Reducing Food Waste Using Information Technology: A Case from Switzerland

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Abstract

About 2.8 million tons of food waste are generated in Switzerland every year. Negative environmental impacts of food waste are on average higher at the end of the food chain than at the beginning. So far there are no quantitative studies to evaluate the requirements for information technology (IT) to reduce food waste in Swiss households. To investigate this matter a representative survey was conducted in Switzerland. Based on its results, the authors conclude that IT is expected to be most effective in reducing food waste in Swiss households when focusing on the management of the entire food stock. Therefore, further research should dive into the management of the food stock items as well as exploring more radical concepts to reduce the food stock itself.

Keywords: food waste, survey, acceptance, IT adoption

1. Introduction

Around 828 million people worldwide are suffering hunger [1]. Roughly one third of the food produced for human consumption every year – approximately 3 billion tons – gets lost or wasted [2]. In Switzerland, currently 2.8 million tons of avoidable food loss is occurring across all stages of the Swiss food chain. This adds up to around 330 kg of avoidable food waste per person per year, or 37% of agricultural production (i.e. food produced in Switzerland and abroad for consumption in Switzerland) [3]. The environmental impact of food waste increases throughout the food chain (transport, processing, cooling, heating etc.) hence, avoidance measures at the end of the food chain (households, catering industry, and retailers) are particularly important. Food waste is a waste of money, no doubt. The cost of food disposed in Swiss households amounts to over 600 US Dollars per person per year [4]. Climate impacts of avoidable food waste amount to just under half a ton of CO_2 equivalent per person per year, or 24% of the climate impacts of Switzerland's entire food system [4]. Therefore, throwing away vast quantities of food is highly questionable from an ecological, economic and ethical point of view. There is an urgent need for action to get a grip on food waste, not only in Switzerland but worldwide. First, a more conscious approach to food can drastically reduce world hunger. Secondly, reducing food waste can effectively reduce environmental pollution and waste of resources.

1.1. Problem Statement

To facilitate the sustainable handling of this topic, various studies, technical implementations, and recommendations have been proposed by both – academia and practice.

Literature research show that over the past ten years, several studies on food waste have been conducted within the European Union and worldwide – e.g. [5]-[7]. Topics is this field are widely spread and are ranging from the identification of sources of food waste [7], investigation of household's behavior [8], [9], up to the classification of waste [10] or reports to transform agrifood systems [1]. Although large organizations like the United Nations are constantly reporting about global hunger and analyzing the effects of food and agriculture at the global level – in academic research very limited information can be found on the impact of using information technology (IT) to reduce food waste. Recent studies in this field are focusing on specific technologies and concepts such as deep learning algorithms for identifying food waste [11], IoT for smart garbage management [12] or image recognition in manufacturing to properly discard, compost, or recycle waste

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[13]. These and other examples of technology implementations raise the question of why this particular solution can solve the problem of food waste and how to be sure that the technology will be accepted by the consumer.

Beretta and Hellweg found out that about 40% of food is wasted at the consumer level [4]. However, literature shows a lack of data for individual consumer behavior (food waste) and their willingness of using IT [8], [9]. Just a few studies focusing on the consumer level and the usage of IT to recused food waste can be found. A case from Baldwin Wallace University (USA) shows that food waste and food insecurity are prevalent challenges on college campuses [15]. The authors presented a system called "Campus Plate", a platform that allows students to quickly identify and retrieve excess food from dining services and campus events using their smartphones. Aydin and colleagues present a mobile application that communicates food safety information to encourage better food management, primarily in consuming purchased food products before they expire [16].

It can be summarized that the main reasons for the high amount of food waste from households are a lack of awareness of one's own food waste, a lack of awareness of the value of food as well as insufficient knowledge about shelf life, storage, and methods for recycling leftovers [20].

1.2. Objectives

This paper steps back to analyzes the requirements for IT usage when it comes to food waste, without initially relying on a specific technology. Hence, the focus is on understanding the problem in the given context. This contribution aims to better understand aspects of household's IT adoption in the specific context of smart food waste management in Switzerland. The assumption that food waste in households is not reduced by IT itself, but rather by technology influencing people's actions is made [19]. Therefore, a focus lies on the following aspects:

- Willingness of Swiss households to use information technology to reduce food waste
- Expected benefits from using IT
- Core functionalities that are required in an IT solution.

