behaviors, following the project’s objective of “assessing the effectivity of the chosen strategies”.

When focusing on waste-inducing behaviors, Household #1 indicated that she participated in a planning behavior which she stated she didn’t usually do in the interviews, see session 60 in Table 2. In Household #2, the combination in which the planning actions occurred were highly variable, though appearing all throughout the study period. It is remarkable that while most sessions occurred after one or two planning behaviors, in the two final sessions the participant partook in all three planning behaviors (see Table 11). In the interview, the participant also expressed that she started buying smaller packages to produce less waste, started using baking implements, and became less strict with expiration dates. She felt the app influenced her wasting habits positively, causing her to avoid cooking and wasting more than necessary. This shows a modification of many of the user’s waste-inducing habits and confirms her intention of reducing her waste. For Household #3, no change was perceived in the participant’s waste-inducing habits, neither in the application data nor in the interviews. It should be considered whether this might be because of a low threshold for waste - he might be already doing everything in his power to prevent waste. In the case of user 3, it was difficult to isolate what actions could be targeted, as he was already partaking in several planning behaviors. The household wastes more due to spoilage, which means that waste is last resort. Combined with an edibility ratio of 0.72 this could mean the user throws a spoiled item in its entirety even if part of the product is still edible, which is a difficult thing to tackle due to health concerns.

Considering the disconnection between actions and perception previously mentioned, it is worth exploring how eco feedback can deal with that disconnect. Feedback did not depend on the users’ habits perceived through the application questionnaires, a possibility which could ultimately help reduce food waste more effectively. This leads to the question of whether a greater impact could be achieved if the feedback included a behavioral layer rather than just giving generic advices depending on the products that were registered. Some ideas that could integrate this with the current type of advice would be a retrofit option based on user habits, messages based on the content and frequency of transaction, such as indicating an ideal amount to purchase if waste of an item has been repeatedly registered before, or reminders to use a product based on previous instances of waste.

The idea that feedback should be adaptable is supported by Brynjarsdottir et al. (2012): their study identified that after an initial period of adjustment, the feedback tends to become uninteresting. This could explain the user's lack of participation towards the final stages. In response to this, Food Watch could also implement a series of "levels" for which the feedback messages change, or a button to indicate that the popping up advice has already been implemented into the user routine, or if they already knew this. Such a function would've been useful in the case of Household #2, who received the same advice several times (see Table 18). By creating a feedback loop the application maintains its relevance in the users' routine, immediacy and constancy being ideal for the efficacy customized feedback.

5.5.4 Changes in users' attitudes

As for the feedback's effect on user's knowledge and attitudes on diet and waste, Household #1 considered herself already aware of her waste. Nonetheless, she mentioned an increased curiosity because the inventory allowed her to see the transactions, instead of forgetting them. Household #2 didn't feel that she learned anything, although she said that she enjoyed receiving the tips. Household #3 did not feel that they learnt new things, or perceived any change otherwise during the experiment. Nonetheless, since all participant had some background in environmental studies and entered the study voluntarily, a degree of bias must be considered. For future studies, it is important to evaluate the effect on users that do not chose to participate because of their interest in the environment. In the case of Household #3, the lack of change could also be attributed to his high degree of food literacy, to the short time that he participated on the study, or to the fact that he did not receive any feedback.

The outside factors affecting food waste proved to be difficult to influence through the application; some of the barriers identified being helplessness about products sizes, impossibility to cook less while still preserving a good nutritional balance, worry about expiration dates and busy schedules affecting their planning, buying and consumption habits.

5.5.5 Interventions' effects in overall waste and footprint rates

Finally, the impact of the eco-feedback on the overall waste rates and footprint of households is examined. In Household #1, although there was a decline in rates of waste and footprint, it is hard to argue that the change was significant, due to the short duration of the second stage. It could also be argued that there was more "room for change", as the user was also the one producing the largest amounts of waste. Her larger amounts of waste could be influenced by several factors other than the displayed lack of food literacy, such as the fact that she has a larger refrigerator, meaning more space for purchases, or simply the fact that she managed to register more waste transactions than the other users.

Household #2 registered very few waste transactions, which makes it hard to stablish conclusions with statistical relevance, although more transactions per week were registered in the second phase. Therefore, her increase in waste mass and emissions despite behavioral changes must be taken with a pinch of salt. The increase could also indicate that she was busier during the study, which might have contrasted her efforts.

Nonetheless, several factors prevent us from reaching a conclusion on whether the impact of eco-feedback could be extrapolated to other cases: the time span of the second stage as well as the sample of participants were too small to assess how eco-feedback influenced the waste footprints, in addition to the large amount of user and application errors and abnormalities in data collection. Besides, the differences in involvement from users, e.g. Household #3 not receiving advice, makes it difficult to compare results. Another bias to consider is the fact that all users knew that the study pertained reduction of household waste, which could have influenced their actions from the beginning. More studies, addressing the weaknesses of the present, would be necessary to verify the hypothesis.

Furthermore, limitations of eco-feedback as a method should also be considered. Strengers (2011) presents how certain assumptions in eco-feedback can work against the goal of a project, such as that the householders interested in eco-feedback are able to change their consumption patterns. For example, many times users will ignore recommendations to avoid practices that they consider non-negotiable. However, while most articles focus on raising awareness (Brynjarsdottir et al., 2012), few articles have a delineated plan which bridges the providing information to turning the provided information into

behaviors changes. It could be argued that the present study's strategy of showing footprint information accompanied by behavior-targeting advices accomplishes this.

5.6 Co-creation

Comparing users and researchers' experience with the literature studied for the project generates many insights that attend to the study's final research question, "What other modifications could facilitate food-related footprint reduction?" While some of these ideas go outside the focus of our investigation, eco-feedback cannot be effective unless users feel comfortable using the application. The resulting suggestions can be considered for future work.

5.6.1 General

Below are presented some of the issues raised during the co-creation section of the interview.

Environmental message - In general, the application was received positively by the participants: Interest was raised about footprints, advices were well received and easily understood. The latter is especially important, as this reduces chance of the user not relating with the information that is given.

However, for various reasons none of the participants would use the application in its current state. It is a possibility that the users found the app engaging because all of them shared a background in environmental studies, given that the ability of a message to influence someone's behavior depends on whether the message is aligned with the user's previous knowledge and values (Bernstad, 2014). Household #2 suggests bridging this by including in the application some education for those who do not perceive the importance of waste prevention. Additionally, to tackle food waste across different segments of the population, several kinds of feedback could be tailored in the app e.g. – seeing waste amounts in terms of money, environment and/or calories. For example, saving money is one the highest motivators for preventing food waste (Quested et al., 2013). In these cases, feedback could be presented in the form of surpassed caloric intake, saved money in comparison to previous shopping sessions, etc. The feedback related to expenditures would benefit from cooperation with stakeholders to obtain information about prices.

Ease of use - The interface was found uncomfortable. Additionally, some users wished to see the effect of their food choices quantified. While this was available in the application, it is evident that some users did not access it. Although this could be because of the short involvement of users, improving the application's navigability is a must; independently of the fact that this does not form part of the scope of this project.

As the involvement of the user is limited to registering transactions, simplifying this process would be useful. Users suggested making the app mobile, enabling barcode reading through cellphone or tablet cameras instead of using the handheld reader, and registering waste through the purchase history instead of scanning the product again. The latter would benefit the study in more ways than making it user friendly: the tracking of items from purchase to waste would be automatic, and therefore the behaviors that surrounded the entire life span of a food would be easier to pinpoint. Other suggestions were a search button to simplify introduction of items, being able to "Refill" products that have been purchased before, allowing transactions to be edited, and having an option for "average waste" in the profile to select that if the amount coincided with the actual waste. The latter would also make the user easily aware of how their waste rate changes with time. Another option such as a "Do I have this at home" function, connected with the barcode scanning, would simplify access to transactions and prevent unnecessary purchases.

Database - All three participants expressed that there were several products they could not find in the database and were unable to add them. As mentioned before, it is necessary to expand the database, placing importance in including a diversity of products from different supermarkets and/or that are not produced in Sweden. This could be a challenging task, but the project could benefit from establishing bonds with stakeholders to obtain such information, such as different retailers. In the case of FoodWatch, collaboration could be established with ICA, the largest Nordic retailer, and Hemköp, both Swedish retailers. Loyalty programs could provide insights on shopping habits that facilitate study of consumption. It is not clear whether supermarkets would agree to provide purchase information, given that this could be perceived as a violation of privacy (Harder, 2013). Nonetheless, stakeholder

involvement would make it easier to unify messages that otherwise might seem contradictory to the users of the app, ensuring engagement of the public and facilitating their participation.

Social eco-feedback - Since food waste is not necessarily “visible”, it is generally not affected by social norms. Thus, it is also observed that FoodWatch could benefit from a social aspect. Household #2 mentioned that she shares food with neighbors as a mean to avoid food waste, an action that supports the idea behind another food waste reduction application, EUPHORIA (Lim et al., 2014a). Furthermore, the same user suggests the introduction of social media into FoodWatch, by allowing users to compare their waste, as is done in step-counting mobile applications. Some people are particularly influenced by the enforcement of social norms (Bernstad, 2014), and social media has been shown to have potential to encourage habit changes but hasn’t been investigated enough (Foster and Lawson, 2013), especially in the area of food waste reduction. In further versions, FoodWatch could be a vehicle for investigation of social media as an accessory for eco-feedback. Including a social media component in the app, as making weekly waste amount visible among friends, a top list, or being able to share how much impact was produced in a meal, could help reduce waste. Eco-feedback has a different effect on individuals than the one it has on groups (Steg et al., 2012), which according to Midden and Ham (2013) might also be culturally based. As participants came from different backgrounds, this is something to evaluate.

5.6.2 Summary of suggestions

A key aspect for the functioning of persuasive technology is the inclusion of users in the design process (Brynjarsdottir et al., 2012). Analysis of the results and discussion of prominent points, as well as suggestions by the participants, have brought up several ideas for development of the application. These could help form a better picture of consumption and waste, and therefore provide information for effective eco-feedback. Suggestions to improve the user experience, and thus help users be consistent in their use of the application, have also come up. Table 27 shows a summary of the suggestions that have been identified in the previous discussion sections.

Table 27 - Suggested changes to FoodWatch and justification for each

Modification	Issue improved
Expansion/clarification of the protocol	<ul style="list-style-type: none"> • Confusion over type of waste to register, i.e. avoidable, partially avoidable, unavoidable • Confusion over how to register certain types of meals, as cooked dishes
Revision of questionnaire for purchase and waste metadata	<ul style="list-style-type: none"> • Misunderstood questions, risk of contradictive data
Expansion of product database Possible cooperation with stakeholders, e.g. retailers	<ul style="list-style-type: none"> • Difficulty finding/adding products
Expansion of footprint database	<ul style="list-style-type: none"> • Accuracy of footprint values per household
Automatic linking of waste to a product that has been registered as a purchase	<ul style="list-style-type: none"> • Difficulty of registering waste of products with barcode due to disposal of the purchase packaged. • Difficulty tracking storage times, consumption values and behaviors along a product’s life span
“Refill” products i.e. registering a new product purchase through selecting a product that is already in the inventory	<ul style="list-style-type: none"> • Time spent looking for products if barcode not available • Registering transactions simplified

“Do I have this at home” button	<ul style="list-style-type: none"> • Purchase of unnecessary items • Registering transactions simplified • Increased visibility
“Average waste” button for registering of waste	<ul style="list-style-type: none"> • Registering transactions simplified • Increased visibility
Mobile registering of barcodes	<ul style="list-style-type: none"> • Registering transactions made easier • Shortcomings with barcode reader
Add options of standard dishes	<ul style="list-style-type: none"> • Confusion over how to register waste from dishes • Accuracy of footprint values per household
Reminders to use application Reminders to use products	<ul style="list-style-type: none"> • Increase user engagement • Waste due to forgotten items
Customize feedback for levels of knowledge, attitudes or advices already taken	<ul style="list-style-type: none"> • Increase user engagement
Add feedback with economy or health as a main argument Possible cooperation with stakeholders	<ul style="list-style-type: none"> • Increase user engagement
Feedback adapted to specific users’ habits - based on frequency of transactions - suggesting ideal portions based on past waste - customized depending on common planning behaviors and waste characteristics - based on storage times	<ul style="list-style-type: none"> • Increase user engagement
Social feedback: top charts, sharing waste values, shared challenges Possible cooperation with stakeholders, e.g. social media, consumer organizations	<ul style="list-style-type: none"> • Appeal to social motives • Increased visibility • Increase user engagement
Pop-up with high emitter transactions	<ul style="list-style-type: none"> • Immediacy of feedback
Improving visibility of sum-up footprint graph/ Pop-up with weekly graph	<ul style="list-style-type: none"> • Periodic feedback • Users missing feedback

6. Conclusions

In its modified version, FoodWatch can collect qualitative and qualitative information of any transaction that is registered. This opens the possibility of capturing all household food flows and food-related routines. Purchase and waste patterns, as well as the motivations behind and the effects of users’ choices, could potentially be identified as well. This level of disaggregation could be helpful to identify the suitable interventions for any given user. In comparison to similar applications, FoodWatch has the advantage that it includes food’s footprints, which could further enhance the feedback process.

Sufficient data was gathered to design an intervention strategy and to pinpoint the culprits of waste production in the households. FoodWatch was perceived by the participants as a good tool for research: The users who received feedback had a positive reaction towards it, and considered the footprint data to be interesting. Participants also noted a raise in their waste production awareness. Nonetheless, the key behaviors to prevent food waste were not generally adopted. While the trial encouraged some of the users to reduce their waste production, it is shown that users’ perception of

their waste production did not correlate with reality. Thus, there is no considerable proof that the feedback in the app helps reduce waste production or its environmental impact.

It must be noted, though, that various technical difficulties and interrupted participation hindered the data collection. This prevented the study from obtaining data in some of the household food management stages, and made it unfeasible to prove the hypothesis. Nonetheless, the study succeeded in creating a system that helps track the life span of a product, and was helpful to detect what improvements are necessary for further research.

Additionally, the aim and objectives of the study were achieved. All research questions but one were responded throughout the Literature Review, Results and Discussion chapters. To be able to respond the research question of “Can FoodWatch contribute to lowering household GHG emissions due to food waste?”, FoodWatch should become a platform that can gather data constantly and reliably. Several suggestions to achieve that, and to improve the eco-feedback reception, are presented. After such changes occur, it is proposed to conduct more trials under a more suitable experiment design, possibly with a larger and more diverse user sample.

7. References

2014. *One tonne life* [Online]. Vattenfall. Available: <https://corporate.vattenfall.com/sustainability/sustainable-consumption/solutions-for-sustainable-use-of-energy/one-tonne-life/> [Accessed 2014].
- A. BERNSTAD, J. L. C. J. 2011. A life cycle approach to the management of household food waste - A Swedish full-scale case study. *Waste Management*, 31, 1879-1896.
- ABRAHAMSE, W., STEG, L., VLEK, C. & ROTHENGATTER, T. 2005. A review of intervention studies aimed at household energy conservation. *Journal of Environmental Psychology*, 25, 273-291.
- ALCOTT, B. 2008. The sufficiency strategy: Would rich-world frugality lower environmental impact? *Ecological Economics*, 64, 770-786.
- ASCHEMANN-WITZEL, J., DE HOOGE, I., AMANI, P., BECH-LARSEN, T. & OOSTINDJER, M. 2015. Consumer-Related Food Waste: Causes and Potential for Action. *Sustainability*, 7, 6457-6477.
- BAKER, L. A., HARTZHEIM, P. M., HOBBIE, S. E., KING, J. Y. & NELSON, K. C. 2007. Effect of consumption choices on fluxes of carbon, nitrogen and phosphorus through households. *Urban Ecosystems*, 10, 97-117.
- BBC NEWS. 2016. Italy adopts new law to slash food waste. *BBC News*.
- BERETTA, C., STOESSEL, F., BAIER, U. & HELLWEG, S. 2013. Quantifying food losses and the potential for reduction in Switzerland. *Waste Management*, 33, 764-773.
- BERNSTAD, A. 2014. Household food waste separation behavior and the importance of convenience. *Waste Management*, 34, 1317-1323.
- BERNSTAD, A. & ANDERSSON, T. 2014. Food waste minimization from a life-cycle perspective. *Journal of Environmental Management*, 147, 219-226.
- BRITZ, W., DUDU, H. & FERRARI, E. 2014. Economy-wide Impacts of Food Waste Reduction: A General Equilibrium Approach. *EAAE 2014 Congress 'Agri-Food and Rural Innovations for Healthier Societies'*. Ljubljana, Slovenia.
- BROWN, T., HIPPS, N. A., EASTEAL, S., PARRY, A. & EVANS, J. A. 2014. Reducing domestic food waste by freezing at home. *International Journal of Refrigeration*, 40, 362-369.
- BRYNGELSSON, D., HEDENUS, F. & LARSSON, J. 2013. Scenarier för klimatpåverkan från matkonsumtionen 2050. Gothenburg: Chalmers University of Technology.
- BRYNJARSDOTTIR, H., HÅKANSSON, M., PIERCE, J., BAUMER, E., DISALVO, C. & SENGERS, P. Sustainably unpersuaded: how persuasion narrows our vision of sustainability. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 2012. ACM, 947-956.
- BULKELEY, H. & GREGSON, N. 2009. Crossing the threshold: municipal waste policy and household waste generation. *Environment and planning A*, 41, 929-945.
- BUZBY, J. C. 2014. Overview of Food Loss in the United States. *The Last Food Mile Conference: Food Loss and Food Waste in the U.S. Supply Chain*. Philadelphia.
- CARLSSON-KANYAMA, A. 1998. Climate change and dietary choices — how can emissions of greenhouse gases from food consumption be reduced? *Food Policy*, 23, 277-293.
- CHALMERS. 2014. *Smart Sustainable Districts - a Climate-KIC flagship* [Online]. Gothenburg: Chalmers University of Technology. Available: <https://www.chalmers.se/en/areas-of-advance/builtenvironment/news/Pages/Smart-Sustainable-Districts.aspx> [Accessed 2015].
- CHALMERS. 2015. *About HSB Living Lab* [Online]. Gothenburg: Chalmers University of Technology. Available: <https://www.chalmers.se/en/departments/cee/industry-society/HSB-Living-Lab/AboutHSBLivingLab/Pages/default.aspx> [Accessed 2016].
- CHENHALL, C. 2011. Improving Cooking and Food Preparation Skills: A Synthesis of the Evidence to Inform Program and Policy Development. Canada: Public Health Agency of Canada.
- CLEAR, A. K., HAZAS, M., MORLEY, J., FRIDAY, A. & BATES, O. 2013. Domestic food and sustainable design: a study of university student cooking and its impacts. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. Paris, France: ACM.

- COLEY, D., HOWARD, M. & WINTER, M. 2009. Local food, food miles and carbon emissions: A comparison of farm shop and mass distribution approaches. *Food Policy*, 34, 150-155.
- CONTENTO, I. 2010. Chapter 2 Overview of Determinants of Food Choice and Dietary Change: Implications for Nutrition Education. *Nutrition Education: Linking Research, Theory, and Practice*.
- DAHLÉN, L. & LAGERKVIST, A. 2008. Methods for household waste composition studies. *Waste Management*, 28, 1100-1112.
- DAHLÉN, L., VUKICEVIC, S., MEIJER, J.-E. & LAGERKVIST, A. 2007. Comparison of different collection systems for sorted household waste in Sweden. *Waste Management*, 27, 1298-1305.
- DEFRA 2008. Framework for pro-environmental behaviours. London Department for Environment, Food and Rural Affairs.
- DRUCKMAN, A. & JACKSON, T. 2010. The bare necessities: How much household carbon do we really need? *Ecological Economics*, 69, 1794-1804.
- EATBYDATE. 2013a. *Can you freeze milk?* [Online]. Available: <http://www.eatbydate.com/can-you-freeze-milk/> [Accessed 2014].
- EATBYDATE. 2013b. *How long does bread last?* [Online]. Available: <http://www.eatbydate.com/grains/baked-goods/bread-shelf-life-expiration-date/> [Accessed 2014].
- ELANDER, M., VIKLUND, L., SÖRME, L. & STENMARCK, Å. 2016. Matavfall i Sverige: Uppkomst och behandling 2014. Naturvårdsverket
- EPA. 2015. *Reducing Wasted Food At Home* [Online]. United States: United States Environmental Protection Agency (EPA). Available: <https://www.epa.gov/recycle/reducing-wasted-food-home> [Accessed 2015].
- EU COMMISSION 2008. Directive 2008/98/EC of the european parliament and of the council of 19 november 2008 on waste and repealing certain directives (waste framework directive).
- EUROPA, C. F. 2011. Das Wegwerfen von Lebensmitteln-Einstellungen und Verhaltensmuster. Ergebnisse Deutschland. *Save Food Studie*.
- FAO 2014. The State of Food Insecurity in the World. Strengthening the enabling environment for food security and nutrition. Rome: FAO
- IFAD
- WFP.
- FARR-WHARTON, G., FOTH, M. & CHOI, J. H.-J. 2012. Colour coding the fridge to reduce food waste. *Proceedings of the 24th Australian Computer-Human Interaction Conference*. Melbourne, Australia: ACM.
- FARR-WHARTON, G., FOTH, M. & CHOI, J. H.-J. EatChaFood: challenging technology design to slice food waste production. Proceedings of the 2013 ACM conference on Pervasive and ubiquitous computing adjunct publication, 2013. ACM, 559-562.
- FENG, F. 2012. *Towards Quantification of Purchases and Waste Generation at the Level of Individual Households*.
- FOGG, B. J. 2002. Persuasive technology: using computers to change what we think and do. *Ubiquity*, 2002, 5.
- FOSTER, D. & LAWSON, S. 2013. 'Liking' persuasion: case studies in social media for behaviour change.
- FROELICH, J., FINDLATER, L. & LANDAY, J. The design of eco-feedback technology. Proceedings of the SIGCHI conference on human factors in computing systems, 2010. ACM, 1999-2008.
- GANGLBAUER, E., FITZPATRICK, G. & COMBER, R. 2013. Negotiating food waste: Using a practice lens to inform design. *ACM Trans. Comput.-Hum. Interact.*, 20, 1-25.
- GANGLBAUER, E., FITZPATRICK, G. & MOLZER, G. 2012. Creating visibility: understanding the design space for food waste. *Proceedings of the 11th International Conference on Mobile and Ubiquitous Multimedia*. Ulm, Germany: ACM.

- GARNETT, T. 2008. Cooking up a storm: Food, greenhouse gas emissions and our changing climate (Summary). Centre for Environmental Strategy, University of Surrey.
- GARNETT, T. 2011. Where are the best opportunities for reducing greenhouse gas emissions in the food system (including the food chain)? *Food Policy*, 36, Supplement 1, S23-S32.
- GRAHAM-ROWE, E., JESSOP, D. C. & SPARKS, P. 2014. Identifying motivations and barriers to minimising household food waste. *Resources, Conservation and Recycling*, 84, 15-23.
- GRISKEVICIUS, V., CANTÚ, S. M. & VUGT, M. V. 2012. The evolutionary bases for sustainable behavior: Implications for marketing, policy, and social entrepreneurship. *Journal of Public Policy & Marketing*, 31, 115-128.
- GUINÉE, J., HEIJUNGS, R., DE KONING, A., VAN, L., GEERKEN, T., VAN HOLDERBEKE, M., VITO, B. J., EDER, P. & DELGADO, L. 2006. Environmental Impact of Products (EIPRO) Analysis of the life cycle environmental impacts related to the final consumption of the EU25. Brussels: European Commission, .
- GUSTAVSSON, J., CEDERBERG, C., SONESSON, U., VAN OTTERDIJK, R. & MEYBECK, A. 2011. Global food losses and food waste: Extent, causes and prevention. Rome: Food and Agriculture Organization of the United Nations (FAO)
- Swedish Institute for Food and Biotechnology (SIK).
- GÖTEBORG STAD. 2013. *Delmål – Minskade avfallsmängder och ökad resurshushållning* [Online]. Gothenburg: Göteborg Stad. Available: http://goteborg.se/wps/portal/start/miljo/goteborgs-tolv-miljomal/god-bebyggd-miljo/avfall!/ut/p/z1/04_Sj9CPykssy0xPLMnMz0vMAfIjo8ziAwy9Ai2cDB0N_N0t3Qw8Q7wD3Py8ffw9Hc31wwkpiAJKG-AAjgb6BbmhigD3y9Rp/dz/d5/L2dBISEvZ0FBIS9nQSEh/ [Accessed 2016].
- GÖTEBORGS STAD. 2013. *Kretslopp och vattens entreprenörer och utförare* [Online]. Available: http://goteborg.se/wps/portal/start/kommun-o-politik/kommunens-organisation/forvaltningar/forvaltningar/forvaltningen-kretslopp-och-vatten/kretslopp-och-vattens-entreprenorer-och-utforare!/ut/p/z1/04_Sj9CPykssy0xPLMnMz0vMAfIjo8ziTYzcDQy9TAy9LfwN3QwcTZ39vAKCTI1dDUz0wwkpiAJKG-AAjgb6BbmhigDFzOsk/dz/d5/L2dBISEvZ0FBIS9nQSEh/#htoc-2 [Accessed 2017].
- HALLORAN, A., CLEMENT, J., KORNUM, N., BUCATARIU, C. & MAGID, J. 2014. Addressing food waste reduction in Denmark. *Food Policy*, 49, 294-301.
- HARDER, R. 2013. Quantifying the Metabolism of Individual Households. *Department of Civil and Environmental Engineering*. Gothenburg, Sweden: CHALMERS UNIVERSITY OF TECHNOLOGY.
- HARDER, R., KALMYKOVA, Y., MORRISON, G. M., FENG, F., MANGOLD, M. & DAHLÉN, L. 2014. Quantification of Goods Purchases and Waste Generation at the Level of Individual Households. *Journal of Industrial Ecology*, 18, 227-241.
- HSB. 2015. *Följ oss på resan mot framtidens boende* [Online]. Gothenburg: HSB Living Lab. Available: <https://www.hsb.se/kampanjer/hsblivinglab/Om/> [Accessed 2016].
- HUNTER, C., CARMICHAEL, K. & PANGBOURNE, K. 2006. Household ecological footprinting using a new diary-based data-gathering approach. *Local Environment*, 11, 307-327.
- IMECHE 2013. Global Food: Waste not, want not. United Kingdom: Institution of Mechanical Engineers.
- KALNIKAITE, V., ROGERS, Y., BIRD, J., VILLAR, N., BACHOUR, K., PAYNE, S., TODD, P. M., SCHÖNING, J., KRÜGER, A. & KREITMAYER, S. How to nudge in Situ: designing lambent devices to deliver salient information in supermarkets. Proceedings of the 13th international conference on Ubiquitous computing, 2011. ACM, 11-20.
- KNUTSSON, J. 2016. Chapter 21: FoodWatch and food resource flows. In: KEYSON, D. V., GUERRA-SANTIN, O. & LOCKTON, D. (eds.) *Living Labs*.
- KOIVUPURO, H. K., HARTIKAINEN, H., SILVENNOINEN, K., KATAJAJUURI, J. M., HEIKINTALO, N., REINIKAINEN, A. & JALKANEN, L. 2012. Influence of socio-demographical, behavioural and attitudinal factors on the amount of avoidable food waste generated in Finnish households. *International Journal of Consumer Studies*, 36, 183-191.

- KUMMU, M., DE MOEL, H., PORKKA, M., SIEBERT, S., VARIS, O. & WARD, P. J. 2012. Lost food, wasted resources: Global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use. *Science of The Total Environment*, 438, 477-489.
- LANTMÄNNEN. 2015. *About Lantmännen* [Online]. Available: <https://lantmannen.com/en/about-lantmannen/> [Accessed June 2017].
- LEBERSORGER, S. & SCHNEIDER, F. 2011. Discussion on the methodology for determining food waste in household waste composition studies. *Waste Management*, 31, 1924-1933.
- LETTENMEIER, M., GÖBEL, C., LIEDTKE, C., ROHN, H. & TEITSCHIED, P. 2012. Material Footprint of a Sustainable Nutrition System in 2050-Need for Dynamic Innovations in Production, Consumption and Politics. *System dynamics and innovation in food networks*. Innsbruck-Igls, Austria.
- LIM, V., FUNK, M., RAUTERBERG, M., MARCENARO, L. & REGAZZONI, C. E-COmate: what's your non-consumption? International Work-Conference on Artificial Neural Networks, 2015. Springer, 486-499.
- LIM, V., YALVAC, F., FUNK, M., HU, J. & RAUTERBERG, M. Can we reduce waste and waist together through EUPHORIA? 2014 IEEE International Conference on Pervasive Computing and Communication Workshops, PERCOM WORKSHOPS 2014, 2014a. 382-387.
- LIM, V., YALVAÇ, F., FUNK, M. & MARCENARO, L. 2014b. Design Implications for a Community-based Social Recipe System. *WCST*.
- MACDIARMID, J., KYLE, J., HORGAN, G., LOE, J., FYFE, C., JOHNSTONE, A. & MCNEILL, G. 2011. Livewell: a balance of healthy and sustainable food choices. United Kingdom: World Wide Fund for Nature UK (WWF-UK).
- MANKOFF, J., HSIEH, G., HUNG, H. C., LEE, S. & NITAO, E. 2002. Using Low-Cost Sensing to Support Nutritional Awareness. In: BORRIELLO, G. & HOLMQUIST, L. E. (eds.) *UbiComp 2002: Ubiquitous Computing: 4th International Conference Göteborg, Sweden, September 29 – October 1, 2002 Proceedings*. Berlin, Heidelberg: Springer Berlin Heidelberg.
- MERRIAM, S. B. 2014. *Qualitative Research : A Guide to Design and Implementation*, Somerset, US, Jossey-Bass.
- MIDDEN, C. & HAM, J. 2013. Environmental Psychology; an introduction.
- MOBLEY, C., VAGIAS, W. M. & DEWARD, S. L. 2009. Exploring additional determinants of environmentally responsible behavior: The influence of environmental literature and environmental attitudes. *Environment and Behavior*.
- MOLL, H. C., NOORMAN, K. J., KOK, R., ENGSTRÖM, R., TRONE-HOLST, H. & CLARK, C. 2005. Pursuing More Sustainable Consumption by Analyzing Household Metabolism in European Countries and Cities. *Journal of Industrial Ecology*.
- MONIER, V., MUDGAL, S., ESCALON, V., O'CONNOR, C., ANDERSON, G., MONToux, H., REISINGER, H., DOLLEY, P., OGLIVIE, S. & MORTON, G. 2011. Preparatory study on food waste across EU 27. *Technical Report (2010-054)*. European Comission.
- NILSSON, A., BERGSTAD, C. J., THUVANDER, L., ANDERSSON, D., ANDERSSON, K. & MEILING, P. 2014. Effects of continuous feedback on households' electricity consumption: Potentials and barriers. *Applied Energy*, 122, 17-23.
- NOMURA, H., JOHN, P. C. & COTTERILL, S. 2011. The use of feedback to enhance environmental outcomes: a randomised controlled trial of a food waste scheme. *Local Environment*, 16, 637-653.
- NOORMAN, K. J. & SCHOOT UITERKAMP, T. 1998. Diagnosing and evaluating household metabolism. *Green Households? Domestic Consumers, Environment, and Sustainability*.
- PARFITT, J., BARTHEL, M. & MACNAUGHTON, S. 2010. Food waste within food supply chains: quantification and potential for change to 2050. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, 365, 3065-3081.
- PARIZEAU, K., VON MASSOW, M. & MARTIN, R. 2015. Household-level dynamics of food waste production and related beliefs, attitudes, and behaviours in Guelph, Ontario. *Waste Management*, 35, 207-217.
- PRÁŠILOVÁ, M., PROCHÁZKOVÁ, R. & VARVAŽOVSKÁ, P. 2015. Pro-environmental behaviour of households in the Czech Republic. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 63, 607-616.

- QUESTED, T. & JOHNSON, H. 2009. Household Food and Drink Waste in the UK. Banbury: Waste and Resources Action Programme (WRAP).
- QUESTED, T. E., MARSH, E., STUNELL, D. & PARRY, A. D. 2013. Spaghetti soup: The complex world of food waste behaviours. *Resources, Conservation and Recycling*, 79, 43-51.
- QUESTED, T. E., PARRY, A., EASTEAL, S. & SWANNELL, R. 2011. Food and drink waste from households in the UK. *Nutrition Bulletin*, 36, 460-467.
- REAY, D. 2005. *Climate change begins at home: life on the two-way street of global warming*, Macmillan.
- ROUILLARD, J. The Pervasive Fridge. A smart computer system against uneaten food loss. Seventh International Conference on Systems (ICONS2012), 2012. pp. 135-140.
- SAVE FOOD INITIATIVE. 2016. *Save Food Initiative: Our mission and objectives* [Online]. Available: http://www.save-food.org/cipp/md_ip/custom/pub/content,oid,47046/lang,2/ticket,g_u_e_s_t/~ /About.html [Accessed 2016].
- SCHMIDT RIVERA, X. C., ESPINOZA ORIAS, N. & AZAPAGIC, A. 2014. Life cycle environmental impacts of convenience food: Comparison of ready and home-made meals. *Journal of Cleaner Production*, 73, 294-309.
- SCHNEIDER, F. 2008. Wasting food—an insistent behaviour. *Proc. Waste: The Social Context*, 8.
- SCHNEIDER, F. & LEBERSORGER, S. Barriers for the implementation of prevention measures concerning food waste. Proceedings of the 3rd International Conference on Waste—The Social Context: People, Policies, Persuasion and Payoffs, Edmonton, AB, Canada, 2011. 8-11.
- SCHNEIDER, F. & OBERSTEINER, G. 2007. Food waste in residual waste of households—regional and socioeconomic differences.
- SCHULTZ, P. W. 2001. The structure of environmental concern: Concern for self, other people, and the biosphere. *Journal of environmental psychology*, 21, 327-339.
- SHAREYOURMEAL. 2012. Available: <https://www.shareyourmeal.net/> [Accessed 2016].
- SHIRAISHI, M., WASHIO, Y., TAKAYAMA, C., LEHDONVIRTA, V., KIMURA, H. & NAKAJIMA, T. Using individual, social and economic persuasion techniques to reduce CO₂ emissions in a family setting. Proceedings of the 4th International Conference on Persuasive Technology, 2009. ACM, 13.
- SONESSON, U., ANTESON, F., DAVIS, J. & SJODEN, P. O. 2005. Home transport and wastage: environmentally relevant household activities in the life cycle of food. *Ambio*, 34, 371-5.
- STEG, L., VAN DEN BERG, A. E. & DE GROOT, J. I. 2012. *Environmental psychology: An introduction*, John Wiley & Sons.
- STEPTOE, A., POLLARD, T. M. & WARDLE, J. 1995. Development of a measure of the motives underlying the selection of food: the food choice questionnaire. *Appetite*, 25, 267-284.
- STOP SPILD AF MAD. 2015. *In English - Stop Spild Af Mad/Stop Wasting Food* [Online]. Available: <http://www.stopspildafmad.dk/inenglish.html> [Accessed].
- STRENGERS, Y. Challenging comfort & cleanliness norms through interactive in-home feedback systems. Proceedings of Green Pervasive Workshop at Pervasive Persuasive, 2008.
- STRENGERS, Y. A. Designing eco-feedback systems for everyday life. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 2011. ACM, 2135-2144.
- THIEME, A., COMBER, R., MIEBACH, J., WEEDEN, J., KRAEMER, N., LAWSON, S. & OLIVIER, P. 2012. "We've bin watching you": designing for reflection and social persuasion to promote sustainable lifestyles. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. Austin, Texas, USA: ACM.
- THINK.EAT.SAVE. 2014a. *Top Tips on Reducing Food Waste* [Online]. UNEP, FAO and Messe Düsseldorf. Available: <http://www.thinkeatsave.org/index.php/top-tips-on-reducing-food-waste> [Accessed].
- THINK.EAT.SAVE. 2014b. *A-Z of Food Saving Tips* [Online]. UNEP, FAO and Messe Düsseldorf. Available: <http://www.thinkeatsave.org/index.php/top-tips-on-reducing-food-waste/14-food-waste-campaign/356-a-z-of-food-saving-tips> [Accessed].
- THÖNISSEN, R. 2010. Fact Sheet: Food Waste in the Netherlands *In: MINISTRY OF AGRICULTURE, N. A. F. Q. (ed.). Netherlands*.

- TUE. 2013. New Plastic Electronics Can Greatly Reduce Food Waste Worldwide. Available: <https://www.tue.nl/en/university/news-and-press/news/27-02-2013-new-plastic-electronics-can-greatly-reduce-food-waste-worldwide/#top>.
- USDA. 2015. *Food Product Dating* [Online]. United States: United States Department of Agriculture: Food Safety and Inspection Service. Available: <http://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/food-labeling/food-product-dating/food-product-dating> [Accessed 2015].
- VERMEULEN, S. J., CAMPBELL, B. M. & INGRAM, J. S. 2012. Climate change and food systems. *Annual Review of Environment and Resources*, 37.
- WILLSHER, K. 2015. Man who forced French supermarkets to donate food wants to take law global. *The Guardian* [Online]. Available: <https://www.theguardian.com/world/2015/may/25/french-supermarkets-donate-food-waste-global-law-campaign> [Accessed 30 May 2015].
- WOOD, G. & NEWBOROUGH, M. 2003. Dynamic energy-consumption indicators for domestic appliances: environment, behaviour and design. *Energy and Buildings*, 35, 821-841.
- WRAP. *Download our Love Food Hate Waste app - for free* [Online]. United Kingdom: Waste and Resources Action Programme (WRAP). Available: <http://www.lovefoodhatewaste.com/content/download-our-love-food-hate-waste-app-free> [Accessed 2016].
- WRAP. *Love Food Hate Waste: About us* [Online]. United Kingdom: Waste and Resources Action Programme (WRAP). Available: <http://www.lovefoodhatewaste.com/content/about-us-2> [Accessed 2016].
- WWW.STOPFOODWASTE.IE. 2013a. *Know your dates* [Online]. EPA National Waste Prevention Programme (NWPP). Available: <http://www.stopfoodwaste.ie/food-we-eat/best-before-use-by/> [Accessed].
- WWW.STOPFOODWASTE.IE. 2013b. *Meal plans for easier living* [Online]. EPA National Waste Prevention Programme (NWPP). Available: <http://www.stopfoodwaste.ie/food-we-buy/planning/> [Accessed 2015].
- WWW.STOPFOODWASTE.IE. 2013c. *Storage – the good, the bad and the ugly* [Online]. EPA National Waste Prevention Programme (NWPP). Available: <http://www.stopfoodwaste.ie/food-we-buy/storage-the-good-the-bad-and-the-ugly/> [Accessed].
- WWW.STOPFOODWASTE.IE. 2013d. *Your friends – the fridge and freezer* [Online]. EPA National Waste Prevention Programme (NWPP). Available: <http://www.stopfoodwaste.ie/food-we-eat/fridge-and-freezer-management/> [Accessed 2015].
- XIE, L., YIN, Y., LU, X., SHENG, B. & LU, S. 2013. iFridge: an intelligent fridge for food management based on RFID technology. *Proceedings of the 2013 ACM conference on Pervasive and ubiquitous computing adjunct publication*. Zurich, Switzerland: ACM.
- YIANNAS, F. 2016. New Initiatives Taking a Bite out of Food Waste. *Walmart Today*. United States.

8. Appendixes

Appendix 1 - Feedback messages implemented in app:

The following is a complete list of the advice that was provided as a form of feedback when users introduced certain food groups within their transactions.