The remainder of this paper is organized as follows: First, the theoretical framework, the state of the art in food waste, and IT adoption (Section 2) are laid out. Therein, challenges and impediments dealing with food waste are shown. The findings of a literature research are used as the basis for structuring the knowledge and understanding of the problem domain at hand [17] – a quantitative representative survey in Swiss households (Section 3). The results are finally discussed and critically examined. A conclusion section with future work forms the final part of this paper.

2. Theoretical background

In the further course of the work, the findings of the literary research are used as the basis for the structure of the survey (Section 3) to identify relevant aspects that can help to avoid food waste.

2.1. Methodology

In order to classify existing approaches and identify their relevance for the identified problem, the taxonomy framework by Cooper [18] is applied. This taxonomy addresses six characteristics: (1) the literature review was conducted investigating contributions ranging from 2014 until 2022, (2) the goal is to explore the field of IT usage reducing food waste thoroughly and identify central issues, (3) perspective is neutral when presenting findings as facts, (4) 181 articles are covered focusing on contributions in English, (5) organized chronologically, emphasizing the progression of contributions in the field over time, and (6) audience are in the intersection of computer science and business, coming from both, science and practice. (p. 109).

Following the approach by Cooper [18], who proposed a stage model for conducting literature reviews, the following databases were searched, using "food waste" AND "IT usage" OR "IT adoption" as search terms in titles and abstracts:

(1) ACM Digital Library, (2) IEEE Xplore Digital Library to explore sources with a technology perspective such as the development and implementation of smart waste management systems, (3) AIS Electronic Library (AISeL) to locate core food waste topics.

The ACM Digital Library yielded 37, the IEEE Xplore 137 and seven contributions were found by AISeL. A total number of 181 contributions is reported. After excluding inappropriate entries, as well as double counts (i.e. the same article listed in several databases) a total of twelve contributions are analyzed. Two papers were dropped as they are non-academic contributions leaving ten for final analysis. No contribution was found dealing with food waste and consumer be-

havior in conjunction with IT adoption. The results of the review have been generalized and are further used within the definition of the hypotheses (Section 3).

2.2. IT adoption frameworks and theory

The Theory of Reasoned Action (TRA) is one of the oldest models in this field [21]. Firstly developed in the '70s for sociological studies, it recently became foundation to investigate individuals' IT usage behavior [22]. In this model, any human behavior is predicted and explained through three main cognitive components including attitudes ((un-)favorableness) of person's feeling), social norms, and intentions. The main disadvantages of TRA are the lack of addressing the role of habit, the cognitive deliberation, misunderstanding through a survey (attitudes, subjective norms, and intention of the respondents) and the moral factors. The Technology Acceptance Model [23] is probably one of the most widely cited model in the field of technology acceptance [24]-[27]. In relation to the problem at hand, this model has limitations - since the intrinsic motivations in TAM are not addressed, it is restricted suitable for application in a customer context in which the acceptance and use of information technologies is intended not only for the fulfillment of tasks, but also for fulfillment of emotional needs. Since this contribution aims to better understand aspects of household's IT adoption in the specific context of smart food waste management in Switzerland, the plethora of TAM studies provide a fruitful source to evaluate the acceptance of a specific technology applied to reduce food waste.

2.3. Food waste drivers

In the United Kingdom, a six-year study by the Waste & Resources Action Program, analyzed the food waste behavior of households [10]. Although the study focused on the situation in the UK, many insights maybe applicable to other developed countries with similar patterns of shopping, food preparation and consumption.

The generation of food waste is the result of multiple behaviors related to many different aspects of food's journey into and through the home planning, shopping, storage, preparation and consumption. Research indicates that there are two main ways of reducing the amount of food waste in households – by influencing people's actions [9] or by making changes to the food that is sold [10].

The factors that encourage people to reduce food waste are varied and cover a range of themes and motivations (Figure 1).