ID	Product Type	Feedback type	Language	Content	Reference
1	Beef	Neutral	Swedish	Mycket av det nötkött som säljs har ett stort ekologiskt fotavtryck, därför kan det vara bra att äta det lite mer sällan och kanske välja kyckling eller fläskkött istället!	
3	Chicken	Diet	English	Chicken is a good climate substitute for beef and lamb.	
4	Chicken	Waste	English	Did you know that you can make a nice soup from chicken bones! See here...	
5	Beef	Diet	English	Did you know that beef have five times higher climate impact than chicken? Exchanging beef for pork or chicken have a great impact.	
6	Milk	Waste	English	If your milk is nearing its expiration date, try freezing it! Frozen milk is safe for 3-6 months and is best used for cooking.	(EatByDate, 2013a)
7	-	Diet	English	Planning your meals before shopping is fun and will help you reduce waste.	(Parizeau et al., 2015) (Quested et al., 2013, Lettenmeier et al., 2012, www.stopfoodwaste.ie, 2013b, Think.Eat.Save, 2014a, EPA, 2015)
8	Eggs	Storage	English	To preserve eggs and butter, it is best to keep them in lidded compartments inside the fridge.	(www.stopfoodwaste.ie, 2013d)
9	Butter	Storage	English	To preserve eggs and butter, it is best to keep them in lidded	(www.stopfoodwaste.ie, 2013d)

				compartments inside the fridge.	
10	Fresh bread	Storage	English	Fresh bread can be kept in the freezer to extend its shelf life! It is safe to keep for up to 6 months.	(www.stopfoodwaste.ie , 2013c, EatByDate, 2013b)
11	Potato	Storage	English	Keep your potatoes in a dark dry place, making sure they're away from onions! Proximity to onions will make them develop sprouts faster.	(Think.Eat.Save, 2014b)
12	Potato	General	English	Using a potato peeler instead of a knife will help you cut down on waste. You can later oven-bake the peels to make a snack!	(Think.Eat.Save, 2014b)
13	Mushroom	Storage	English	To preserve mushrooms for longer, keep them in a paper bag inside the fridge!	(Think.Eat.Save, 2014b)
14	Yoghurt	Waste	English	If your yogurt is nearing its expiration date, you can add it to smoothies or freeze it to be eaten as ice cream.	(Think.Eat.Save, 2014b)
15	Banana	Storage	English	Store bananas away from other fruit! They will make them ripen faster.	(www.stopfoodwaste.ie , 2013c)
16	Potato	Waste	English	If a potato has sprouts, it can still be eaten! Just cut away the sprouts and eat the rest.	(Think.Eat.Save, 2014b)
17	Milk	Storage	English	"Use by" dates mean that the food shouldn't be eaten after this date unless it has been frozen. "Best before" dates, on the other hand, indicate that the food is to optimal quality until this date. It may lose texture or flavor, but it is still safe to eat!	(www.stopfoodwaste.ie , 2013a, USDA, 2015)
18	Beef	Storage	English	"Use by" dates mean that the food shouldn't be eaten after this date unless it has been frozen. "Best before" dates, on the other hand, indicate that the food is to optimal quality until this date. It may lose texture or	(www.stopfoodwaste.ie , 2013a, USDA, 2015)

				flavor, but it is still safe to eat!	
19	Fresh flat fish	Storage	English	"Use by" dates mean that the food shouldn't be eaten after this date unless it has been frozen. "Best before" dates, on the other hand, indicate that the food is to optimal quality until this date. It may lose texture or flavor, but it is still safe to eat!	(www.stopfoodwaste.ie , 2013a, USDA, 2015)
20	Chicken	Storage	English	"Use by" dates mean that the food shouldn't be eaten after this date unless it has been frozen. "Best before" dates, on the other hand, indicate that the food is to optimal quality until this date. It may lose texture or flavor, but it is still safe to eat!	(www.stopfoodwaste.ie , 2013a, USDA, 2015)
21	Eggs	Storage	English	Store eggs in the fridge with the pointy tip down. This way eggs can safely be kept for 2-3 months.	
22	Butter	Waste	English	Leftover butter? Try place it in the freezer where it can be safely stored for months, if not years!	
23	Beef	Waste	English	Got some leftover beef? Freeze any meat left over to use at a later date in a tasty curry.	
24	Lentils	Waste	English	Store in cool, dry area. After opening, store the dried lentils in an airtight container or place original package in a re-sealable plastic bag. Storage time shown is for best quality only — after that, the beans' texture, color or flavor may change, but in most cases, they will still be safe to consume if they have been stored properly.	

25	Chicken	Diet	English	Replacing beef and lamb with chicken and egg greatly reduce the CO ₂ -footprint of your food consumption	
26	Milk	Diet	English	Did you know dairy based Milk can be replaced by soy based Milk, which has a much lower environmental footprint?	
27	Eggs	Waste	English	Eggs can safely be kept in the fridge for 2-3 months. Use eggs for tasty omelets before they are spoiled.	
28	Hard cheese	Waste	English	Cheese that has dried up and which is not so tasty can be grated and stored in a bag in the freezer for later use as topping, e.g. on a pizza.	
29	Hard cheese	Diet	English	Replacing dairy based cheese with soy based alternatives will reduce CO ₂ -footprint significantly.	

Appendix 2 - Participant protocol:

Below are shown the instructions that were handed in physical form to each participant at the beginning of the study. After giving them the printed protocol, some minutes were given for the participants to read it and clarify any doubts. Said instructions were also presented verbally, alongside practical examples on the tablet.

Hej [User name]!

For the duration of the study, you receive:

1 tablet + charger, 1 barcode lector, 1 kitchen scale

Information you need:

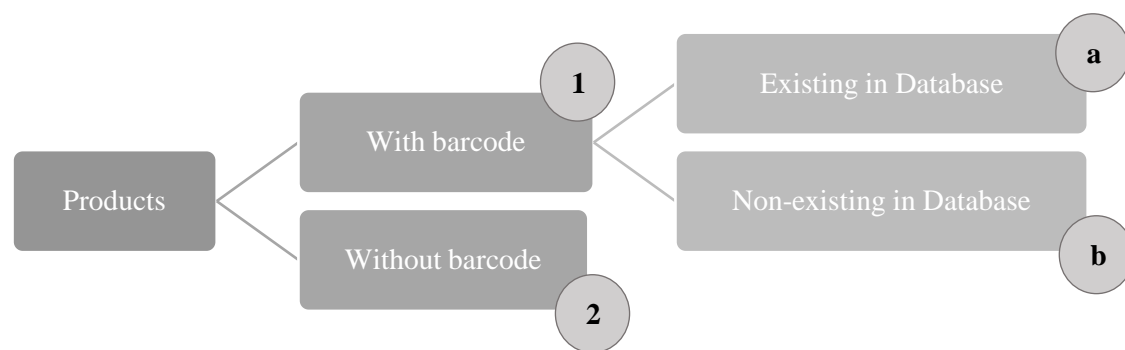
Website: www.food-watch.se

Username:

Password:

Tablet SIM pin:

What's the procedure?



To add products:

1. Click on "Add". Important!

For case 1:

2. Click on the text bar
3. Point barcode lector towards product's barcode. Click on barcode lector's button. You should hear a beep.
4. In case **1a**, code will appear briefly on text bar. *Be patient! Sometimes it takes a while for code to appear on screen.*

5. A few questions will appear. Answer them and press submit. This will start a “shopping session” along with the products you introduce during the next 30 min.
6. Two messages saying “The session survey was successfully saved” and “Product was added to inventory” will appear.
7. Continue to introduce remaining products.
8. In case **1b**, a message saying “Unknown product” will appear. Press “Tap to enter into database”
9. Start writing what kind of product it is. Select desired product from drop down menu. Proceed.
10. Introduce weight, unit, and image if you’d like. *It is always nice if you help us expand the database!* Submit.
11. Continue to introduce remaining products.

For case **2**:

2. Click on “Add product without a barcode?”
3. Select one of the predetermined products, or select from the list. Press Next.
4. Select amount and unit. Submit.
5. Continue to introduce remaining products.

To remove products:

1. Click on "Remove"


For case **1**:

2. Follow steps 2-4 as in Add product.
3. A question about avoidable waste will appear. Select percentage of entire product that you think was wasted.
4. Answer questions that will appear next. Submit.
5. Continue to remove remaining products



For case **2**:

2. Follow steps 2-4 as in Add product.
3. Answer questions that will appear next. Submit.
4. Continue to remove remaining products.

To see inventory:

Press  on top bar. This will take you to your transactions. If you want to see your shopping sessions, press “View shopping sessions”.

If barcode scanner refuses to work:

- a) Wait a few seconds. Sometimes it takes a while for the code to register.
- b) Go to Settings -> Bluetooth. Check that there is a paired device (*Something named CT+numbers*). Press in the  symbol to the right of the paired device. Check that the box to the right of “Input Device” has a green check mark . If it does not, check it.
- c) Contact me ASAP

Some guidelines:

Household consumption will cover foods that enter the household **after purchase in the supermarket**. These foods will be considered within the household system even if they are consumed and/or wasted outside. For example, an apple that is taken home from the supermarket, and is then taken as a snack to work, will still be part of the system. In this case, please try to measure the waste and log it in!

Under the same criteria, foods that enter the household as **leftovers from restaurants will not be considered** within the study.

Ready-to-eat frozen meals will not be considered in the study. However, **frozen pizzas can be logged in**.

Salt, sugar, dried herbs, spices and powder sauces will be omitted in the study.

Oils and fats used in cooking **will also be excluded**.

Prepared meals that contain several ingredients mixed, as in curries, or soups, might be difficult to quantify. In order to register waste of these kinds of meals, **you can provide a rough estimate of the main ingredients** based on their percentage in the dish.

Is my waste avoidable, possibly avoidable or unavoidable?

Avoidable waste refers to food and drink thrown away because they are no longer wanted, e.g. because they spoiled or exceeded their date of expiry. Avoidable waste is food that at some point was edible.

Possibly avoidable waste, refers to food and drink that some people eat and others do not (e.g. apple peels), or that can be eaten when prepared in one way but not in another (e.g. potato or pumpkin skins).

Unavoidable waste comes from food and drink preparation. It is not edible under normal circumstances. This includes apple cores, banana skin, tea leaves, coffee grounds, bones, egg shells, etc. *You are not required to log in Unavoidable waste.*

To contact me:

Facebook: Divia Jimenez
[email address]
[phone number]

Eternal thanks for your cooperation!!

Appendix 3 - First questionnaire to participants:

Below is presented the model for the first interview performed to the study participants.

General:

- Age
- Provide a rough description of your daily routine.
- How many people live in your household?
- Is food shared? (If applicable)
- Do you have any food preferences/sensitivities?
- What are your meat/dairy consumption habits?
- What drives your food choices?
 - Local
 - Flavor
 - Culture
 - Price
 - Sustainability
 - Convenience

Planning:

- Do you check what you have in the fridge/cupboard before purchasing?
- Do you make shopping lists?
- Do you plan meals? Why/why not?
- Do you feel you have enough time to plan it?
- Is it planned together? (If applicable)

Shopping:

- How often do you shop?
- Is it regular or improvised, what does it depend on?
- Distance to supermarkets
- Is shopping made together? (If applicable)
- Do you buy in bulk?
- Do you buy in discount?
- Do you buy ready to eat meals?
- Do you check best buy dates when shopping?
- Do you find that the sizes of food packages are appropriate for your needs?
- How much do you usually spend?

Storage:

- How do you store (be detailed)?
 - Meat
 - Cheese
 - Fruits
 - Vegetables
 - Bread
- Are you aware of guidelines for proper storage of foods?

- Do you have enough space in fridge to store all you want to?
- Does the shape of your fridge allow you to see all foods inside?
- Has something ever spoiled because you did not see it?
- Do you use the freezer to extend shelf life of food? When/why?
 - Freshly bought food
 - Leftovers
 - Bulk cooking
 - Frozen food

Preparation and consumption:

- Do you use specific portions to cook rice/pasta/others?
- Do you possess/use measuring implements?
- How often do you cook? In bulk? Using recipes?
- Do you usually have leftovers?
- What do you do with them? Store/throw away? Why?

Wasting:

- How do you use date-labels on food?
- Has the package size of a product influenced your waste?
- Has buying in discount influenced your waste?
- How do ready to eat meals influence your waste?
- What do you more often waste?
- Why do you usually throw away food?
- Is there waste that you feel you can prevent?
- What kind of waste do you feel you cannot prevent? Why?
- What would prevent you from wasting food? What tools would help you waste less?
- Are there moments where you waste more/less?
- At what stage do you waste more? (Unopened, preparation, cooking, storing, spoilage etc.)
- How do you feel about wasting food?
- How do these influence your waste?
 - Food system
 - Culture
 - Economy
 - Social factors
 - Family's lifestyle
 - Emotional state
 - Health concerns
- Do you separate food waste? Why, why not? What do you do with it?
- Does food waste sorting influence your attitude towards producing waste?

Environmental attitudes:

- To you, what is sustainable food consumption?
- How much do you know about GHG emissions related to food?
- Do you attempt to consume sustainably? Why/why not?
- Is it important to you?
- Do you know benefits of reducing food waste?

Appendix 4 - Final questionnaire to participants:

Below is presented the model for the final interview performed to the study participants.

General:

- Did any of the initial status change?
Routine, household, distance to supermarket, sharing food with other people ...
- Did you develop any changes in your eating habits? Why?
What is eaten, frequency...

Planning:

- Did you start/continue/stopped checking the fridge and cupboard before shopping? Why?
- Did you start/continue/stopped making a shopping list? Why?
- Did you start/continue/stopped planning your meals? Why?

Shopping:

- Did any buying habits change? Why?
Frequency of shopping, buying in bulk, buying in discount, ready to eat meals, size of packages
- Did your food budget change in any way? How?

Storage:

- Did your way of storing the food change? Why?

Preparation and consumption:

- Did you start/continue/stopped using measuring implements? Why?
- Did you start/continue/stopped using recipes? Why?
- Did the amount of leftovers you produce change?
- Did you start/continue/stop using leftovers? Why?

Wasting/attitude towards wasting:

- Did your use of use-by/expiration dates in labels change? Why?
- Did you perceive a change in the amount or composition of preventable waste? Why?
- Did you find things spoiled sooner or slower?
- Did you perceive a change in your most usual reason for wasting food? How so?
- Did you perceive a change in the stage at which you waste more? How/why?
- (Opened, unopened, cooked, etc.)
- Has your attitude in regards to food waste changed in any way?
- Did your recycling/ waste sorting situation change in any way? How/why?
Recycling system, distance to stations, etc.
- Did you notice any change in your garbage sorting habits? How and/or why?

Environmental attitudes:

- Have you learnt anything about impact of waste from the study?
- Has the study influenced your perception about waste in regards to environment?
- Would you estimate this change it to be long-standing? (If applicable)

Equipment used during study:

- Were there any problems with barcode reader?
- Were there any problems while using the scale?

Study design and app use:

- Was anything in the study protocol confusing?
- Were there any problems while using the app?
- Did you find the questions in the app relevant?
- How did you find the ratio between registering foods with and without barcode? Did you perceive any change in any of these categories?
- Was it common for you to buy products that weren't in the database? Did you add them to database? (Expand on which supermarket depending on answer)
- Was it easy to identify whether the waste was avoidable or not?
- Were there any foods that were hard to register or didn't register at all?
- How did you perceive the accuracy of your estimated percentages of waste?
Somewhat accurate, not very sure about it, etc...
- Would you use the app in daily life?

Feedback functions:

- Did you use any of the food tips suggested in the app?
- Did you start incurring in any of the recommended behaviors during study?
- Did you check your inventory? Did you do anything with the information on the inventory?
- Did you check the environmental impact of your waste? Did it cause any reaction on you?

Suggestions:

- Is there anything that could be added to the app that could help you waste less?
- What changes would you recommend in the app?

Final thoughts:

- Did the study impact your buying/consuming/wasting habits in any way that was unexpected for you?

Appendix 5 - Participant interviews transcripts:

Below are presented the transcriptions for each interview in their entirety. All interviews have been edited for clarity. The transcriptions subscribe to the following code:

Bolded- Standard questions

***** - Additional questions

[Brackets] – Clarification

“-“ – Non applicable

Initial interview – Participant #1

General:

Age

I was born in 1982 [33].

Provide a rough description of your daily routine:

Wake up, every second I take a shower, breakfast, get ready for work, go to work, come back from work, eat my dinner and watch some TV program and then go to sleep.

How many people live in household?

I share my apartment every second week, I'd say. Half a month I'm sharing the apartment with my boyfriend. I am living there the whole month, and he comes to visit every two weeks because he works offshore for two weeks, that's why.

Is food shared?

We buy together, and when he's not here and I'm at school every single day I eat at school, and I have light dinner at home all 14 days. It's so simple, my program is so simple. I don't cook anything, I can say it like this, just light dinner and when he's here for two weeks we share food and we cook at home. Maybe 2 times per week we go out, otherwise we cook at home.

Do you have any food preferences/sensitivities?

No, but we don't put oil at all, and not salt at all.

***Why?**

I don't know, maybe he thinks he will get a heart attack. No, really, he puts little fat in and uses some salt that is inside of the... [food] like in bacon, that is very salty; or some food taster, the little thing, bouillon, that has salt in it.

***And you?**

For me, for dinner I eat yogurt with some different things, some walnuts... You know, you have different mixes like havregryn [oatmeal] or something like that... it's prepared and the store can have it and you can put it on yogurt, you can put it in some milk or something like that.

***Is that cooked or something that already comes prepared?**

It's kind of prepared but it depends on what kind of havregryn [oatmeal] you have. You can put it in milk or in water and put it in the microwave and it's ready.

***So you're generally having that for dinner**

Yes

***Do you eat breakfast?**

Yes, I eat breakfast. It's so important for me. For breakfast, I drink milk and eat toasted bread with butter and jam, or butter and honey. It's routine breakfast; I have to eat some breakfast.

***So you're generally not cooking much**

No, actually, I don't cook. I'm not good at cooking. I like it but it's not my [preference]... Many times, I've tried it but it's not good, it's just disappointing. But I bake cakes. Every week I have to bake one cake, yesterday I baked a carrot cake.

What are your meat/dairy consumption habits?

***So you seem to consume a lot of dairy, do you eat meat a lot?**

Yeah, when he is here we eat a lot of meat.

***Okay, so he's cooking the meat.**

Yes, fish and meat, so much. Not chicken.

***And are you eating more cheese when he's here?**

No, not nowadays. Before yes, he was making pizza so much, and so much cheese but not lately.

What drives your food choices?

- Local
- Flavor
- Culture
- Price
- Sustainability
- Convenience

I don't know... Honey, I like to have honey, from the beginning I saw it kind of good to have it. It gives energy and is sweet; I like sweet so that's why. And milk, I think it's good. From the childhood they teach us it's good, so that's why.

***And the havregryn?**

That I think because of health, because in kindergarten they give it to the children and they grow up very fast, so I think that's health. And that's why I choose it, easy and good to eat it.

Planning:

Do you check what you have in the fridge/cupboard before purchasing?

Not actually.

Do you make shopping lists?

Yes, when I want to go because I forget everything, so I put in the Lidl or Hemköp site and I see what I want to shop.

Do you plan meals? Why/why not?

(Usually has the same for dinner and breakfast)

***When your boyfriend is here, do you plan the meals before?**

Um no, actually, he just decides.

Do you feel you have enough time to plan it?

No, actually it's a big problem. It's a really good question because always, when I'm at school I just want to go home and eat the food, and then just maybe half an hour before, I know when I and the group mates are finishing here, and if they're OK to leave earlier or you know... You cannot plan for everybody; you should see how it works. And then half an hour before I go home, because it takes almost 20 min to go home, I just send a message, "I'm coming home, I'm so hungry, I need the food" so we cannot decide which kind of food you want, maybe he already began with some food. That's why I cannot say, I cannot plan for it.

Shopping:**How often do you shop?**

It depends, whenever he comes, first we go to the supermarket and shop a lot, for maybe ten days, because we have two refrigerators so we can store it, and after he's gone I go to the supermarket when I need to, maybe every second day but I don't shop a lot.

Is it regular or improvised, what does it depend on?

[Answered in previous questions]

Distance to supermarkets

[Shops at Hemköp in Frölunda Torg, 5 min walk from her apartment]. Also sometimes in Lidl.

Is shopping made together?

[Answered in previous questions]

Do you buy in bulk?

No, we do not.

***So just normal packages**

Yes

Do you buy in discount?

It depends, when we want to use the meat, for example, we buy the red mark, discounted. But we just buy that if we don't want to freeze it. If we're sure that we're going to use it today or tomorrow.

Do you buy ready to eat meals?

That kind of food, sometimes like pirog [hand-pies], or in the oven, we can put it in the oven. It's really good for lazy people.

Do you check best buy dates when shopping?

Yes, I do. Even if I want to eat the food soon and not freeze it, sometimes I buy food which is soon past the best date for use and has price off.

Do you find that the sizes of food packages are appropriate for your needs?

No, actually, but I think I should do that. Instead of buying two little [packages containing] one liter of milk, I should buy one and a half liter, one milk instead of having two. Maybe it's better because in the end there's a little bit left, you know what I mean, when you have one liter with some lock on. Instead of having two of those it's better if you have one without lock, just to have one, but maybe the date is gone and still there's some there because you are alone and...

***Does it happen often? That the date is gone and you have some leftover milk or something?**

Yes, because I buy so much milk. But as I said, I like to buy that kind of milk so if I want to be honest it's just easy to drink of it from here, not in a glass, and not make a mess, more mess to wash it up later. Lazy... and yes, it has happened to have leftover milk using this.

How much do you usually spend?

In Hemköp I spend between 400 and 500 [kr] for two weeks that I am alone, because I don't buy food, as you say, meat and some expensive things, meat is the most expensive thing if you want to make food. But as I don't make that kind of food I don't spend so much money. But I buy fruit and juice, so much juice, I don't drink coca cola at all so I drink juice, so it's a little bit costly.

Storage:

How do you store (be detailed)?

-Meat

[Answered in previous questions]

-Cheese

When I open the pack put the rest of the cheese in a bag before putting it in refrigerator.

-Fruit

I buy so much of it. I don't store it in the refrigerator, I just put it in the air, outside, and that's maybe why I go to Hemköp every second day. I don't shop a lot but I go shop every second day because it's so close to my place.

-Vegetables

Not so much... if you can call the salad vegetables, and carrots vegetables, I use them. Or when he is here we use frozen vegetables actually.