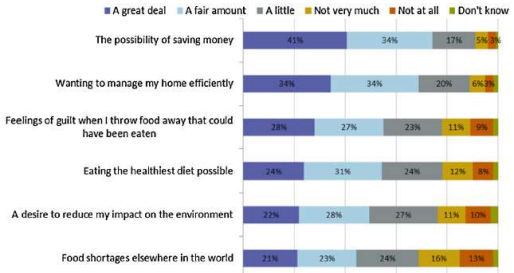

Figure 1. Factors that encourage people to reduce food waste.

The fact that environmental concerns and those associated with food shortages elsewhere in the world have less weight placed on them indicates that the link between food waste and environmental impact is not firmly established in people's minds [10].

2.4. Food waste in Swiss households

According to the Swiss Federal Office for the Environment [3] Swiss households generate around one million tons of food waste every year. The main reasons for the high level of avoidable household food waste in Swiss households are a general lack of awareness of the waste generated and of the value of food, insufficient knowledge about shelf life and storage, as well as insufficient knowledge about ways to make use of leftover food [4]. A study conducted in 2014 by Bieri and colleagues shows that 77% of Swiss residents aged 15+ would like to see the problem of food waste dealt with great or rather great commitment but that the problem is not urgent [29]. In addition, food waste is seen mainly a problem of others: 82% believe that a very small or rather small amount of their own food ends up in waste, whereas 56% believe that all over Switzerland a very large or rather large amount of food ends up in waste.

2.5. Food waste interventions

Literature reports on several design measures to reduce food waste in households – some prototyped and tested, some just suggestions for improvement, and others already on the market. Hebrok and Boks [5] noted that one of the dominant categories of interventions is technology

"that helps people plan, share, and track inventories." The authors wondered if there might be potential interventions in the form of [new products,] systems and infrastructure that could push consumers to reduce their food waste.

A recent study by Seiler and colleagues (2022) developed a virtual reality (VR) application with the help of a focus group [28]. It turned out, that VR is considered suitable for building awareness on an individual level to reduce food waste. A prototype developed to track the shelf life of groceries to reduce rood waste, indicates that the utilized methods for the automated and assisted entry of groceries can have a positive influence on the acceptance and usage of such a system [30]. A more quantifiable study by Phiri and Trevorrow, turned out that the usage of a mobile app called "FoodTrek" showed a 10% decrease in food waste [31]. The study intended to investigate food waste using IT to initiate consumer's behavior change. The app alerts consumers with regards to end dates of food items in their household. Gayathri et al. [32] provides further insights on user motivation and social interaction in connection with IT usage and food waste. Based on RFID sensors they have created a system that measures the food waste and provides rewards for the "non-food wasting" consumers. The systems allows tracking real-time food wastage. This research mainly focuses on monitoring the food wastage of everyone. Literature review, as summarized above, revealed that although researchers have thoroughly analyzed food waste in Switzerland. However, the use of IT to reduce food waste has not yet been thoroughly examined. Recent studies in this field are focusing on specific technologies and concepts such as deep learning algorithms for identifying food waste [11], IoT for smart garbage management [12], image recognition in manufacturing to properly discard, compost, or recycle waste [13], using VR [28], mobile app technology [15], [16], [30], [31], RFID sensors [32] or smart refrigerators [33]. Furthermore, frameworks for smart city platforms have been developed containing smart people and smart environment as elements where the topic of food waste could be incorporated to contribute to smart cities [34]. The review revealed that reward systems and social interaction in IT systems could be powerful supportive tools on food waste. In addition, these examples of technology implementations suggest that the use of IT in relation to food waste avoidance can have a positive learning effect on the consumer. On the other hand, it became obvious that technology concepts such as IoT with RFID sensors and deep learning algorithms allowing to track real-time food wastage are calling for data privacy. The results of the review have been generalized and are further used within the definition of the hypotheses (Section 3). The investigated aspects of (1) motivation, (2) social interaction and (3) data privacy turned out important factors for successful IT adoption for food waste avoidance.