-Bread

Yes, toast bread, just toast bread. I put half of it in the freezer and half of it in the refrigerator. So I use the one in the refrigerator once, until it's finished, and the one in the freezer and then go to the shop again.

Are you aware of guidelines for proper storage of foods?

Not me, but he knows.

Do you have enough space in fridge to store all you want to?

[Has two fridges]

Does the shape of your fridge allow you to see all foods inside?

It depends on which date we are, the first day after going to the shop not everything is visible. In the latest time after shopping, yes.

Has something ever spoiled because you did not see it?

No, but I think I throw so much sauce, because I'm scared to get sick with it. I think it's a little bit sensitive to eat the old sauces, so I just throw it out, even if I don't check it so much.

***So you throw them out when you feel that they're getting old? After a certain time or?**

No, after a certain time, you know, during two weeks everything is fresh, because he cooks every day. He doesn't freeze fresh food; we cook every day. So when he's gone, we always have sauce from different things. You know, we have different sauces for different food and he makes it that it can stay for maybe 10 days or one week, I don't know, he knows better. After that one, I don't use the sauce because I know it gets old or I have nothing to eat with that sauce, so I just throw them out. I throw so much sauce out. The sauce that we cook and the sauce for salad...Béarnaise sauce, that one, we have it for using it maybe three or four days, and then again make it new for 3 or 4 days, and then suddenly he's gone and the sauce is left, so...

Do you use the freezer to extend shelf life of food? When/why?

- Freshly bought food
- Leftovers
- Bulk cooking
- Frozen food

With the bread, yes.

***Some of the meat?**

Yes. When we go to Hemköp and shop a lot, we have to put it in the freezer, not in the refrigerator.

***Do you use the freezer for anything else?**

No, I don't think so. Just if it is vegetables that we have, we put it again in the freezer, some meat, some fish, we put it in the freezer and nothing more.

***Leftovers?**

Sometimes. I guess when we have meatballs and I want to have them two days later, so I put them there. But I'm not a fan of eating food that is left and put it in the freezer and then unfreeze, no, I'm not fan of that.

***Because of the taste or because of food safety?**

No, it's because of food safety, I'm so scared because here I am alone and I should not get sick at all here. [It's] Better [if] you die.

Preparation and consumption:

Do you use specific portions to cook rice/pasta/others?

-

Do you possess/use measuring implements?

No, he's so good at cooking so no...

***And for you?**

No actually, but for my baking cake yes, I measure it.

How often do you cook? In bulk? Using recipes?

[Answered in previous questions]

For him, no, he doesn't use recipes; but if it has happened that I want to cook something, I have to use recipes.

***Following a recipe and then having too much food**

No, it hasn't happened so much for us. When we are two people and he cooks for over two people, which makes me really angry. I come from some country where it's not so easy for everybody to have food, as here in Sweden they have. And is not [hard] for me personally, of course I have had food whenever I wanted, whenever I want to eat, but generally I mean, and it's so hard for me to waste food. It's not because of money, he pays for it, it's just... I don't know what to call it, but it's hard for me to waste the food we make, and I can't even let him to open the water tap for a long time just to be cold or for it to be warm. It's annoying me a little bit, actually, maybe it's kind of people say "she's so economic", and no, I am not economical, but it's my feeling for water and food, yeah.

Do you usually have leftovers?

[Answered in previous questions]

Wasting:

How do you use date-labels on food?

Yes, I do it, but he makes sure that it's old, maybe it's the item's best date, but sometimes it's gone... the best date is gone but you can use it, so he makes sure if he can use it, but not me. When I see the date I throw it away, because I'm very scared of being sick from food.

***Is that with all foods?**

Actually yes, but when my boyfriend comes he tests it if it can be used or not, even after the best date, but not me.

***Do you know how he's testing it?**

I don't know, he knows how the healthy food should be, even the color of the meat or the smell of the milk or...

Has the package size of a product influenced your waste?

No actually. Maybe just the milk, because I'm only one person and I buy milk that has a lock, so sometimes I have not noticed that the best date is gone, so I should just throw it away.

***And in general?**

When you are one person sometimes it's too big, so you should look which size you buy. Like yesterday, I tried to buy a little pack of milk.

Has buying in discount influenced your waste?

I don't think so, because if it's meat I try to use it as much as I need it, because I know if it's, umm... if I cannot use all of it. I try to put it in the freezer or I don't make food with it, I just try to make half of it.

How do ready to eat meals influence your waste?

Doesn't.

What do you more often waste?

Sauces, he makes some kind of sauces: sauce for this, sauce for that; and I think it's safe for using it one week, so he makes it several times during the time he's here. So when he's gone, we still have two or three kinds of sauce, so I don't want to use it. The sauce that he makes has all the taste of the food, you cannot eat the food without sauce and maybe that's why they're [Swedish people] always looking for sauce, it's just part of the food.

Why do you usually throw away food?

When I see that it gets old. I am so careful with food, if it's healthy or not, and if it's more than 2 days, even if it's in the refrigerator I am not eager to eat it, it's always like that.

Is there waste that you feel you can prevent?

***Or do you feel like there's no other choice?**

I think so, because what can I do? I cannot eat it, I am alone so I could not cook less than that, it's not worth to cook because let's say, I cook, maybe I eat it today for lunch and a little bit for dinner if it's left anything, so you already cook little when you are one person, you cannot say "I will eat less than this" so it's too little, so always there's something left.

What kind of waste do you feel you cannot prevent? Why?

[Answered in previous questions]

What would prevent you from wasting food? What tools would help you waste less?

I think, just looking at the best date when you are going to shop, that would be important.

Are there moments where you waste more/less?

Yes, when I want to suddenly decide to go away from my place for some days, so of course I will leave something to waste.

*** So if you travel?**

Yes. Also when I don't plan to go out for food many times, when you go outside for food, that's the time you waste food.

At what stage do you waste more? (Unopened, preparation, cooking, storing, spoilage etc.)

Half used

How do you feel about wasting food?

I feel so bad; I don't like to waste food at all. I'm careful about not wasting food.

***Is there a reason for that?**

Yes, actually, I think when I waste food I eat some other people's rights; it's my way of feeling. I cannot help other people with giving [them] food, but I see [that] even [with] this, not wasting food, I am kind of helping other people.

How do these influence your waste?

- Food system
- Culture
- Economy

- Social factors
- Family's lifestyle
- Emotional state
- Health concerns

[Answered in previous questions]

Do you separate food waste? Why, why not? What do you do with it?

Actually no, I do not separate the waste, I just put all of it together.

***Is it because there's no system here or because of ease?**

I have no sorting system.

Does food waste sorting influence your attitude towards producing waste?

If you are many people, then yes, it could affect actually; but when you are one or two people it will not affect so much, that's my idea.

Environmental attitudes:

Do you know what sustainable food consumption is?

No actually.

***Relation of food with the environment**

I don't know so much about it, but I heard that ecological food is better to use because when you use more ecological food, then they have to produce more ecological food, so they don't add some chemical things to produce that food. So if it's not so much difference between the prices, I buy the ecological food, I think about something like that and it will be healthier. Actually, I don't think about all over the world, but I think about my health and if everybody thinks like that so it could be something good.

How much do you know about GHG emissions related to food?

Maybe if you use more some special kinds of food, so they have to produce more of that one, so it will affect the environment and green gas emissions.

Do you attempt to consume sustainably? Why/why not?

[Answered in previous questions]

Is it important to you?

[Answered in previous questions]

Do you know benefits of reducing food waste?

I cannot see any direct benefit, but I just think that for producing this food they put some energy from some sources, so of course it will not be nice to just waste it.

Initial interview – Participant #2

General:

Age

25

Provide a rough description of your daily routine:

In summer, I travel around, so I do not have a routine during the trips. So maybe, yeah, the time before [traveling]... let's see, I got up around 7:30 or 8:00, and usually I had lectures from 9 a.m. and it ended before 12 o'clock, so I had lunch with my friend here. I have lunch break of one hour or one and a half hour, and then back to work again; and then I get out of work at 5:00... 4 or 5, if it's not the month before deadlines. In the months before the deadline I probably don't have time for dinner or have a short time for dinner, and then work until like 9:00 or 11:00 in the afternoon; it's quite late, and then go back home to sleep.

***Now in the month that is coming, are you going to be working or?**

No, I do not have work during summer, but I will work out a lot, hang out with friends, and have some time for myself.

***So no specific routine?**

No

How many people live in household?

[I have] Neighbors. Now I live alone.

Is food shared?

[Answered below]

Do you have any food preferences/sensitivities?

No, but I don't like olives, haha. I can eat them in bread or maybe some pizza, but I will not eat them or buy them myself.

What are your meat/dairy consumption habits?

***Meat**

Well, including fish or not? Like, I wouldn't say every day, but almost every day, yeah.

***Dairy**

I think almost every day.

What drives your food choices?

- Local**
- Flavor**
- Culture**
- Price**
- Sustainability**
- Convenience**

Well, I think it depends, all the elements you mentioned, also the package of the food, I guess.

***What do you mean?**

Like, when I choose the rice, for instance there are different packages of rice and different pictures on it.

***When asked further:**

Does not think about sustainability, convenience or local.

***But mainly, what is the first thing that you think about?**

What I want to eat.

Planning:

Do you check what you have in the fridge/cupboard before purchasing?

Maybe not in the fridge. I will know how much I have in the fridge, but maybe not in the cupboard. Because some things, like rice, I can keep them for a long time. But I know it by heart so...

Do you make shopping lists?

Oh, I might.

Do you plan meals? Why/why not?

Yes, sometimes. Not plan in break, but in hours, maybe. Or in that day, yes, in hours really.

Do you feel you have enough time to plan it?

-

Is it planned together?

-

Shopping:

How often do you shop?

Probably three days, two or three days during the week.

Is it regular or improvised, what does it depend on?

When I don't have food.

***So mainly you are buying small amounts?**

Yes, exactly

Distance to supermarkets

Close to supermarket? Not really actually.

***What supermarket do you go to?**

Mainly I go to Hemköp. I do go to other shops, like ICA, Asian market, Willys.

Is shopping made together?

-

Do you buy in bulk?

The amount is very large for me; it depends on the amount. Maybe for others it's not a big amount, but for me, maybe yes. Maybe some things, for instance, the bread is not too much for others but it is for me, and I couldn't consume them before expiring time, and I couldn't eat it every day or every meal, so it's bulk for me. But if you say generally, I won't I usually don't do that.

Do you buy in discount?

If they're not that bad quality and I like to eat it, yes.

***But then, is it something that you would buy usually or maybe something that is in discount and you say "ok, maybe let's try this"?**

If I have tried that before.

***Okay, so you are not motivated to buy it because it is in discount...**

For instance, if some cheese I've never tried before is in discount, I won't buy it, maybe. It depends on my culture, what I want.

Do you buy ready to eat meals?

No, almost never. Hardly.

Do you check best buy dates when shopping?

Yes.

Do you find that the sizes of food packages are appropriate for your needs?

Some of them no, some are, for instance, I said before the bread is too much for me. But if you buy a very little amount of bread it's the same price, so it happens.

***Can you think of anything else?**

And meat.

How much do you usually spend?

I don't know.

Storage:**How do you store (be detailed)?****-Meat**

I keep it in the refrigerator and after I find it will go bad, I put it in the freezer

-Cheese

Refrigerator

-Fruits

Mostly in the refrigerator, but some of the fruit I will keep in the cupboard. Like jam, which is on packages, or bread, cereals and muesli, something like that.

-Vegetables

In the refrigerator

-Bread

In the cupboard.

Are you aware of guidelines for proper storage of foods?

No, I know some but maybe not all of them.

Do you have enough space in fridge to store all you want to?

Not really, I only have one shelf so it's not much space, because I share the kitchen with my neighbors. Specially after shopping, it's not enough.

***Does that make you sometimes put things out things that you want to put inside the fridge?**

No, I will figure it out. Steal some space from others, haha.

Does the shape of your fridge allow you to see all foods that are inside?

If it's full, no, I have to move them.

Has something ever spoiled because you did not see it?

Not really, only when I forget them.

Do you use the freezer to extend shelf life of food? When/why?

- Freshly bought food
- Leftovers
- Bulk cooking
- Frozen food

With meat and fish, of course. And some desserts I bake myself.

***Do you cook for the week?**

Usually not, maybe one or two days, or three days, not more.

***Do you keep that in the fridge?**

In the refrigerator, yes.

Preparation and consumption:

Do you use specific portions to cook rice/pasta/others?

Just an estimate. Sometimes I will use a cup, use that for measuring. I did before, when I was in China, because we don't have small cups for measuring here, so I don't do it [anymore].

Do you possess/use measuring implements?

[Answered in previous questions]

How often do you cook? In bulk?

[Answered in previous questions]

***Using recipes?**

Sometimes, yes.

***What do you do when the recipe has more portions than needed?**

Depends on which kind of food I cook. So if I'm cooking Chinese food, from my culture, we just count dishes; we share the dishes together, so we don't have that kind of thing. If I cook... no, I don't usually cook western things for my guests, if I cook that [western dishes] we all follow the recipe actually, if I have a recipe.

Do you usually have leftovers?

***So you said you usually have leftovers for 2 or 3 days, that you cook 2 or 3 times per week?**

Or more. Or I just buy food from the canteen.

I eat out 4-5 times/week, including lunch in Kårhuset.

***So when you have leftovers, do you put them in the refrigerator, or throw them away...?**

So we are not talking about the breakfast, right, just cooking? For food, for the second day, I won't cook vegetables with leaves, like green vegetables. I won't cook them because I know if you leave them, after cooking, for 3 or 4 hours it's not good to eat, so I want to do that only for the meat and some potatoes or tomatoes, which can keep longer. I will cook them for the second day and I will put them in the refrigerator.

***If there is food that is remaining, do you throw it away?**

No, I can consume them. Unless they have been there for a week or something.

Wasting:

How do you use date-labels on food?

I usually follow them, unless it's like some butter. Usually if butter expired that date, sometimes I will use it, but for most of the food, no, I follow the date.

Has the package size of a product influenced your waste?

Yeah, bread mostly. And meat.

Has buying in discount influenced your waste?

No, no, they're food for me, so I won't consider the price when I consume them.

How do ready to eat meals influence your waste?

-

What do you more often waste?

Bread and meat, if they're too much, yeah, and the expiration time.

Why do you usually throw away food?

[Answered in previous questions]

Is there waste that you feel you can prevent?

I try to share it with my neighbors, before the expiration time.

What kind of waste do you feel you cannot prevent? Why?

Can't prevent, what do you mean?

***For example, someone else I interviewed mentioned the yogurt because it was very little inside.**

Ah, like it's stuck? Yeah, maybe that's a thing, like with some dessert. I usually use cream and it's hard to take it all out of the package, it's not a smart design maybe.

What would prevent you from wasting food? What tools would help you waste less?

Do you mean approach or a real tool?

***Anything.**

Like, my roommates, we are neighbors, we are sharing the refrigerator. Actually, I have a Chinese neighbor and Swedish neighbor; the Chinese neighbor, she sometimes is so lazy to go to the grocery, so she just grabs some food that I couldn't eat. And for my Swedish neighbor I bought something that I haven't tried before and I didn't like it, so I gave it to him; actually he doesn't mind, so it's good to share food like that. But only if that person wouldn't mind to eat the food, if we are in good relations, let's say.

Are there moments where you waste more/less?

When I moved here. The amount of the food is different from what I bought back in China, so I got so much waste, and I figured out how much I can consume most of the time, so now I won't waste that much. At the beginning, I wasn't used to things here.

***How about stress or a lot of work?**

No, not really.

At what stage do you waste more? (Unopened, preparation, cooking, storing, spoilage etc.)

I waste at every stage. Oh, one more thing, sometimes will waste something because I opened it and I don't like the view, or something that is very sticky or gross, maybe. I will throw them if I couldn't... if it's too complicated to deal with them, then sometimes I did get rid of them. You know, the thing that you have a fish in them and then some water, not sauce in it, and put it in [the refrigerator] a long time, because I bought this big package, I couldn't eat it more. I haven't thrown it away, but for some case I will do it, but very rarely. And the smells.

How do you feel about wasting food?

Ah, if I throw away some food that I think is good, that I can eat, but it's past its expiration time, I feel a little bit guilty about it, too much waste, a waste of food. But if it goes bad I think "Well, it's a shame, haha". I hope I can consume more, but sometimes you can't eat that much, and I live alone so I have to cook for only one person. I won't eat one thing in the meal; I need to eat this, this and this to balance the nutrition. So I need to buy three things instead of one thing, and I only eat a small amount of three things, and [if] I do this, maybe something will go bad. There's no way to avoid it, and I think it's not right, but it's not necessary to consider the waste and lose your culture of eating of your food.

How do these influence your waste?

- Food system
- Culture
- Economy
- Social factors
- Family's lifestyle
- Emotional state
- Health concerns

Maybe health and cultural, maybe. Because we don't eat potatoes with sprouts, but for some people here they will eat it, so I think this maybe differs because of the culture. And also we don't eat the peel of some fruits in China, but here they eat it, so it's different. But I've changed a little bit, sometimes...

Do you separate food waste? Why, why not? What do you do with it?

I put all the food together. I sort it, because I did a course in waste management in the first semester, so I really care about that.

Does food waste sorting influence your attitude towards producing waste?

Not really

Environmental attitudes:

What is sustainable food consumption?

***Do you associate food consumption with sustainability?**

Sometimes, not really. But you mean the Eco food or?

***For example, would you be aware of what is sustainable food?**

No, no, when I consume them, no.

How much do you know about *climate change related to food?

I know some.

Do you attempt to consume sustainably? Why/why not?

[Answered in previous questions]

Is it important to you?

I like to know, like, I went to a lecture about food consumption; I think it's interesting to know how your behavior influences the climate change, yes.

Do you know benefits of reducing food waste?

From energy loss? Not much. I know some like, some energy and the gas, if you eat meat...

Initial interview – Participant #3

General:

Age

27

Provide a rough description of your daily routine:

Uh, depends on what I'm doing, but, if it's a school day I wake up...

***For the following month?**

I wake up, either at 5 am or 11 am, eat breakfast, take a shower, and go to work. And then I come back 9 hours later.

***And do you cook daily?**

No, I cook once or twice per week.

***And then you freeze it, or put it in the fridge?**

I usually put it on the fridge. I do grocery shopping maybe... whenever I'm ready to cook. I go buy stuff, the meat, I always freeze. And breakfast stuff, such as, I mean, butter, bread, jam, that stuff I put in the fridge.

How many people live in household?

[Lives alone]

Do you have any food preferences/sensitivities?

I don't eat pork.

What are your meat/dairy consumption habits?

I used to consume meat very often. It used to be in every meal that I ate. Right now I'm trying to cut back, so I try to eat, like, every other or every third meal that I prepare with meat.

***For any specific reason?**

Yes, because I want to reduce my meat consumption.

*** And how about dairy?**

Dairy I consume.

What drives your food choices?

- Local**
- Flavor**
- Culture**
- Price**
- Sustainability**
- Convenience**

Right now the major thing is price. If I have a few options, then I will always take the cheapest one. Sometimes, for some things, I prefer eating locally, so usually if it's, say that I want to buy... what is this called? Coriander? That I take ecological. Meat, I prefer Swedish meat.

***For any specific reason?**

No, just that I trust it, but sometimes the Swedish meat is 20 kr per kilo more expensive than the other ones, then I will take that one [the cheapest].

***Is there anything that you buy out of convenience, just to make it easier? For example, frozen meals.**

No, in that case I will buy baguettes for every occasion.

***Okay, so you eat out for convenience.**

Yes.

Planning:

Do you check what you have in the fridge/cupboard before purchasing?

Yes

Do you make shopping lists?

No, well... I make a mental list. I don't write it down.

Do you plan meals? Why/why not?

Sort of, well, I plan what I am going to cook. That's as much planning as I do. So I would say that, okay, right now I want vegetarian so I know that I have one or two recipes [mentally] for vegetarian. And then sometimes I want chicken and then I have a few recipes for chicken. So it's usually, I am in the mood for steak or like beef or I want chicken or I don't want any of those.

***So it kind of depends on your mood, what you crave in the moment.**

Yes, and sometimes it depends on time, something that goes really fast to cook.

Do you feel you have enough time to plan it?

Yes

Shopping:

How often do you shop?

It depends on when I want to cook. So for instance, I might know that this week I'm very busy and I will not have time to cook or I will not have time to eat it at home; then I won't cook and I only shop for whatever I need, so that might be the breakfast things.

Is it regular or improvised, what does it depend on?

-

Distance to supermarkets

[Buys in Willys Hemma Eklandagatan and Utlandagatan and Ica Maxi Mölndalsvägen. Lives in Chalmers Studentbostäder Mossen].

Do you buy in bulk?

Not usually. I saw a coffee, if you buy it like four packages, it will be cheaper, so I did. So that's kind of a bulk because that will last me for a few months, but otherwise, no.

Do you buy in discount?

Yes. If I see something that is really, really cheap I will take it, but usually it's only if I know that I am going to use it. I don't just buy it and then let it sit. If it's something that I know I can use in one of my recipes, then yes.

Do you buy ready to eat meals?

Sometimes

***What does it depend on?**

What kind of meal that is, and for what occasion. I don't really buy too much now, but I used to buy a lot of frozen food; that was usually when I studied and I spent a lot of time in school. But nowadays I study at home so I cook at home and then I eat at home.

Do you check best buy dates when shopping?

I always look at date when I shop, and I take the package with longest date remaining

Do you find that the sizes of food packages are appropriate for your needs?

I haven't really thought about it. Some things I think could be better if I could find them in bulk, like pasta and macaroni, because right now it's like this 500 grams and then they are like 10 kr each. But I mean, it's kind of good because I know that I take three of them and then that will last me for two meals or two times that I cook food, but it would be nice if I could buy like 5 kilos and then I would have it, because it doesn't go bad. But then the problem with that would be that it might get wasted.

How much do you usually spend?

Grocery shopping... it varies between 1500 and 2500 kr, I guess, and then I eat out quite a lot. Perhaps for or five times per month.

Storage:

How do you store (be detailed)?

-Meat

Freezer

-Cheese

Fridge

-Fruits

I don't buy fruits normally, but when I buy it I keep it out.

-Vegetables

Fridge

-Bread

Fridge. Sometimes frozen, if I buy a big loaf of bread then half of it will go in the freezer and the other half in the fridge.

Are you aware of guidelines for proper storage of foods?

More or less. I'm comfortable with the way I store food right now.

***How did you learn about it?**

Part family, part school, yes.

Do you have enough space in fridge to store all you want to?

No, no. Sometimes I don't buy as much as I want to, and that's why I also can't buy in bulk.

Does the shape of your fridge allow you to see all foods inside?

My fridge is very low, so I would have to, like, squat, but yes.

Has something ever spoiled because you did not see it?

No, it usually spoils because I'm not home that often so I don't use it.

Do you use the freezer to extend shelf life of food? When/why?

- Freshly bought food
- Leftovers
- Bulk cooking
- Frozen food

Yes, like bread, that's the typical thing that I would put in there. I have put some vegetables in the fridge for some occasions if I'm going away. For instance, for two weeks and then I know they will go bad. Then when have put them in the freezer it hasn't really given me the... it's not really good because when you take it out it gets very soggy and it doesn't taste that well, but it has happened. Not very often though.

***Leftovers? Do you put them in the freezer ever?**

No, it's usually I cook and then I put it in lunch boxes and then I put them in the fridge; and if I have a lot of them up, I put a few of them in the freezer so I will eat the ones in the fridge and take out the ones in the freezer. Leftovers I throw away because if I cook and put it in the fridge, I have to heat it up and then once I heat it up I don't re-freeze it.

Preparation and consumption:

Do you use specific portions to cook rice/pasta/others?

I go with my eye.

Do you possess/use measuring implements?

No... well, when I cook rice I do I use cups, so I have the cups that I drink coffee out of. And then I use one cup or two cups and a half or something like that. But for pasta I just use my fingers or hands, and macaroni I know that this level (gestures with hands).

How often do you cook? In bulk? Using recipes?

[Answered in previous questions]

Do you usually have leftovers?

From the boxes after eating? No, I eat everything that is in the box. Usually I put either too much or too little in the box, but then I would have to stop myself or make a sandwich or the other ones with less.

What do you do with them? Store/throw away? Why?

[Answered in previous questions]

Wasting:

How do you use date-labels on food?

It depends what it is. But meat, as soon as I buy it I put it in smaller bags, these freezing bags, and then I put it in the freezer. When it comes to fruit or vegetables I keep it in the fridge and then...

*** No, I mean date labels when it expires**

The only thing that it would say for me would be bread or milk, and bread I usually just look at it because I normally eat quite a lot of bread for the morning, so I know that "okay, this one is expiring in one day, two days" then I will try to finish. Because sometimes it's like two or three days passed before the due date and then I will just look at it, if it's good then I eat it. And milk, I smell it and then I just see if there's any lumps, yeah and then I try to finish it up fast as possible.

***So basically, you see it as a recommendation, but once it has passed you use some cues?**

No, I'm not very strict, what I usually waste a lot is yogurt. I buy yogurt for muesli and then it's usually a little bit left, and I think I will take that sometime, and then it's only little left, so I say "okay, I'm going to buy a new one and then I'm going to use that" and then I don't have time to do it. Then that has been there for two weeks and then I just throw it away. So that's the thing that I waste the most, but I do not buy it very often, so it doesn't happen often.

***So in that case it's not really about the expiration date?**

No, because if the yogurt expires, it can last, I mean, almost a week more, but it's such a low quantity that I can't use it on its own. I have to buy some more and mix it.

Has the package size of a product influenced your waste?

[Answered in previous questions]

***How about bulk?**

I want to say yes, but can't give specifics... I just don't remember. I know that milk I usually waste for some reason. I buy 1 liter or 1.5, and for a week I'll be good and finish everything, and then next time I buy I just forget to drink it and it goes bad. Same with cooking cream.

Has buying in discount influenced your waste?

Yes, usually if I buy something in discount, if it's not part of a recipe then it will stay in the shelf or fridge for longer. Yeah, but no, I usually do not waste because the things that I buy in discount are usually pasta or rice or stuff like that, and then that can be in the shelf for a longer time.

How do ready to eat meals influence your waste?

No [doesn't influence].

What do you more often waste?

***You said that what you waste the most is yogurt, can you think of anything else that you waste frequently?**

Vegetables. It might happen that I buy some chili or onion and then I kind of forget about it, because the onions I put up in the shelf and then I don't see it, and then when I look at it it's already moldy. So yeah, it's yogurt, and chili gets like very dry, yeah, very weird... and paprika sometimes, it get holes and I just throw it away.

***So yogurt it's because it's a little amount and it's hard to use, onion would be a matter of visibility, you don't see it, you forget about it, and then chili and paprika?**

It's the amount of time that I spend at home.

Why do you usually throw away food?

[Answered in previous questions]

Is there waste that you feel you can prevent?

Yes

What kind of waste do you feel you cannot prevent? Why?

No, so I mean, yeah. Yes and no, the yogurt part is kind of difficult because I would like it to be in bigger packages; that would be perfect because I could just like, squeeze all of it, because right now it's like three and a half plates or two and a half big plates.

***Literature usually says that people want smaller packages but you're saying you want bigger, that's super interesting.**

Yeah, I want bigger packages for yogurt.

What would prevent you from wasting food? What tools would help you waste less?

Well, I don't consider myself as wasting much, the thing that I get the most upset about is the packaging. I don't like how they pack stuff, so I waste a lot of packages. Most of my garbage is packages, it's a lot of bags and paper and stuff like that, and not too much food.

Are there moments where you waste more/less?

Yes. The more I buy and consume, the more I waste, I guess. Because there's moments in my life where I do not eat much because I just don't have time to eat, and then there is times when I have time and then it's like "yeah, whatever, I have this there and this there". And then once in a while, I eat too many sandwiches and I cannot finish that one so I save it for later. But then I go out and then when I come back it's all dried out and I really don't want to eat it. Oh yes, the thing that I really waste the most of is coffee, I waste so much coffee. I brew it myself, I just make too much, and it's perfect because when I'm at home all day then I can just drink it throughout the day and the last cup I can have it at 10 p.m. But for this morning I made coffee and then I drank it and then I was like "oh no, I'm late, I have to go" so I couldn't even finish that cup. I usually drink two cups at least in the morning, I couldn't finish my second cup, so I wasted that cup and then whatever was left in the pot; but when I get home maybe I will try to heat it up, but it doesn't really taste that well. So I waste a lot of coffee, a lot.

***That's also interesting, we have to think how to quantify coffee waste, because coffee grinds were not bothered because that's on avoidable, but then the product that results, yeah, interesting.**

***So you said that you don't really waste unopened things, for example let's say that you buy a pack of bread and it goes bad before you open it.**

No, because it has happened sometimes that I bought bread and put it in the fridge and then I was away for some time, and then I came back and it expired yesterday, so I take half of it, I put it in the freezer and then I eat as much as possible in as little time as possible.

At what stage do you waste more? (Unopened, preparation, cooking, storing, spoilage etc.)

Stuff that is already opened, I think, because I bought a lot of boxes of mashed potatoes and sauces and stuff, and I still have them on the shelf and they're like 2 years old. So, all of that, I have to throw it away... And then sometimes I buy stuff by mistake, so I bought some spaghetti, but then I realized this is not the spaghetti kind that I like and it's still in my drawer, and I don't really want to use it because I don't like that kind of spaghetti, but I guess I will have to at some point. So I'm saving it for when I'm like "Agh, I have to cook, but hmm, I don't have any pasta, and okay, I'll just use this", but I don't think that's going to happen because usually I want to cook and then I go to the shop and then,

because I don't usually have stuff ready, if one thing goes out then most of the things go out, so I have to, yeah.

How do you feel about wasting food?

Very bad.

***Why?**

I don't like wasting because then it's such a waste! Haha, and I do not condone it at all and I get super pissed if people waste. I mean, sometimes it's just like "yeah, whatever, it's wasted, nothing to do about it" but if you can prevent it, then no, it's not good. You should not waste with the intention of wasting. Then if it happens, it's okay, but no.

*** What has led you to feel like that?**

Just the way I was brought up.

How do these influence your waste?

- Food system
- Culture
- Economy
- Social factors
- Family's lifestyle
- Emotional state
- Health concerns

[Answered in previous questions]

Do you separate food waste? Why, why not? What do you do with it?

No, not food waste, because in my place, where I throw the trash is very inconvenient, so it would stink or it would get really, really wet. I have to clean it every time and that's very annoying to me. I just put it in the same box, as in, with the rest of the garbage. I take away all the cans, all the metal tins or whatever, but plastic, most of the small packages and the food waste goes in the same box, so I put that in the combustible. But then if it is pieces of carton or bigger plastic stuff, then I will take that into the recycling station.

Does food waste sorting influence your attitude towards producing waste?

No. Oh well yes, it makes me more conscious. If I would sort it better I would be more conscious of what I consume, right now it's just a big box and I throw it away and I don't really know what I'm throwing. But if I would, like... I notice when I separate the cans and the plastic bottles and all of that stuff, then I kind of realize that I'm consuming a lot of that or a lot of this.

Environmental attitudes:

What is sustainable food consumption?

[Malfunction of the recording]

How much do you know about GHG emissions related to food?

[Malfunction of the recording]

Do you attempt to consume sustainably? Why/why not?

Well, I mean, me trying to eat less meat I would say it's an environmental choice, so yes. So I try sometimes to buy locally, but then I don't really have the economy to do that right now, so yeah.

Is it important to you?

[Answered in previous questions].

***Aware of how food choices affect the environment?**

Yes

Do you know benefits of reducing food waste?

Yes

Final interview – Participant #1

General:

Did any of the initial status change?

People living in the household, distance to supermarket, sharing food with other people, time spent studying or working ...

Yes, actually. I have had a big change, 5 weeks my parents were here, so we didn't eat... I can say we didn't eat anything at home, and before that one, I had 3 courses; every single day I was at school, so I ate a lot at school because of the three courses, so maybe that can be.

***So that happened during the experiment?**

Yes

***Same supermarket?**

Yes

Did you develop any changes in your eating habits? Why?

What is eaten, how often...?

No actually, I ate the same as before, at least I don't notice it [a change].

***And then it was the same as before, generally your boyfriend cooking more and you cooking breakfast...**

Fast food, kind of fast food. I can say prepared food.

Planning:

Did you start/continue/stopped checking the fridge and cupboard before shopping? Why?

Not me, but when he comes he checks what he needs and then buy.

***Did that change?**

No

Did you start/continue/stopped making a shopping list? Why?

I think he still does it in his smartphone

***And that was the same from the beginning**

Yeah.

Did you start/continue/stopped planning your meals? Why?

***You weren't planning before, did that change?**

No. Honestly not.

Shopping:

Did any buying habits change? Why?

Frequency of shopping, buying in bulk, buying in discount, ready to eat meals, size of packages

Frequency

No, I shop almost every second day because I shop very little, but when he comes we have some shopping list and we shop a lot. And just eat at home.

***And when your parents where here?**

Actually, I can say no, I didn't shop almost anything.

***For how long was that?**

5 weeks. I almost moved out of home.

***At the beginning, you said maybe you should buy larger packages. Did you start doing so?**

No, not yet.

***Ready to eat meals?**

Right now I kind of stopped buying pirog and try to have pizza from nearby pizzeria instead.

Did your food budget change in any way? How?

The same thing.

Storage:

Did your way of storing the food change? Why?

As it is winter time, no, I put the fruits outside the fridge, or you mean refrigerator or freezer?

***Just any difference in the way you were storing your food.**

No

Preparation and consumption:

Did you start/continue/stopped using measuring implements? Why?

No, I don't use that. Even when I make some cake, for baking, I don't measure.

Did you start/continue/stopped using recipes? Why?

No

Did the amount of leftovers you produce change?

I have a very small amount of leftovers, I can say.

***So it didn't increase or decrease, it was routine leftovers?**

I think it was routine, because even before I didn't have so many leftovers, because I don't cook so much. Maybe that's why. My leftover was more milk and such these things, not leftover [from the] food that you make.

Did you start/continue/stop using leftovers? Why?

-

Wasting/attitude towards wasting:

Did your use of use-by/expiration dates in labels change? Why?

No, when I see something is expired I don't look at the inside, I just throw it out because I don't want to get any problem here. It's really hard if you get some problem from eating some toxic food or something like that.

Did you perceive a change in the amount or composition of preventable waste? Why?

Actually I don't know because I'm not a lot of people, maybe if it was a lot [of people] it could have some changes, using the... what do you call it? Skin of some fruits, you could... if it was a big family, you could use even that one, but not for me. Even when my boyfriend is here we eat potato skin and so.

Did you find things spoiled sooner or slower?

Yeah, in the warmest time it went bad very fast but in winter, no. Maybe I eat a lot, or, I don't know. They stay longer.

It happened that milk got spoiled before the date (in summer time) or yoghurt which is opened (the best date was not over but I forgot to use it up after opening the yoghurt pack and I could feel the smell was unusual).

Did you perceive a change in your most usual reason for wasting food? How so?

It mostly was because of the same reasons.

Did you perceive a change in the stage at which you waste more? How/why?

(Opened, unopened, cooked, etc.)

Mine was not so much leftover food that you make, it's much about packages that you open and then you could not use the rest.

***And it stayed like that?**

I can say yes.

Has your attitude in regards to food waste changed in any way?

[Answered in previous questions]

Did your recycling/ waste sorting situation change in any way? How/why?

Recycling system, distance to stations, etc.

No, I don't separate the waste. Because I have no... that one... [Buckets at home for each kind of waste]. I know some people that they separate their waste at home, but I don't have that one.

***So no change happened?**

No, as I said, I know some people have two packages in their cabinet and they use two different... like a drawer. Not in mine. Because I have just one hole here, outside at the wall. If it was, for example, two; and they said that it is better that you put it in there, I think I would do that.

Did you notice any change in your garbage sorting habits? How and/or why?

[Answered in previous questions]

Environmental attitudes:

[Malfunction of the recording]

Equipment used during study:

Were there any problems with barcode reader?

Yes actually, there was a lot of problem with the barcode reader. After a while, the barcode reader, it just turned off and on in my hand.

***So what was the problem, it didn't register or?**

No, it didn't register, it just said unknown and unknown and unknown.

***So everything was unknown?**

Yeah, everything was unknown! I thought maybe this comes from another country, or some other place that they don't have in the database, but it wasn't the problem. For some Swedish products it was the same.

***And it was things that you had bought before?**

Yeah, [at the beginning] I thought that was the problem, but I just didn't use my head.

Were there any problems while using the scale?

No, I don't think so, I used it well.

Study design and app use:

Was anything in the study protocol confusing? *Did you understand it correctly?

Yes.

Were there any problems while using the app?

No. In the beginning, yeah, for example I registered, I didn't know if it registered and I registered one time again, and then I deleted it but then it just worked.

***And after that, you had any bugs?**

Just I got some message, like "Did you know that your leftover bones you can use them in some chicken soup" and it was some nice advice.

Did you find the questions in the app relevant?

[Malfunction of the recording]

How did you find the ratio between registering foods with and without barcode? Did you perceive any change in any of these categories?

I think, lately I've bought some things that I couldn't use the barcode, such as meat, freshly canned, uh, some vegetables, fresh vegetables, that I couldn't use the barcode.

***So, there was a change? Do you feel that before you were buying more things...?**

With barcode, yeah. But lately I used some things that had no barcode. That's just because of my boyfriend, that he's interested in fresh meat and vegetables. When you buy fresh meat, it was some fresh vegetables as well, so we had those fresh vegetables that have no barcode.

***Do you know why he was interested in fresh things?**

No

Was it common for you to buy products that weren't in the database? (Expand on which supermarket depending on answer)

Sometimes it happened, but not always.

***Did you register them?**

The name wasn't in the database, at least what I have to register.

***These things that you didn't find in the database, did you buy them in the same supermarket?**

Yeah. I always shop my things from Hemköp. It seems like maybe you have the database from another supermarket. I think that's why, the problem could be that.

***I mean, either way I'll try to check. Verify everything**

Did you add them to database?

[Answered in previous questions].

Were there any foods that were hard to register or didn't register at all?

***You said that by the end, there were a lot of things that didn't register, right?**

Yes, a lot.

***So it was like mostly everything or one specific item**

No, it was everything.

[A section of the interview is missing because of technical difficulties in the recording. Work in progress]

Would you use the app in daily life?

No, actually.

***Why**

You see, an app for how to waste and how to eat, how to watch, no, it's not my interest actually. Because I don't have that much waste, I'm a little bit careful, I'm not economic person, but I come from some country where it's a little bit hard to waste things, even wasting the water. I'm so careful of this, but it doesn't mean that I'm a really economic person, no, it's not that, but yeah, I'm really careful with that.

***So it's not something that you feel that you need?**

No.

Feedback functions:

Did you use any of the food tips suggested in the app?

Not actually, because lately I used the app much less. I just used it maybe one month after you said you finished with your program, and after that just passed four months but I used it for one month I think.

Did you start incurring in any of the recommended behaviors during study?

[Answered in previous questions].

[Malfunction in the recording]

***Yeah, of course. I'm really interested in seeing the results, to see what impact is generated in the waste that you produce, you and all the other participants. Because as you say, it's curious to look at it when it's a single person, when it's not a big household, maybe a lot of people don't pay attention to it.**

Ok, so there was no particular change in your mindset, just that, just thinking about it?

Yeah just that now I'm thinking about it. Because I'm curious.

***Yeah it's in your head, haha.**

Suggestions:

Is there anything that could be added to the app that could help you waste less?

I guess that nice message, that you get it when you are wasting; if you have some app it's good to have some message from the program to say "do you know if it's like this". You feel something, some kind of guilt and next time it's hard to do it. Yeah, to have some message to evaluate how you waste and how you eat, if the program is like this, then that's good.

***Any other ideas?**

No, I think that kind of message you can get in the app is good for me as well.

What changes would you recommend in the app?

[Malfunction in the recording]

Final thoughts:

Did the study impact your buying/consuming/wasting habits in any way that was unexpected for you?

Just that happened was that I was looking at the inventory, at the stuff I waste and what I waste it was... not like, well... what you eat and what you waste like but it stays for you here, in your head and it's the only reason that you forgot it what you waste.

Otherwise you don't think about it because it's unknown, it's kind of...

***It just disappears, I get what you mean.**

Final interview – Participant #2

General:

Did any of the initial status change?

People living in the household, distance to supermarket, sharing food with other people, time spent studying or working ...

No, I'm still living in the same room.

***Are you going to the same supermarket?**

I'm going mostly to Hemköp now. But recently that one more than others.

***For any reason?**

They have a lot of groceries, like lunch, so it's very convenient, and they have what I want. And also I have a membership at Hemköp.

***Did you have any changes in your routine? In general.**

It quite depends. But if I'm quite busy I probably cook less or I go grocery shopping less

Did you develop any changes in your eating habits? Why?

What is eaten, how often...?

None of that, not for me at least. But somehow during certain times I really like the vegetarian meal at the Student Union. But it doesn't mean I become a vegetarian, that's not really good.

Planning:

Did you start/continue/stopped checking the fridge and cupboard before shopping? Why?

Usually I have it in mind, so I know what I have.

***So there wasn't any change in this?**

Not really

Did you start/continue/stopped making a shopping list? Why?