3. Survey design

3.1. Methodology

Since this work aims to be both scientifically rigid and relevant for practice, we use the "Information Systems Research Framework" for orientation (Figure 2). Within the framework proposed by Hevner et al., the two phases *'develop/build'*, and *'justify/evaluate'* can be found [17] (p.80). These phases illustrates the meshing of the two research paradigms «design science research» and «behavioural-science» in order to position and compare them. The study at hand contributes to the behavioural-science paradigm, which aims at the description, prediction and explanation of phenomena through the application of appropriate theories in terms of gaining insights and deeper perceptions of the research object itself [17] (p.76). The initial literature review and the investigation of results from conducted surveys are utilized within the justification phase, conveying gaps in current research and examining potential avenues for approaching the problem. We first conducted a literature review to understand food waste in households and its influencing factors (Section 2). We then formulated hypotheses on how IT can influence the identified factors and help to solve the problem of food waste.

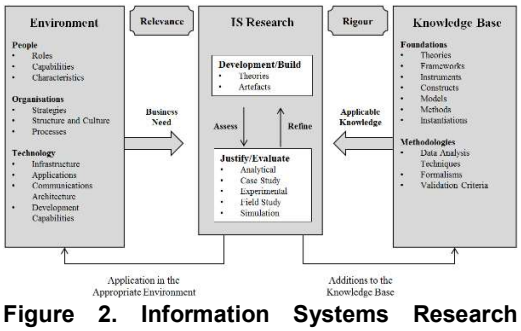

Figure 2. Information Systems Research Framework [17].

Subsequently, the data was analyzed and interpreted. Based on the results the hypotheses were

tested. Finally, key findings were summarized and the need for further research derived.

3.2. Hypotheses

Given the problem statement outlined and substantiated by the previous literature review –

our contribution aims to better understand aspects of household's IT adoption in the specific context of smart food waste management in Switzerland.

The fact that environmental concerns and those associated with food shortages elsewhere in the world show less weight than factors that benefit the households and its members themselves (e.g. saving money, manage home efficiently, feeling of guilt, eating healthiest diet) (Figure 1) leads us to the assumption that also IT supporting those factors are encouraging Swiss households most to reduce food waste. Therefore, we set the following hypotheses on Swiss households on using IT to reduce food waste:

- H1: Swiss households are willing to use IT to reduce food waste mainly to the benefit of saving money and manage their home effectively.
- H2: Swiss households see the most benefit of using IT in managing their food stocks.
- H3: Swiss households consider time efficient use and high level of data privacy as the main general condition for using IT.
- H4: Swiss households do not consider motivation and social interaction as relevant factors using IT.

3.3. Quantitative survey

To obtain a representative sample (regarding age, gender, language, and permanent residence) a Swiss online panel was used (see Table 1 and Table 2 [35], [36] for age as well as gender and see Table 4 for the main languages of the permanent resident population 2017 in Switzerland [37] according to the Swiss Federal Statistical Office (FSO)).

Table 1. Age group of the permanent resident population in Switzerland, 2018.

Age group	In millions	In %
0-19	1.7096	20.0
20-39	2.2679	26.5
40-64	2.9898	35.0
65+	1.5773	18.5
Total	8.5445	100.0

Table 2. Gender of the permanent resident population in Switzerland, 2018.

Gender	In millions	In %
Men	4.237121	49.6
Women	4.307406	50.4

Table 3. Main languages of the permanent resident population, 2017.

Language	In millions	In %
German or Swiss German	5.193954	62.6
French	1.896014	22.9
Italian or Italian dialect	0.678234	8.2
Romansh	0.044354	0.5
English	0.448359	5.4
Other languages	1.569292	18.4

Under 20-year-old members are not considered as it is assumed that they live with their parents and neither cooking nor shopping themselves is predominant in this age group. Of the four official Swiss languages the three largest ones are surveyed (see Table 4 for age distribution and Table 5 for language target distributions).

Table 4. Age group target quota.

Age group	In millions	In %
20-39	2.2679	33.2
40-64	2.9898	43.7
65+	1.5773	23.1
Total	6.8350	100.0

Table 5. Language target quota.

Language	In millions	In %
German (G)	5.193954	66.9
French (F)	1.896014	24.4
Italian (I)	0.678234	8.7
Total	7.768202	100.0

The questions in the survey covered our four main areas of interest:

- Sociodemographic information to cluster the results and to enable specific statements on individual groups.
- Expected benefits of using IT to identify the most important drivers for using IT.
- Preferred functionality to determine the phases on the food's journey to be supported the most by IT.
- General conditions for the use of IT.