***Before**

Sometimes, yeah. When I need some that is, like, necessary. Otherwise I will go. If I go for food, I won't make any special shop list. I think it's also because if I cook Chinese food, I don't need recipes; it's a different way of cooking, you just put things together or I know how to cook so I don't need the recipe, so I don't make lists.

***Was there any change in the habit?**

No. Sometimes I made a shopping list, to remind me, I will make it. But if it's normal shopping I won't.

Did you start/continue/stopped planning your meals? Why?

After I make a schedule of the week. But, before shopping sometimes I will not eat at home.

***Was there any change in this regard?**

No, no, it's quite spontaneous.

Shopping:

Did any buying habits change? Why?

Frequency of shopping, buying in bulk, buying in discount, ready to eat meals, size of packages

***Frequency**

Changed a bit. I think recently, I guess it passes less time in between [purchases]. Not like in the beginning of the study. I will go twice a week, like that, when I'm not busy at school. I won't buy a lot each time.

***Buying**

Sometimes I will buy some discount things, if I like it, and I want to try some new stuff. And I kind of stopped buying the big amount on packages of stuff.

***Did you start buying ready to eat meals?**

No.

***Why is that**

Because I can't eat them all, like on the experiment time, I said "I'll buy half of this bread, because if I waste some food I need to type" so, I tried to eat it all.

***Hahaha, that's really interesting.**

Yeah, that's true

Did your food budget change in any way? How?

No, but if I go the restaurant more, maybe. Yeah.

Storage:

Did your way of storing the food change? Why?

Yeah, some of them. Yes. Before I put the vegetables in the fridge. But now some of them I don't have to put in the fridge, I will put them in the cupboard.

***Like what, and why**

Like onions. I would put onion or celeries in the fridge but now I don't, because it doesn't have to

***How did you decide that you didn't have to put them in the fridge?**

One, because the fridge is quite full, also when I bought them they're outside.

***Did anything else change?**

If I buy more meat and fish for more than one meal, I'll store it in the freezer no matter if it is going to become bad. Opened (or cut) fruits I'll store them in fridge too, now.

Preparation and consumption:

Did you start/continue/stopped using measuring implements? Why?

For baking, yes, otherwise no.

Did you start/continue/stopped using recipes? Why?

If I make like Italian food, or food from other countries that I don't know how to cook, I will use a recipe, or baking. But cooking from my own food usually not.

***Change during the study**

No, I would say no. The recipe is not... maybe I will check what I need to put in a dish but wouldn't check how much amount, how the amount is, I will have some idea.

Did the amount of leftovers you produce change?

Yes, I think less leftovers, I would say. Oh well, doesn't count if I leave some for tomorrow lunch, right?

***Well yeah, it depends how you put it.**

If I decide to make one lunch only I will finish them. I don't like to waste them; I push myself to finish the plate. And sometimes I plan to leave something for tomorrow. I think I don't have that much leftovers, I usually prepare them.

***And then when you have leftovers you eat them?**

Yes, I will eat them.

Did you start/continue/stop using leftovers? Why?

[Answered in previous questions].

Wasting/attitude towards wasting:

Did your use of use-by/expiration dates in labels change? Why?

Ah it quite depends, like the minced meat is really easy to get bad so if they are over the expiration date I will throw it. If I can smell that it goes bad I will definitely throw it, but for bread and eggs, they can last a bit longer than that, I will keep it.

***But do you keep it in the same way you were keeping it before?**

Ah, no, I put it in the fridge. Bread I used to put in the cupboard and when it's close to the expiring time I will put in the fridge

Did you perceive a change in the amount or composition of preventable waste? Why?

***About the non-preventable:**

No, I didn't put that, for instance the bones in the meat, I didn't count that, also the peel of some [foods]; I didn't count that.

***So you said you were producing less preventable waste?**

Yes, less residue. But somehow counting what you discard, it's a bit tricky, some food you might eat them but for us it doesn't count as preventable. It's kind of limited, of some options.

***Aha, so, that's really good that you say it, so what other options would be better for you?**

I can't really remember, but I remember that some of the options I couldn't put, or is hard to define because of different culture, so yeah.

***Do you remember some of the things that you discard because you don't use them but they use it here?**

Maybe for us it's not appropriate, for instance like figs or some other fruits, I will peel them. Although it's a very small amount to put it in the app, because you don't have fixed the thing and the other thing like the bar. So for this, somehow I feel like I discard them, throw them away but somehow it's... yeah.

***That's good to know, especially with the small amounts**

And I was thinking, like, the onion, they have like a very thin peel, and also like the bit thicker peel, I feel you can use that part but when you're cutting it, you just cut directly through it, so how do you balance the point, where's the balance point? Should you count the thin part like unpreventable waste or not? Because, haha, I feel a bit confused for this.

***For onions then**

Yeah I feel like it's somehow hard to define.

Did you find things spoiled sooner or slower?

Not sooner, maybe they can last longer, it's what I feel. In general. Not something specific...

***Yeah, in general, like some vegetables or...**

Yes, and some eggs. For a long time, I used it [the app], then I stopped and then [when used again] there were some tips, it's really good!

***Ah! You saw the tips, nice!**

Yeah. I think I put... the egg, put it somehow differently. I think it's really good when you know, learn how to store them. The tips showed later, not in the beginning. At the last stage. At a certain time they show it. That's sweet!

Did you perceive a change in your most usual reason for wasting food? How so?

Maybe it changed a bit, but I'm not sure because it's a long time ago... because the leftover food is less than before, so I guess this part maybe [was] changing a bit... yeah, because I avoid to waste food, so I guess it changed, haha.

***That's good, for the others, all the answers were no.**

Yeah it has quite forced me, I'm kind of "Aw, I better eat them rather than throw them away and type it in". I'm just lazy!

Did you perceive a change in the stage at which you waste more? How/why?

(Opened, unopened, cooked, etc.)

Yes, if you compared to now. Unopened and cooked have reduced.

Has your attitude in regards to food waste changed in any way?

Because I didn't use to waste food, so before using this, app I still didn't like to waste food, so I think that doesn't change much.

Did your recycling/ waste sorting situation change in any way? How/why?

Recycling system, distance to stations, etc.

Like separate them? Well, unless the product is too complicated to separate, I can do that.

***So no change**

Because I think I did quite well before, because I did some project about waste management as well so I know a bit about this.

***There's also cases in which the building changes the system, for example the recycling station is moved**

Ah yeah, that's true

***So my friend just started putting everything together because the station was so far away**

Yeah, that happens, like "I don't want to separate everything" so, I feel the same...

***Ok so there was no change in your building**

No. Our recycling room is in the building so it's really good.

Did you notice any change in your garbage sorting habits? How and/or why?

[Answered in previous questions].

Environmental attitudes:

Have you learnt anything about impact of food waste from the study?

Not really

Has the study influenced your wasting habits or perception about waste in regards to environment?

***You said that when you were in the study you were wasting less to not register it. But after that, have you continued to produce less waste?**

I think so.

I don't want to waste food, so I surely will finish it. On the other hand, I eat at the student union quite a lot. Once I ate there and they put food in my plate and I can't finish it, so I asked for a lunch box; they said "Oh, it's not allowed" but they still gave me the lunchbox, so I took it back home.

***So it's not allowed? That's bad.**

Yeah... I got a lot of food and I can't finish it, so then I just tell them later than that, when I get the food, I say "Oh, it's enough".

And one way is that, I cook for myself, so sometimes I cook a lot, and then I put it for too long time, so I don't want to eat it so I just throw them away. Sometimes it goes bad, sometimes it doesn't go bad but it's so long.

***Has your perception about waste changed?**

No

Would you estimate (if any) this change to be long-standing?

Like before, I wished to do that, so I think so.

Equipment used during study:

Were there any problems with barcode reader?

Barcode... generally it's fine.

***So there was no problem**

Not with the barcode reader, but I think the tablet... [There's] not a good connection, or the screen, at least, it's not as good as others, like a phone. It's not that sensible when you touch it. I don't know it's, for example...

***So what was it? For example, was it not registering what you were doing, or was it slower?**

It's hard to press exactly what I want, like, the question. And I also feel like the app can be more user friendly haha. Now it's quite engineering.

Were there any problems while using the scale?

No

Study design and app use:

Was anything in the study protocol confusing?

I didn't read it, because you explained it to me and I remember.

***So you felt that the (verbal) explanation was ok?**

Yeah.

Were there any problems while using the app?

The egg, it's supposed to be 15 eggs in that barcode but I touched one and somehow, I don't know how to change it, so every time I bought it I needed to press scan like 15 times.

***Anything else?**

Yeah, maybe a better database and more options of the food because sometimes I like some food, I can't find it in it.

***The food that you didn't find, could you register it?**

No, I can't put in the names, I guess. I remember that I can't, so I didn't put it in, but it's not that much.

***Do you remember what kind of things?**

Yeah, I think they don't have figs, and I have some food from china, I didn't put it in.

***In that case it could be different, the ecological info.**

You can't really count it... So I think it's fine, not so much... But for the meat products, some are minced and some are mixed beef and pork, and some are beef, so it's not in the app. Minced meat, half pork half beef.

***So there's no half-half meat?**

I put it separately. And also beef, they only have beef, not minced beef, or, I don't know if there's a difference, but if you're calculating, then I think it's fine.

Did you find the questions in the app relevant?

Kind of, yeah.

***But you said that at some point you didn't find the option for what you were looking for**

Like for shopping, it asks if you check that, if you make a shopping list or some, so I didn't do that much, I don't remember, really...

How did you find the ratio between registering foods with and without barcode? Did you perceive any change in any of these categories?

Manually... that's really... haha.

***Yeah, I guess it's tiresome.**

No, no, I just tried it. Oh you mean food, yeah, I usually I buy vegetables... With codes, I'm thinking half/ half.

***Did you perceive any change in that proportion? You said it was 50/50?**

Yes, with barcode and without barcode.

***Was there any change in that?**

In general, I don't really care or didn't pay any attention to it... but, no.

Was it common for you to buy products that weren't in the database? (*Expand on which supermarket depending on answer*)

***Apart from figs and Chinese products.**

Just the half/half meat

***Do you remember from which supermarket?**

They're different, and I think it's in Hemköp, and also I found some chicken heart, I got one, but I don't think I.. I can't remember if I put it new, I think I didn't find it, I bought it.

Did you add them to database?

[Answered in previous questions]

Was it easy to identify whether the waste was avoidable or not?

[Answered in previous questions]

Were there any foods that were hard to register or didn't register at all?

[Answered in previous questions]

How did you perceive the accuracy of your estimated percentages of waste?

Somewhat accurate, not very sure about it, etc...

Yeah, it's the percentage, it's hard to count.

Would you use the app in daily life?

Ah, I don't think so, because I think it's... for this app I was using, I feel it's only for research, for collecting data, and I don't feel fun in it, and I don't feel other benefits for me.

I just use it without... If I was amused then I would use it, but if there's no other thing, why would I record my things? Just like, if you want to know how much you spend this month, you keep every

receipt but you wouldn't look back at it, at least I'm not that kind of person; someone might do it, but not for me. I think I need some fun at some point to make me want to do it.

***How about if there were some discounts for not wasting?**

Yeah, I know, it kind of makes me... might influence it a bit but I think if people don't care about discounts, then it doesn't work. I think somehow you can use it like, do the psychology, how they compare who wastes less; I don't know how but... Like we have a counting [app], how many steps you walk, at least of our friends. Or a chat in the app, like Facebook also has it, and everyone can see how many steps you walked a day, and who walked more. It's healthy and you can walk more.

Feedback functions:

Did you use any of the food tips suggested in the app?

I didn't see many tips, actually, but I think I used one. It was something.

Did you start incurring in any of the recommended behaviors during study?

[Answered in previous questions]

Did you check your inventory?

I checked one or twice, but no...

Did you do anything with the information on the inventory?

No

Did you check the environmental impact of your waste? Was it easy to understand?

I checked that once or twice.

***Was it easy to understand?**

The icon is quite easy to understand.

***And the graph?**

I didn't see the graph.

Did it cause any reaction on you?

Yeah, for some food I bought I didn't realize they cause a lot of eco footprint. I was bit... not shocked, but yeah... Unexpected.

Suggestions:

Is there anything that could be added to the app that could help you waste less?

I think the tips are pretty good, and also [to] tell people about the knowledge of how to separate waste, of how important [it is] or somehow... because people don't know, they only know we need to separate them but they don't know if we don't do that, how harmful it is. And also I think it's good to quantify the effect, to quantify that. I think it's in the app, like you know how much you spend of the resources.

What changes would you recommend in the app?

[Answered in previous questions]

Final thoughts:

Did the study impact your buying/consuming/wasting habits in any way that was unexpected for you?

Not really, I can't come up with anything now.

Final interview – Participant #3

General:

Did any of the initial status change?

People living in the household, distance to supermarket, sharing food with other people, time spent studying or working ...

No.

Did you develop any changes in your eating habits? Why?

What is eaten, how often...?

Yes, I cut back on beef.

***You said you were planning to do that before, right?**

I did, I had an epiphany then I said “No more beef”, and then I couldn’t hold it but I haven’t bought any more beef, I’ve eaten it but I haven’t bought it.

***Why?**

Just because of the environmental impact of beef.

***Are you eating in the same schedule as before?**

No, my eating schedule is very weird, it goes from season to season; so sometimes I eat many times and a lot, and sometimes I barely eat anything. Right now I’m eating like normal, I don’t remember how it was last time but now it’s like, yeah, twice a day.

***Do you know why it changes?**

No. Just one of those things.

Planning:

Did you start/continue/stopped checking the fridge and cupboard before shopping? Why?

Continued checking before shopping.

Did you start/continue/stopped making a shopping list? Why?

It’s a mental list, continued to do the same.

Did you start/continue/stopped planning your meals? Why?

Continued doing as before.

Shopping:

Did any buying habits change? Why?

Frequency of shopping, buying in bulk, buying in discount, ready to eat meals, size of packages

***Shopping in the same frequency?**

Yes.

***Content of the shop:**

No, it's just the same. What I want to cook, I buy the day before or the same day.

***How about the size of the packages that you buy?**

Yeah, before I wanted more, bigger packages, right? Now I've realized that in some items I want smaller packages. Because sometimes, I've forgotten... I was thinking about that the other day, but it was one specific item that I need as an ingredient to a meal, then it comes in a huge package, like a big package and I don't have time to finish it and I don't cook that meal that often, so it would get spoiled until the next time. So then I decided not to buy it because it would get spoiled. Yeah, so I would like the three sizes, the small, the medium and the big one.

But I have been buying the same sizes. Because most of the stuff I want in big quantities, since I use almost the same ingredients in most of my food, so I want it in big and then I can make like three batches, three times, or two times, so yeah, most of the stuff is like that.

***Supermarket:**

Same.

Did your food budget change in any way? How?

Yes, it shrunk, not by much.

Storage:

Did your way of storing the food change? Why?

No

Preparation and consumption:

Did you start/continue/stopped using measuring implements? Why?

I used them only if I'm baking, and I've been doing more baking actually. It started off with a cake, and then I was like yeah, I want to bake, and then I did it. It failed after that, like almost every time I've wanted to bake the outcome wasn't what I wanted, but yeah, I'm still trying.

Did you start/continue/stopped using recipes? Why?

Usually I already have my recipe in my mind, but sometimes I do check... No, not really, not much.

Did the amount of leftovers you produce change?

No

Did you start/continue/stop using leftovers? Why?

[Generally packs lunch for week and eats that] No.

Wasting/attitude towards wasting:

Did your use of use-by/expiration dates in labels change? Why?

No

Did you perceive a change in the amount or composition of preventable waste? Why?

No, not really.

Did you find things spoiled sooner or slower?

No, just the same. Because if there's something fresh, well, the only fresh thing that I buy is the vegetables, and the vegetables I use, and then it's like potato and onion, those can last for some time. And I don't buy fruit.

Did you perceive a change in your most usual reason for wasting food? How so?

No

Did you perceive a change in the stage at which you waste more? How/why?

(Opened, unopened, cooked, etc.)

No.

Has your attitude in regards to food waste changed in any way?

No, not really. My general view of waste is the same.

Did your recycling/ waste sorting situation change in any way? How/why?

Recycling system, distance to stations, etc.

Same recycling station and system.

Did you notice any change in your garbage sorting habits? How and/or why?

A bit. Now, I recycle a bit more. I still don't recycle food waste because it's annoying in my kitchen. I don't know if I said it last time, but it kind of started around that time, so now plastic, cardboard, those packages, and metal are separate from that stuff, and then it's usually just food boxes, or boxes that I use when I cook, not so much wrappers, those go into the same bin.

***Why did it change?**

It was me, something that I've been wanting to do, haven't had the space but then I realized that even though I don't recycle the food waste, I can at least recycle the other waste. So the metal stuff I take away, all of it, then most of the cardboard, and some plastics I take away.

The recycling station is close to my place, it's by the bus stop, so it's not that far, so usually when I'm going to work, sometimes I get out 10, 15 minutes earlier, and then I go there and I recycle. It takes a little while but it's alright.

Also because of environmental reasons.

***Answered afterwards:**

Now I separate most of food packages but I don't do compost. With food packages I mean whatever the food comes in (except meat and frozen food bags). Tomato puree boxes, metal tins and milk cartons I wash and throw at designated place

Environmental concern:

Have you learnt anything about impact of waste from the study?

No

Has the study influenced your wasting habits or perception about waste in regards to environment?

No

Equipment used during study:

Were there any problems with barcode reader?

It was sometimes a bit difficult to know, "Is it working, is it not working?" But most of the time it was ok, the barcode reader was alright, didn't have a problem with that one.

***About not knowing if it was working:**

Yeah, I scanned it, it's not the barcode, it's this thing [the app open in the tablet]; did it actually register? Because sometimes it has a lag with the tablet, so it's like I register and then move on to the next one, "But wait, did it actually register or not?" Then I was like, scanning the same thing a few times.

Were there any problems while using the scale?

No

Study design and app use:

Was anything in the study protocol confusing?

No, the protocol was ok.

Were there any problems while using the app?

The content of the app, I think I sent you a few messages about some improvements, like this would be further down the road, but it was like, I scanned something, I've bought it, it would be much better if you could just go inside and say that this thing that I scanned at that point, I wasted this much of. Because then you don't have to scan it again, save the packages and all of that, it would save a lot of hassle. And then sometimes you scan something that you've scanned before, it's registered, and all of a sudden it doesn't work. And then sometimes there's like a lot of items that just don't exist, and it's ok because it's not unlimited stock in the options, I understand that, but then I want to register it and it just didn't want to register, I had that problem quite a lot.

***Was it continuous or not?**

I have no idea what it was, because I bought some stuff and it was like a different brand; I went to another store, it was a different sort of the same thing. It was some turkey, or beef, the stuff you put on a sandwich [ham], so I bought that and I scanned it, and it didn't work. I didn't expect it to be in the place but I wanted to put it in, and it just didn't work. And then it was something else, like a milk that I got and it didn't work. I couldn't register it, but then I could register it another time, like some time later.

I think it was just random for me because sometimes I bought some stuff and I had it at home a few days and then I registered and something like that... but yeah, it was like at some point it just didn't work and then I didn't understand why it didn't work, so yeah, I guess there was a point [in which it happened].

Did you find the questions in the app relevant?

Yes, I would say. I don't remember all of the questions now but I don't remember I had any problem with any question. Just one problem that I had was with the input, to put stuff in. Sometimes the kilo

and the liter, it didn't work, and it was a pain to go in and change something, because I wrote something and then all of a sudden "10 kilos? No, I meant 10 liters", so I had to delete it all and scan it again, that was a hassle. So it should be like having an option to go in and just modify whatever you have already put in.

Also, being able to go in and say like, "Previously I have bought this, and I bought this again". Just like, add a new one instead of going and scanning. Because that you can do when you're on your way home on the tram or the bus from the shop, "ok, today I bought rice, then I bought the milk, then I bought the butter and the bread" and it's just like, you just go through your history and then you just add a new one, "refill, refill, refill". And then that would be much faster.

I totally understand that you have to put some of the stuff in the first time, because not everything can be in the history, or the portfolio, or whatever, so you have to put it in. But then once you have put it in, then it's in your history so you might as well use the history instead of just going "So ok, two months ago I bought this, so exciting".

How did you find the ratio between registering foods with and without barcode? Did you perceive any change in any of these categories?

No, I, well actually yes, there was one time that I, that the barcode didn't work and then I had put in the numbers manually, but it wasn't that much, I mean it wasn't that many times, it was a few times. The biggest problem was that it wasn't in the list and then I had put it in and then it didn't work when I was trying to register that product. The barcode wasn't the biggest issue... it wasn't a big issue actually, so it was just like, you put it there, then if it doesn't work you write it; but when you're trying to register it, it didn't work and then you had to start again from scratch and put the barcode again, and then, after you've done this two or three times, you're like "I'm done with this".

***But in the things that you bought, were there more things with or without barcode?**

Most of it had a barcode. Mostly. It was just like onions, potato, garlic, but almost all of it had a barcode. Because those stuff I bought in bigger quantity, then I don't use onions and potatoes that much. And then I would buy that maybe twice a month.

***After cutting back on beef, did you buy more vegetables?**

No, just more chicken, and eating more vegetarian, which basically means that I cook the same food but just no beef.

***How about in amounts?**

Actually, yes... more mushrooms, more beans and more corn. Mushrooms don't have a barcode so it's, yeah, just the mushrooms. But it would be, I mean, a bigger quantity of beans.

***But the beans do have a barcode?**

Yeah.

Was it common for you to buy products that weren't in the database? (*Expand on which supermarket depending on answer*)

Yes, I mean, I think I used it for a month, so not for very long, and then during that month I went to a store, in Kortedala, and I bought some stuff in an Arabic store, and a lot of those things weren't at the list, but I think it was because they were from that store, they're not that common, but the other stuff... [Yes].

***But was that a one-time thing?**

Yeah, it's so far away so I didn't go more. All the other stuff is from ICA Konsum, Willys, just those I buy, so most things would've been there.

Did you add them to database?

No, I couldn't manage it, and then it went so long, so I had to throw away the package, so I didn't have the package anymore.

Was it easy to identify whether the waste was avoidable or not?

No, I had some trouble with that, I don't remember exactly what it was, but it was something like, "Is it avoidable? Is it not?" Because some people would use it and then some don't; so for me it's not avoidable, because I don't like that part, but how do I... what do I do? So I just put not avoidable. I don't remember, I really don't remember, it was something.

Were there any foods that were hard to register or didn't register at all?

***The ones that you said that were hard to register or didn't register at all, you said it was some turkey?**

Yeah, it was some turkey, I think it was three of them of a different kind. Turkey, two beefs actually, and then one chicken, and it's like these salamis or these things that you put on sandwiches, for breakfast or whatever, those didn't register. One of them actually did register at some point but then I couldn't get it to go in again, like the new ones... but I stopped buying those, because it's beef and I just didn't need it, it wasn't necessary. Although it's tasty and it is also quite expensive so I save money and I save the environment.

How did you perceive the accuracy of your estimated percentages of waste?

Somewhat accurate, not very sure about it, etc...

It was ok, some of it might have been too much, or too little, but in general it was alright, it was 5% or 10%, it was ok.

Would you use the app in daily life?

A variation of it, definitely, if it didn't include all of these gadgets, like that thing, the barcode scanner. It's like... it's ok, but it's not like anybody is going to hand it to me for free, so I'd have to buy it. I wouldn't have bought it. If I could use my phone and scan, something like that, or if it was an app on the phone, then it would have been ok. Then if it's simple to use, like I said, if you can go inside and you can say "This much of it". And then if it had options that are common, say that, "usually when most people buy this product, this much goes to waste", like "5% of this item goes to waste", for example, because most people would go for that one and then you would have an option if it's more or less, but then it would be much more easier and faster, so you scan it and then bam, bam, bam, done. Instead of "scan, wait, ok, put it in, all of this".

***Do you mean something that would reflect your habits?**

Yeah, if I've been using the app for some time, then it could reflect my habits, but if I'm new to this app, it would be the general average of all of the users, so everybody that has bought this product has reported a waste of 10% for instance, and then it would adjust that, so you would click it. But it doesn't have to be that, it can be like maybe a scale of 5 to 15, 20, you have the options and you click it, that would speed things up.

Feedback functions:**Did you use any of the food tips suggested in the app?**

***Did you get the tips in the app? Like for example, if you wasted chicken some tip would show up.**

I didn't waste chicken, haha... no, I don't think so, I put in once that I made a meal and then I wasted it, I forgot to put it in the fridge, it was out, so then I had to put like yeah, 100 g of this, but I didn't get that tip.

***So you didn't get any of the tips?**

No, not that I remember. I hope that I put that... I remember that I had bought a vegetable, like a zucchini or something and I wasted half of that, I think I should've have put it in, but it was at the same time that I had the problem with the app, so then I tried to put it in and then it didn't want to work; so I don't remember if I put it off and never did it or if I actually did it.

Did you start incurring in any of the recommended behaviors during study?

No

Did you check your inventory?

Yeah, I did. When I couldn't register something, I went in there. It was like, ok, I had something there, it didn't work, and then I think once something didn't register, I couldn't put it in; so I just used something that was already there, the same. I think it was with the milk, just put that thing and then I wrote the code down and I put it in, so it's like "yeah, whatever, it's milk, milk..." It shouldn't be... [Too different].

***So you just used it to use the information within the same app, or for anything else?**

No, I just went in to check what was registered, because sometimes it's like I put in something but "did it register, did it go through or did it not go through?", so I check "yeah, it's there", and a few times it was like "it's not there, why is it not there?" so I had to do it again. So it was just double check, "did it go through or did it not go through?"

Did you do anything with the information on the inventory?

[Answered in previous questions]

Did you check the environmental impact of your waste?

No... I think I went in but, wasn't it like a "Coming soon"? Yeah, and then I didn't check it.

***And the icons?**

No, when I used it, I just used the two and put it away.

Did it cause any reaction on you?

No, the only thing is that I thought it was nice and that I would like to do it more. If it's easier, yeah, if it's easier I would like to do it, because I think it's a good thing, like to keep statistics. Yeah, that's the only thing, but I kind of knew most of what I buy. Most of it, not all of it.

Suggestions:

Is there anything that could be added to the app that could help you waste less?

I guess if you do have waste, it would be a good way to quantify how much waste you produce, to see it in actual numbers, like "this much I have wasted or this much I have wasted", or it makes you think about it when you put it in. But for me, not really, because I've always been conscious of my waste.

What changes would you recommend in the app?

[Answered in previous questions].

***Other ideas:**

Mobile app. That would be awesome. But it's ok. I understand. And even if it's in on an iPad or tablet it should be fine, but it's just that, can I go in and put all of my purchases. That would be so much simpler. Or if you can use the camera on the tablet or the phone to register the barcode... splendid!

***Talking about visual recognition of waste:**

I don't know, the stuff that I usually waste is already cooked food, most of the time, cause' I don't have that much vegetables... then the vegetables is... how do you do with that app? If it's 100 g or 200 g, so that thing, you would still have to weigh it, but if it's a volume, like a plate, take a photo of the food. But then the next thing is you would have to put the recipe, like what did you put, and how much of it.

Final thoughts:

Did the study impact your buying/consuming/wasting habits in any way that was unexpected for you?

No.

Appendix 6 - Additional participant comments and interactions during study:

All dates are placed in 2015.

Participant #1

June 22nd - First part of interview. Didn't know if she would be able to participate due to living arrangement, but was very enthusiastic and offered to cook more.

July 16th - Received equipment and continued first interview. Said she would be off from work for the following 3 weeks. Offered to cook more during study because she really wanted to participate.

July 24th - Said that she got a message saying "Unsuccessful submission" several times. Couldn't remember what product, but it had a barcode. See Figure 33. Was a little confused about how to submit waste, with percentages and weights. Pasta registered as 0 kg and couldn't change.

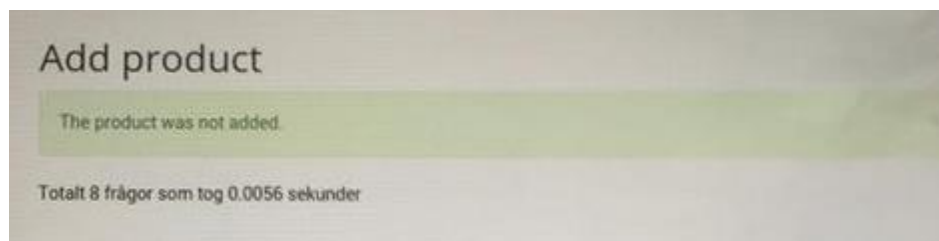


Figure 33 - Screen capture taken by participant #1, showing unsuccessful submission of a transaction

August 5th-August 12th - Couldn't use barcode reader it seemed disconnected from the app. Couldn't register input or waste of products with barcode, so put them as products without barcode. Waste transaction of pasta registered with weight of 0 kg, see Figure 34.

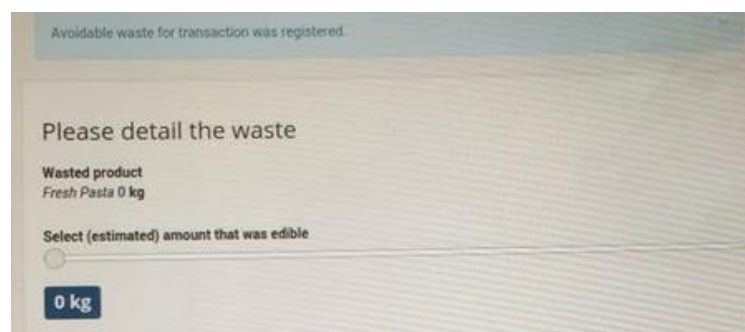


Figure 34 - Screen capture taken by participant #1, showing unsuccessful submission of waste of fresh pasta

December 3rd - Final interview.

Participant #2

July 16th - Had first interview. Attempted to add mushrooms with barcode to the database. The product registered successfully, but next time she attempted to input it, it wasn't in the database. Had to add again.

July 24th - When added eggs to the database, she set the weight for one egg instead of 15, so from then on, had to add egg 15 times because she couldn't go back and edit it. Confused about adding flour.

August 25th- September 7th - Didn't have the account and password.

October 10th-October 14th - Didn't have tablet password. Provided phone number for contact with Jesper.

November 30th - Set appointment for interview.

December 10th - Had final interview.

Participant #3

July 16th - First interview. Said he throws away food packages right after purchase, so thinks that is a case that should be considered in the app for registering waste. Wonders about distinction between products wasted and fully consumed within app. Wants a bigger picture (?). Asked him about it afterwards. Reply was:

"I'm not sure, but maybe I was just talking about your thesis and what might be the result of it. So, I think I meant that it would be nice if the app/service could provide a bigger picture of my food consumption??? Haha, not sure though"

Wonders about quantifying coffee waste, since it's one of his major waste sources.

July 18th - Thinks there should be a possibility to go to the transactions and choose what item to register waste for, in order not to have to scan it again. Thinks it would save a lot of time and effort.

Wonders how to register with waste from cooked meals.

August 4th - Can't add products that the app doesn't recognize. Some are added and some aren't without any specific pattern. Cooking oil and salami weren't successful, but cheese and milk were.

December 4th - Final interview.

Appendix 7 - Data obtained through app:

Below is presented all data retrieved from the use of the application by the participants.

Household #1 – All transactions

Week	Session	Timestamp	Product name	Amount	Transaction type	Carbon footprint (eCO ₂)	Water footprint (m ³)	Land use (gha)
Week 1	32	2015-07-16 17:42	Fruit Juice	2 l	add	2,8	2,04	2,2
		2015-07-16 17:42	Apelsinjuice	2 l	add	2,8	2,04	2,2
		2015-07-16 17:45	Fruit Juice	0,75 l	add	1,05	0,76	0,83
		2015-07-16 17:45	Standardmjölk	1 l	add	1,31	1,53	2,29
		2015-07-16 17:48	vispgrädde 36%	0,25 l	add	1,32	0	1,53
		2015-07-16 17:52	Eggs	0,165 kg	add	1,13	0,97	1,92
		2015-07-16 17:55	Yoghurt	0,2 l	add	0,78	0	0,34
		2015-07-16 17:56	Normalsaltat matfetsblandning 75%	0,6 kg	add	0,99	0	3,96
		2015-07-16 18:01	Beef	0,5 kg	add	9,83	7,91	21,97
		2015-07-16 18:01	X-tra Allt Kebab	0,165 kg	add	1,02	0	0
		2015-07-16 18:02	X-tra Allt Kebab	0,165 kg	add	1,02	0	0
		2015-07-16 18:03	frozen veg	0,6 kg	add	1,8	0	0
		2015-07-16 18:04	Pommes Frites	1 kg	add	0,36	0,16	0,92
		2015-07-16 18:04	X-tra Allt Kebab	0,165 kg	add	1,02	0	0
	WHH11	2015-07-18 11:59	vispgrädde 36%	-0,25 l	waste	1,32	0	1,53
	36	2015-07-19 10:51	Cucumber	0,55 kg	add	1,4	0,19	0,33
		2015-07-19 10:53	lettuce	0,65 kg	add	0,23	0,15	0,33
		2015-07-19 10:59	museli	0,2 kg	add	0,17	0,63	0
		2015-07-19 11:11	Breakfast Cereals	0,75 kg	add	0,64	1,05	6,26
Week 2	WHH12	2015-07-23 17:09	Coca Cola 1,5 liter PET	-1,5 l	waste	0,6	0	0,15
		2015-07-23 17:12	lettuce	-0,25 kg	waste	0,09	0,06	0,13
	39	2015-07-24 13:18	watermelon	2,45 kg	add	3,75	0	0
	40	2015-07-25 11:55	Ice Cream	2 l	add	4,2	0	86
	43	2015-07-28 22:52	watermelon	1,65 kg	add	2,52	0	0
		2015-07-28 22:56	watermelon	-0,65 kg	waste	0,99	0	0
		2015-07-28 23:01	Butter	-0,35 kg	waste	3,61	6,3	4,03
Week 3	47	2015-07-30 20:43	lettuce	0,55 kg	add	0,19	0,13	0,28
		2015-07-30 20:44	Lamb	2 kg	add	30,81	14,36	60,38
		2015-07-30 20:46	Coca Cola 1,5 liter PET	1,5 l	add	1,2	0	0,3
		2015-07-30 20:47	Apricot	1 kg	add	0,43	1,29	1,4
		2015-07-30 20:47	watermelon	1 kg	add	1,53	0	0
		2015-07-30 20:49	Potato	-0,2 kg	waste	0,07	0,03	0,18
		2015-07-30 20:50	Lamb	-0,15 kg	waste	2,31	1,08	4,53
		2015-07-30 20:53	Pizza	-0,2 kg	waste	1,24	0	0
	48	2015-08-01 11:23	Sausages & Meat Balls	0,8 kg	add	10	0	0
		2015-08-01 11:31	Vispgrädde	0,5 l	add	2,65	0	3,05
		2015-08-01 11:34	Tomato	0,4 kg	add	1,28	0,07	0,16
		2015-08-01 11:39	Eggs	0,7 kg	add	2,63	2,26	4,47
		2015-08-01 11:41	Potato	1,55 kg	add	0,55	0,24	1,42
		2015-08-01 11:43	Jättefranska	1,2 kg	add	1,2	1,93	1,2
		2015-08-01 12:24	Mushroom	-0,05 kg	waste	0,11	0	0
		2015-08-01 12:26	Fresh pasta	-0,1 kg	waste	0,62	0	0
		2015-08-01 12:28	Butter	-0,05 kg	waste	0,52	0,9	0,58

Week 4	WHH13	2015-08-06 21:51	lettuce	-0,25	kg	waste	0,09	0,06	0,13
		2015-08-06 21:53	Beef	-0,2	kg	waste	3,93	3,17	8,79
		2015-08-06 21:59	museli	-0,1	kg	waste	0,09	0,31	0
		2015-08-06 22:02	Carrot	-0,1	kg	waste	0,03	0,02	0,04
		2015-08-06 22:04	Onion	-0,1	kg	waste	0,03	0,03	0,07
		2015-08-06 22:08	Potato	-0,2	kg	waste	0,07	0,03	0,18
	52	2015-08-08 08:11	Standardmjölk	1,5	l	add	1,96	2,3	3,43
		2015-08-08 08:12	Standardmjölk	1,5	l	add	1,96	2,3	3,43
		2015-08-08 08:15	Fruit Juice	1	l	add	1,4	1,02	1,1
		2015-08-08 08:16	Fruit Juice	1	l	add	1,4	1,02	1,1
		2015-08-08 08:17	Äpplejuice	2	l	add	2,8	2,04	2,2
		2015-08-08 08:20	Cream	0,5	l	add	2,65	0	3,05
		2015-08-08 08:22	Soft Cheese	0,2	kg	add	2,5	0,97	2,27
		2015-08-08 08:23	CrispNiblets 3-pack	0,45	kg	add	0	0	0
		2015-08-08 08:23	Tomatketchup	0,5	kg	add	3,1	0,27	0
		2015-08-08 08:27	prepared flat fish	0,5	kg	add	1,93	0	26,18
	WHH14	2015-08-09 13:17	fresh flat fish	-0,1	kg	waste	0,39	0	5,24
		2015-08-09 13:19	Onion	-0,05	kg	waste	0,02	0,01	0,03
		2015-08-09 13:20	Cucumber	-0,05	kg	waste	0,13	0,02	0,03
	55	2015-08-12 20:41	bread	1,2	kg	add	0,61	0,56	0,94
		2015-08-12 20:41	Beef	1,5	kg	add	29,49	23,74	65,92
		2015-08-12 20:42	Cucumber	-0,3	kg	waste	0,76	0,11	0,18
		2015-08-12 20:43	lettuce	-0,25	kg	waste	0,09	0,06	0,13
		2015-08-12 20:44	Milk	-1,2	l	waste	1,57	1,84	2,75
		2015-08-12 20:46	Potato	-0,3	kg	waste	0,11	0,05	0,27
		2015-08-12 20:48	Alcoholic beverages	-0,9	l	waste	0,91	1,56	2,56
		2015-08-12 20:50	mustard	-0,2	l	waste	0,5	0	2,94
		2015-08-12 20:52	Mushroom	-0,1	kg	waste	0,21	0	0
Week 5	56	2015-08-18 19:39	watermeloen	2,15	kg	add	3,29	0	0
		2015-08-18 19:42	Cream	0,2	l	add	1,06	0	1,22
		2015-08-18 19:43	Olives	-0,15	kg	waste	0,55	0,41	1,16
		2015-08-18 19:44	Cucumber	-0,2	kg	waste	0,51	0,07	0,12
Week 6									
Week 7									
Week 8									
Week 9	60	2015-09-12 08:47	Standardmjölk	-1,5	l	waste	0,98	1,15	1,72
		2015-09-12 15:05	Eggs	0,3	kg	add	1,13	0,97	1,92
		2015-09-12 15:07	Eggplant	1	kg	add	1,3	0,36	0,6
		2015-09-12 15:08	watermeloen	1,05	kg	add	1,61	0	0
		2015-09-12 15:09	Beef	0,5	kg	add	9,83	7,91	21,97
		2015-09-12 15:10	museli	0,55	kg	add	0,47	1,73	0
		2015-09-12 15:10	Cucumber	0,4	kg	add	1,02	0,14	0,24
	62	2015-09-14 17:00	Original skogsbär (Yoghurt)	1	kg	add	3,9	0	1,7
		2015-09-14 17:00	Original skogsbär (Yoghurt)	1	kg	add	3,9	0	1,7
		2015-09-14 17:01	Original skogsbär (Yoghurt)	1	kg	add	3,9	0	1,7
		2015-09-14 17:02	Röd Grape (Juice)	1	l	add	1,4	1,02	1,1
		2015-09-14 17:03	Apelsin/Röd Grape (Juice)	1	l	add	1,4	1,02	1,1
		2015-09-14 17:04	Pineapple	1,05	kg	add	1,87	0,35	0,53
		2015-09-14 17:05	Pear	1,05	kg	add	0,49	0,63	1,46
		2015-09-14 17:06	watermeloen	-0,1	kg	waste	0,15	0	0
Week 10	64	2015-09-18 19:18	normalsaltat matfettblandning 75%	0,3	kg	add	0,5	0	1,98
		2015-09-18 19:18	normalsaltat matfettblandning 75%	0,3	kg	add	0,5	0	1,98
		2015-09-18 19:19	Apelsin/Röd Grape (Juice)	1	l	add	1,4	1,02	1,1
		2015-09-18 19:20	Apelsin (Juice)	1	l	add	1,4	1,02	1,1
		2015-09-18 19:21	Cream	0,25	l	add	1,32	0	1,53
		2015-09-18 19:23	Tomatoes (Crushed/Sliced/Peeled)	0,2	kg	add	0,57	0,05	0
		2015-09-18 19:23	Granatäpple Juicedrink Prisma	1	l	add	1,4	1,02	1,1
		2015-09-18 19:24	Eggs	0,3	kg	add	1,13	0,97	1,92
		2015-09-18 19:25	prepared flat fish	1	kg	add	7,4	0	0