To test hypothesis H1 we decided to ask the reasons to reduce food waste by using IT by differentiating the expected benefits to either the individuals/households or to other beneficiaries (e.g. reducing the impact on the environment or food shortages elsewhere in the world). To further

test hypothesis H1, and based on the results shown in Figure 1, we limited our questions on functionality to the benefits most associated to individuals and households (Figure 3). For every phase of the food's journey in households we've chosen at least one functionality supported by IT. Food consumption we did not consider to be supported by technology (Figure 3). For every functionality we asked the households about their willingness to use it.

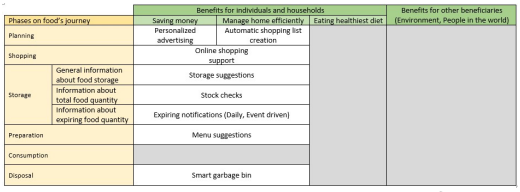

Figure 3. Functionality grouped to benefits and phases of the food's journey.

To test hypothesis H2 and to learn more about the management of food stocks in Swiss households, we added additional questions specific to this phase in the food's journey. To test hypothesis H3 we asked the households about non-functional requirements to use technology. The answers were measured using statements rated via five-point Likert scales, with the endpoints "strongly disagree" (=1) and "strongly agree" (=5) and the additional option "don't know". The questions were pretested with experts and adapted according to their feedback.

4. Results

The survey was conducted between December 6 and December 13, 2019 using the Bilendi online panel [38]. The questionnaire was fully completed by 1316 participants. Table shows the sample of fully completed questionnaires grouped by age group, gender, and the languages German (G), French (F) and Italian (I).

Table 6. Survey sample (n=1'316).

Age group	Men			Women			Others		
	G	F	I	G	F	I	G	F	I
20-39	139	51	19	161	55	21	4	4	1
40-64	182	67	24	185	68	29	5	2	0
65+	96	38	13	100	36	9	6	0	1

The FSO only provides data for the gender "men" and "women", so no quota was defined for the gender "other". Based on discussions with the FSO, and in order to compare the effective and targeted numbers, we decided to allocate participants with gender "other" to the genders "men" and "women" based on the distribution. Participants after the gender reallocation is shown in Table 7.

Table 7. Survey sample after gender reallocation (n=1'316)

Age group	Men			Women		
	G	F	I	G	F	I
20-39	141	53	19	163	57	22
40-64	184	68	24	188	69	29
65+	99	38	13	103	36	10

Based on the target quota we expected our survey with 1316 participants to have the distribution target shown in Table 8.

Table 8. Survey target (n=1'316).

Age group	Men			Women		
	G	F	I	G	F	I
20-39	145	53	19	147	54	19
40-64	191	70	25	194	71	25
65+	101	37	13	103	37	13

Bilendi, provider of the used survey panel, communicated in advance that the quota in the Italian speaking part of Switzerland would be difficult to reach [38]. The differences in percentages between the effective quote and the targeted quota are as shown in Table 9. Green marked cells show that the targeted quota of participants was exceeded, and orange marked cells show that the targeted quota was undercut.

Table 9. Quota differences in %.

Age group	Men			Women		
	G	F	I	G	F	I
20-39	2.8	0.2	3.4	10.7	6.1	12.2
40-64	3.3	2.3	3.3	3.3	2.4	15.0
65+	1.9	3.3	2.9	0.5	3.7	28.7

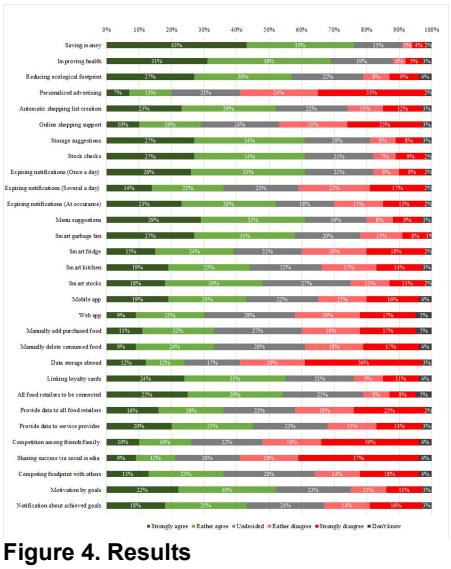

Figure 4. Results

Due to these results and since the following analysis will focus on the Swiss households as a whole, no additional adjustments of the sample were made. To answer the research question, we build on the answers to the questions shown in Figure 4.

5. Findings

In this section, we examine various aspects related to our hypotheses in more detail. The percentages given in the following sub-sections show the aggregated share of households answering with "strongly agree" or "rather agree".

5.1. Reasons for using technology to reduce food waste

The focus of this study is on reducing food waste by using IT to save money and to manage households efficiently, i.e. without wasting time, money, or energy. Asked about the reasons why households would use technology to reduce food waste, the reason most agreed on was "if I can save money" (76%), followed by "if I can improve my health" (69%) and "if it minimizes my environmental footprint" (57%) (Figure 5).

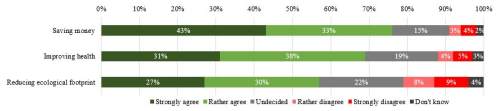

Figure 5. Reasons to use technology to reduce food waste.

Because households agree on an additional question in the survey, not specifically targeted to the use of IT, that "increased avoidance of food waste could save households significant costs" (83%), the use of technology to save money underlines even more the importance of saving money by using IT. Another perspective of the answers shown in Figure 5 could be the differentiation on benefits inside and outside a household. Whereas the reason of minimizing of the ecological footprint has more a focus on the outside of a household, saving money and improving health has more a focus on the inside. This could mean that providing IT with a stronger focus on the benefits inside a household could help to reduce food waste more effectively.

5.2 Functionality of information technology supporting households

To determine the functionality of IT resp. information systems that households are most willing to use, we structured examples of functionality according to the phases on the food's journey through households, i.e. from receiving personalized advertising to receiving information from a smart garbage bin (Figure 3). Functionality supporting the phases shopping (29%) and planning (36%) were the least wanted. Functionality of the two subsequent phases storage (61%) and preparation (61%) were supported the most, followed by functionality that is supporting the phase disposal (58%). This leads us to the conclusion that IT supports households preferably with functionality from the storage phase onwards.

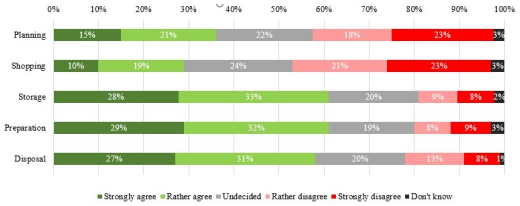

Figure 6. Functionality by phases.

To get more insight into functionality that supports the storage phase, households were asked about their wanted information about stored food. To reduce food waste, Swiss households are considering using IT for recording the current quantity in the food inventory and for notifying when items are no longer available in the fridge (39%), in the kitchen (44%) or in the entire household (48%) (Figure 7). Based on these results, we conclude that functionality should not be limited to only partial aspects of storage, such as stocks in the refrigerator or kitchen, but cover the management of the food stock in the entire household.

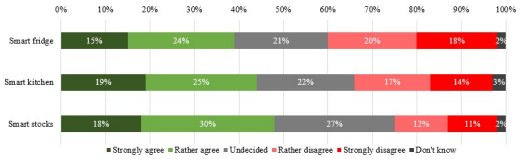

Figure 7. Food storage information.

An important information to reduce food waste in households is to know about the expiry date of stock items in order to use the items before they get bad. Asked about the notification for food items close to expiry date, the majority prefers to be noticed once a day (61%) but not more than once a day (36%). An idea that food scraps could be packaged in a "smart tupperware" which notifies the household before the food scraps go bad

by visual and tactile means is supported by 62% (Figure 8). Based on that feedback we conclude, that Swiss households do not want to be much "spammed" by IT and rather be the ones that trigger an information flow themselves.

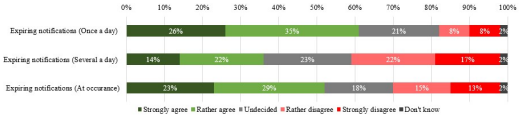

Figure 8. Food expiry information.