	68	2015-09-21 08:19	Sugar	-0,2 kg	waste	0,11	0,24	3,72
		2015-09-21 08:21	Wheat Flour	-0,45 kg	waste	0,43	0,64	0,47
		2015-09-21 08:29	Eggs	-0,05 kg	waste	0,19	0,16	0,32
		2015-09-21 08:30	Cream	-0,15 l	waste	0,79	0	0,92
		2015-09-21 08:33	Butter	-0,15 kg	waste	1,55	2,7	1,73
		2015-09-21 08:35	Apelsin (Juice)	1 l	add	1,4	1,02	1,1
		2015-09-21 08:35	Apelsin (Juice)	1 l	add	1,4	1,02	1,1
		2015-09-21 08:35	Äpple (Juice)	1 l	add	1,4	1,02	1,1
2nd Phase								
Week 11	WHH15	2015-09-24 09:30	Chicken	-0,05 kg	waste	0,17	0,18	0,48
		2015-09-24 09:32	frozen veg	-0,1 kg	waste	0,3	0	0
		2015-09-24 09:33	Pommes Frites	-0,1 kg	waste	0,31	0	0
	71	2015-09-26 15:28	Pommes Frites	2 kg	add	6,2	0	0
		2015-09-26 15:32	Tomato	1,22 kg	add	3,9	0,21	0,49
		2015-09-26 15:33	Eggs	0,06 kg	add	0,23	0,19	0,38
		2015-09-26 15:34	Hard Cheese	0,5 kg	add	6,24	2,44	5,68
		2015-09-26 15:35	Standardmjölk	1,5 l	add	1,96	2,3	3,43
		2015-09-26 15:36	Apelsinjuice	1 l	add	1,4	1,02	1,1
		2015-09-26 15:36	Apelsin (Juice)	1 l	add	1,4	1,02	1,1
		2015-09-26 15:37	Vispgrädde	0,5 l	add	2,65	0	3,05
		2015-09-26 15:39	Beef	1 kg	add	19,66	15,83	43,95
	WHH16	2015-09-27 08:41	museli	-0,05 kg	waste	0,04	0,16	0
		2015-09-27 08:42	bread	-0,05 kg	waste	0,03	0,02	0,04
		2015-09-27 08:45	Hard Cheese	-0,05 kg	waste	0,62	0,24	0,57
Week 12	WHH17	2015-10-04 12:43	Carrot	-0,05 kg	waste	0,01	0,01	0,02
		2015-10-04 12:44	Potato	-0,05 kg	waste	0,02	0,01	0,05
		2015-10-04 12:45	fresh flat fish	-0,05 kg	waste	0,19	0	2,62
		2015-10-04 12:46	Milk	-0,3 l	waste	0,39	0,46	0,69

Household #1 – Waste characteristics

Waste date	Product	Amount	Type of waste	Edible ratio	Reason	State	Last of item
2015-07-18 11:59	vispgräddade 36%	-0.25 l	avoidable waste	-	-	-	-
2015-07-23 17:09	Coca Cola 1,5 liter PET	-1.5 l	avoidable waste	0,94	large package	opened package	yes
2015-07-23 17:12	lettuce	-0.25 kg	avoidable waste	0,05	large package	opened package	yes
2015-07-28 22:56	watermeloen	-0.65 kg	avoidable waste	0,51	spoiled	opened packaging	yes
2015-07-28 23:01	Butter	-0.35 kg	avoidable waste	0,06	large package	opened packaging	yes
2015-07-30 20:49	Potato	-0.2 kg	avoidable waste	0,1	large package	half eaten food	no
2015-07-30 20:50	Lamb	-0.15 kg	avoidable waste	1	large package	half eaten food	no
2015-07-30 20:53	Pizza	-0.2 kg	avoidable waste	1	large package	half eaten food	yes
2015-08-01 12:24	Mushroom	-0.05 kg	avoidable waste	1	large package	half eaten food	yes
2015-08-01 12:26	Fresh pasta	-0.1 kg	avoidable waste	1	large package	half eaten food	no
2015-08-01 12:28	Butter	-0.05 kg	avoidable waste	1	large package	half eaten food	no
2015-08-06 21:51	lettuce	-0.25 kg	avoidable waste	1	large package	half eaten food	yes
2015-08-06 21:53	Beef	-0.2 kg	avoidable waste	1	large package	half eaten food	no
2015-08-06 21:59	museli	-0.1 l	avoidable waste	1	large package	half eaten food	no
2015-08-06 22:02	Carrot	-0.1 kg	avoidable waste	1	large package	half eaten food	yes
2015-08-06 22:04	Onion	-0.1 kg	avoidable waste	1	large package	opened packaging	yes
2015-08-06 22:08	Potato	-0.2 kg	avoidable waste	1	large package	half eaten food	no
2015-08-09 13:17	fresh flat fish	-0.1 kg	avoidable waste	1	large package	half eaten food	no
2015-08-09 13:19	Onion	-0.05 kg	avoidable waste	1	large package	half eaten food	no
2015-08-09 13:20	Cucumber	-0.05 kg	avoidable waste	1	large package	half eaten food	no
2015-08-12 20:42	Cucumber	-0.3 kg	avoidable waste	1	wrong storage	opened packaging	yes
2015-08-12 20:43	lettuce	-0.25 kg	avoidable waste	1	wrong storage	opened packaging	yes
2015-08-12 20:44	Milk	-1.2 l	avoidable waste	1	wrong storage	opened packaging	yes
2015-08-12 20:46	Potato	-0.3 kg	avoidable waste	1	wrong storage	opened packaging	yes
2015-08-12 20:48	Alcoholic beverages	-0.9 l	avoidable waste	1	not tasty	opened packaging	yes
2015-08-12 20:50	mustard	-0.2 l	avoidable waste	1	wrong storage	opened packaging	yes
2015-08-12 20:52	Mushroom	-0.1 kg	avoidable waste	1	wrong storage	half eaten food	yes
2015-08-18 19:43	Olives	-0.15 kg	avoidable waste	1	wrong storage	opened package	yes
2015-08-18 19:44	Cucumber	-0.2 kg	avoidable waste	1	wrong storage	opened package	yes
2015-09-12 08:47	Standardmjölk	-1.5 l	avoidable waste	1	passed expiration date	opened package	yes
2015-09-14 17:06	watermeloen	-0.1 kg	possibly avoidable	0,46	not tasty	opened package	yes
2015-09-21 08:19	Sugar	-0.2 l	avoidable waste	1	not tasty	half eaten food	no
2015-09-21 08:21	Wheat Flour	-0.45 l	avoidable waste	1	not tasty	half eaten food	no
2015-09-21 08:29	Eggs	-0.05 l	avoidable waste	1	not tasty	half eaten food	no
2015-09-21 08:30	Cream	-0.15 l	avoidable waste	1	not tasty	half eaten food	no
2015-09-21 08:33	Butter	-0.15 kg	avoidable waste	1	not tasty	half eaten food	no
2nd phase							
2015-09-24 09:30	Chicken	-0.05 kg	avoidable waste	1	wrong storage	half eaten food	yes
2015-09-24 09:32	frozen veg	-0.1 kg	avoidable waste	1	wrong storage	half eaten food	yes
2015-09-24 09:33	Pommes Frites	-0.1 kg	avoidable waste	0	wrong storage	half eaten food	yes
2015-09-27 08:41	museli	-0.05 l	possibly avoidable	1	wrong storage	half eaten food	yes
2015-09-27 08:42	bread	-0.05 kg	possibly avoidable	1	wrong storage	half eaten food	yes
2015-09-27 08:45	Hard Cheese	-0.05 kg	possibly avoidable	1	wrong storage	half eaten food	yes
2015-10-04 12:43	Carrot	-0.05 kg	avoidable waste	1	wrong storage	half eaten food	no
2015-10-04 12:44	Potato	-0.05 kg	avoidable waste	0	wrong storage	half eaten food	no
2015-10-04 12:45	fresh flat fish	-0.05 kg	avoidable waste	0	wrong storage	half eaten food	no
2015-10-04 12:46	Milk	-0.3 l	not sure	1	passed expiration date	opened package	yes

Household #2 – All transactions

Week	Session	Timestamp	Product name	Amount	Transaction type	Carbon footprint (eCO ₂)	Water footprint (m3)	Land use (gha)
Week 1	33	2015-07-16 21:11	Mushroom	0,5 kg	add	1,07	0	0
		2015-07-16 21:15	Cabbage	0,5 kg	add	0,19	0	0,25
	WHH21	2015-07-20 12:10	Cabbage	-0,1 kg	waste	0,04	0	0,05
		2015-07-20 12:13	Mushroom	-0,05 kg	waste	0,11	0	0
	37	2015-07-22 13:15	Mellanmjölk 1,5%	1 l	add	1,31	1,53	2,29
		2015-07-22 13:16	cherries	0,5 kg	add	0,27	0,8	0,95
		2015-07-22 13:21	Cauliflower	0,8 kg	add	1,43	0,23	0
Week 2	38	2015-07-23 18:07	Carrot	1 kg	add	0,28	0,2	0,35
		2015-07-23 18:08	Lamb	0,5 kg	add	7,7	3,59	15,1
		2015-07-23 18:09	Pork	0,5 kg	add	2,98	2,58	7,72
		2015-07-23 18:15	Apple	0,45 kg	add	0,21	0,27	0,63
		2015-07-23 18:17	Eggs	0,06 kg	add	0,23	0,19	0,38
		2015-07-23 18:17	Eggs	0,06 kg	add	0,23	0,19	0,38
		2015-07-23 18:18	Eggs	0,06 kg	add	0,23	0,19	0,38
		2015-07-23 18:18	Eggs	0,06 kg	add	0,23	0,19	0,38
		2015-07-23 18:18	Eggs	0,06 kg	add	0,23	0,19	0,38
		2015-07-23 18:18	Eggs	0,06 kg	add	0,23	0,19	0,38
		2015-07-23 18:18	Eggs	0,06 kg	add	0,23	0,19	0,38
		2015-07-23 18:19	Eggs	0,06 kg	add	0,23	0,19	0,38
		2015-07-23 18:19	Eggs	0,06 kg	add	0,23	0,19	0,38
		2015-07-23 18:19	Eggs	0,06 kg	add	0,23	0,19	0,38
		2015-07-23 18:19	Eggs	0,06 kg	add	0,23	0,19	0,38
		2015-07-23 18:19	Eggs	0,06 kg	add	0,23	0,19	0,38
		2015-07-23 18:19	Eggs	0,06 kg	add	0,23	0,19	0,38
		2015-07-23 18:19	Eggs	0,06 kg	add	0,23	0,19	0,38
		2015-07-23 18:19	Eggs	0,06 kg	add	0,23	0,19	0,38
		2015-07-23 18:19	Eggs	0,06 kg	add	0,23	0,19	0,38
		2015-07-23 18:19	Eggs	0,06 kg	add	0,23	0,19	0,38
	42	2015-07-26 00:32	Pork	0,5 kg	add	2,98	2,58	7,72
	44	2015-07-28 23:45	Salad	0,175 kg	add	0,65	0	8,84
		2015-07-28 23:46	Peanuts	0,2 kg	add	0,53	0,95	3,07
		2015-07-28 23:47	Peanuts	0,2 kg	add	0,53	0,95	3,07
		2015-07-28 23:48	Apricot	0,2 kg	add	0,09	0,26	0,28
		2015-07-28 23:48	Sport 275g	0,275 kg	add	0	0	0
Week 3	45	2015-07-30 16:18	Milk	1,5 l	add	1,96	2,3	3,43
		2015-07-30 16:18	Osaltat 83%	0,25 kg	add	2,58	4,5	2,88
		2015-07-30 16:19	Salad	0,2 kg	add	0,74	0	10,11
	50	2015-08-05 19:01	Skärgårdskaka	0,75 kg	add	0,73	0	0,75
	51	2015-08-05 19:03	Blueberries	0,1 kg	add	0,11	0,04	0,19
		2015-08-05 19:04	Nectarine	1 kg	add	0,66	0,91	0,8
Week 4	54	2015-08-12 19:16	Tomato	0,25 kg	add	0,8	0,04	0,1
		2015-08-12 19:17	Spinach	0,07 kg	add	0,16	0,02	0,04
		2015-08-12 19:18	Mushroom	0,25 kg	add	0,53	0	0
		2015-08-12 19:20	Mushroom	0,15 kg	add	0,32	0	0
		2015-08-12 19:20	Tomato	0,3 kg	add	0,96	0,05	0,12
		2015-08-12 19:23	Raspberry	0,5 kg	add	0,46	0,17	0,35
		2015-08-12 19:23	Mild Lättyoghurt Vanilj	1 kg	add	3,9	0	1,7
		2015-08-12 19:25	Peach	0,3 kg	add	0,2	0,27	0,24
		2015-08-12 19:27	Nectarine	-0,35 kg	waste	0,23	0,32	0,28
Week 5	WHH22	2015-08-18 22:38	Tomato	-0,1 kg	waste	0,32	0,02	0,04
	57	2015-08-19 16:00	Eggs	0,8 kg	add	3	2,58	5,11
		2015-08-19 16:00	Mushroom	0,15 kg	add	0,32	0	0
		2015-08-19 16:01	Onion	0,4 kg	add	0,14	0,11	0,27
Week 6	58	2015-08-20 17:11	Grape	0,5 kg	add	0,85	0	0
		2015-08-20 17:12	Tomato	1 kg	add	3,2	0,17	0,4

[illegible]

Week 13	73	2015-10-14 21:13	Banan	0,8	kg	add	0,62	0,52	0,8
		2015-10-14 21:14	Cabbage	2	kg	add	0,77	0	1
		2015-10-14 21:14	Carrot	0,4	kg	add	0,11	0,08	0,14
		2015-10-14 21:15	lettuce	0,4	kg	add	0,14	0,09	0,2
		2015-10-14 21:21	Beef	0,4	kg	add	7,86	6,33	17,58
		2015-10-14 21:22	Pork	0,4	kg	add	2,39	2,07	6,18
		2015-10-14 21:23	Chicken	-0,45	kg	waste	1,51	1,61	4,31

Household #2 – Waste characteristics

Waste date	Product	Amount	Type of waste	Edible ratio	Reason	State	Last of item
2015-07-20 12:10	Cabbage	-0.1 kg	possibly avoidable	0	not tasty	opened package	no
2015-07-20 12:13	Mushroom	-0.05 kg	possibly avoidable	1	not tasty	opened package	yes
2015-08-12 19:27	Nectarine	-0.35 kg	avoidable waste	-	-	-	-
2015-08-18 22:38	Tomato	-0.1 kg	avoidable waste	0	forgot about it	opened package	yes
2015-09-22 22:17	Cabbage	-0.1 kg	not sure	0	spoiled	opened package	no
2015-09-22 22:18	Onion	-0.05 kg	not sure	0	spoiled	opened package	yes
2nd Phase							
2015-10-14 21:23	Chicken	-0.45 kg	avoidable waste	0	forgot about it	half eaten food	yes

Household #3 – All transactions

Week	Session	Timestamp	Product name	Amount	Transaction type	Carbon footprint (eCO ₂)	Water footprint (m3)	Land use (gha)
Week 1	34	2015-07-17 16:50	Hellmann's Real Mayonaise	0,4 kg	add	1	0	5,88
	35	2015-07-18 16:36	Tomatoes (Crushed/Sliced/Peeled)	0,5 kg	add	1,43	0,13	0
		2015-07-18 16:38	Tomato Puree	0,8 kg	add	2,56	0,57	0
		2015-07-18 16:38	Tomatoes (Crushed/Sliced/Peeled)	0,5 kg	add	1,43	0,13	0
		2015-07-18 16:39	Mix Bolognese	0,079 kg	add	0,2	0	1,16
		2015-07-18 16:39	Tomato	0,3 kg	add	0,96	0,05	0,12
		2015-07-18 16:40	Tomatoes (Crushed/Sliced/Peeled)	-0,5 kg	waste	0,14	0,01	0
		2015-07-18 16:45	Tuna	0,185 kg	add	0,74	0	0
		2015-07-18 16:46	Tomatoes (Crushed/Sliced/Peeled)	0,4 kg	add	1,14	0,11	0
		2015-07-18 16:48	Beans	0,42 kg	add	0,32	1,5	2,63
		2015-07-18 16:49	Tinned Sweetcorn	0,6 kg	add	1,32	0	3
		2015-07-18 16:52	Pepper	0,4 kg	add	1	0	5,88
		2015-07-18 16:53	Garlic	0,15 kg	add	0,09	0,09	0,12
		2015-07-18 16:55	Spinach	0,25 kg	add	0,56	0,07	0,15
		2015-07-18 16:56	Lemon	0,25 kg	add	0,13	0,12	0,26
		2015-07-18 16:56	Fanta Exotic 1,5 liter PET	1,5 l	add	1,2	0	0,3
		2015-07-18 16:58	Jam	0,75 kg	add	2,25	0	0
		2015-07-18 16:59	Milk	1 l	add	1,31	1,53	2,29
		2015-07-18 16:59	Butter	0,75 kg	add	7,73	13,5	8,63
		2015-07-18 17:00	Milk	1 l	add	1,31	1,53	2,29
		2015-07-18 17:02	Coca Cola 1,5 liter PET	1,5 l	add	1,2	0	0,3
		2015-07-18 17:04	Beer pripps	0,5 l	add	0,65	1,32	0,6
		2015-07-18 17:04	Beer pripps	0,5 l	add	0,65	1,32	0,6
		2015-07-18 17:04	Beer pripps	0,5 l	add	0,65	1,32	0,6
		2015-07-18 17:04	Beer pripps	0,5 l	add	0,65	1,32	0,6
		2015-07-18 17:04	Beer pripps	0,5 l	add	0,65	1,32	0,6
		2015-07-18 17:04	Beer pripps	0,5 l	add	0,65	1,32	0,6
		2015-07-18 17:04	Bryggkaffe Mellanrost	0,5 kg	add	4,05	6,55	11,21
Week 2								
Week 3	49	2015-08-04 16:51	Mellanmjölk	1,5 l	add	1,96	2,3	3,43
		2015-08-04 16:51	Yellow Label Tea 100-pack	0,2 kg	add	0,17	1,81	3,31
		2015-08-04 16:52	Milk	1,5 l	add	1,96	2,3	3,43
		2015-08-04 16:57	Mellanmjölk	1,5 l	add	1,96	2,3	3,43
		2015-08-04 16:59	Soft Cheese	0,2 kg	add	2,5	0,97	2,27
		2015-08-04 17:01	Hard Cheese	0,1 kg	add	1,25	0,49	1,14
		2015-08-04 17:01	Butter	0,75 kg	add	7,73	13,5	8,63
		2015-08-04 17:07	Beef	2,15 kg	add	42,26	34,03	94,48
		2015-08-04 17:08	Chicken	0,9 kg	add	3,02	3,22	8,63
		2015-08-04 17:09	Sausages & Meat Balls	0,45 kg	add	5,63	0	0
		2015-08-04 17:12	Hard Cheese	0,18 kg	add	2,25	0,88	2,05
		2015-08-04 17:13	Chili	1 kg	add	0,87	7,37	18,55
		2015-08-04 17:16	Cream	0,3 l	add	1,59	0	1,83
		2015-08-04 17:16	Cream	0,3 l	add	1,59	0	1,83
		2015-08-04 18:51	Lemon	-0,15 kg	waste	0,08	0,07	0,15
Week 4	53	2015-08-11 16:53	Fiberrost, skivad	1 kg	add	1	1,61	1
		2015-08-11 16:55	Spaghetti	1 kg	add	1,6	0	0
		2015-08-11 16:55	Spaghetti	1 kg	add	1,6	0	0
		2015-08-11 16:55	Tomatoes (Crushed/Sliced/Peeled)	1,2 kg	add	3,43	0,32	0
		2015-08-11 16:56	Beans	0,42 kg	add	0,32	1,5	2,63
		2015-08-11 16:56	Beans	0,42 kg	add	0,32	1,5	2,63
		2015-08-11 16:56	Peach	1 kg	add	0,66	0,91	0,8
		2015-08-11 16:57	Onion	0,3 kg	add	0,1	0,08	0,21
	WHH31	2015-08-12 14:38	Rice	-0,7 kg	waste	2,56	1,66	2,21
Week 5	WHH32	2015-08-18 23:17	Peach	-0,1 kg	waste	0,07	0,09	0,08
		2015-08-18 23:21	Hard Cheese	-0,1 kg	waste	1,12	0,44	1,02

Household #3 – Waste characteristics

Waste date	Product	Amount	Type of waste	Edible ratio	Reason	State	Last of item
2015-07-18 16:40	Tomatoes (Crushed/Sliced/Peeled)	-0.5 kg	avoidable waste	0	Spoiled	opened package	yes
2015-08-04 18:51	Lemon	-0.15 kg	avoidable waste	1	forgot about it	half eaten food	yes
2015-08-12 14:38	Rice	-0.7 kg	avoidable waste	0,79	wrong storage	prepared food	no
2015-08-18 23:17	Peach	-0.1 kg	avoidable waste	0,79	Spoiled	opened package	no
2015-08-18 23:21	Hard Cheese	-0.1 kg	avoidable waste	1	spoiled	opened package	yes