In addition to information on the quantity and the expiry date of stored food, Swiss households are strongly interested in functionality to help them store their food best. 61% of the respondents are willing to use technology when it provides them with tips on correctly storing food (Figure 9).

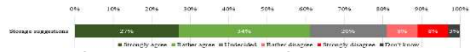

Figure 9. Information on best food storage.

For the last two phases of the food's journey, preparation and disposal, households are ready to use technology when it suggests menus based on the available food stock (61%) and when "smart waste bins" register food waste and show how much of which food was thrown away (58%). The latter could be enables by food storage information discussed above (Figure 6 and Figure 7) and underlines the importance of functionality resp. IT solutions supporting the storage phase in the food's journey. However, it turned out that H1 and H2 statement are to be accepted.

5.3. Functionality to support motivation and social interaction

Based on H4 that Swiss households do not consider motivation and social interaction relevant factors to increase the use of technology, several questions in the questionnaire were about motivating household to use technology to reduce food waste (Figure 10).

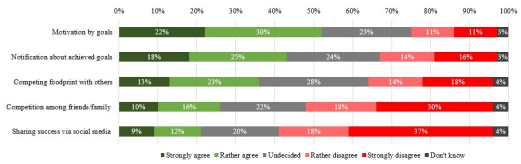

Figure 10. Motivation and social interaction.

The main functionality to motivate households to use technology is the setting (52%) and controlling (43%) of autonomous goals. Motivation by comparing or competing with others, e.g. comparison the ecological footprints with others (36%) or competition with family/friends on reducing food waste (26%) are much less motivating. Sharing someone's success in reducing food waste via social media (21%) was evaluated as the least motivating functionality. It turned out that H4 is to be accepted.

5.4. General requirements for using information technology

Beside functionality, we asked households for other requirements supporting the use of IT to reduce food waste. Focusing on the user interface, households prefer to use applications via a mobile app on smart phones and tablets (43%) or via a web app (30%) on other devices. Households are willing to use technology when they need to manually record food purchases (33%) or manually delete consumed food (33%) (Figure 11).

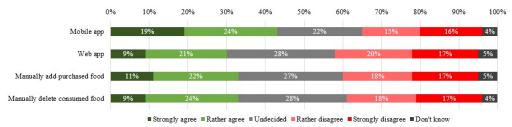

Figure 11. Data access.

Only 33% of all respondents strongly agree or agree to manually record or delete data on purchased or consumed food. However, when asked how much effort/time they are personally willing to put in to reduce food waste, more than 50% of all Swiss households that did not answer with "Don't know" are ready to invest more than nine minutes per day to reduce food waste (Figure 12). Bringing those two facts together, we understand that households are willing to spend time on reducing food waste, but not for manually maintaining data in information systems supporting this goal.

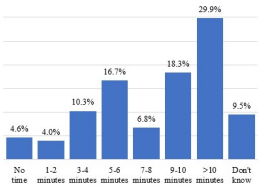

Figure 12. Willingness to manually maintain food data.

Swiss households are concerned about data privacy. Only 24% agree on storing their data

abroad. Although they agree to link existing loyalty cards with a technical solution (55%) and prefer that all food retailers in Switzerland should be connected to the solution (54%), they do much less agree on their data on purchases should being available to all food retailers (36%) but rather only to the solution provider (45%) (Figure 13). Based on these results, households want to receive useful information and other benefits from retailers and other involved parties in the food chain, but they want much less to provide others with their own private data.

Figure 13. Concerns on data privacy.

In the survey we did not differentiate between providing identifying data or anonymized data, so we can only assume that households are concerned about providing identifying data. This has to be investigated in future studies in more detail. It turned out that H3 is accepted. However, Swiss households expect, that data given to a service provider should be kept rather with him. This seems to support H3, already mentioned above, food and food waste seem to be a rather personal, perhaps even a somewhat intimate topic for Swiss households, which they do not want to share too much with others.

6. Concluding remarks and future research

A motivation and social interaction related approach should, if ever, motivate households above all by giving feedback about on their self-imposed achievements. Data input should preferably happen automatically as Swiss households are not willing to waste time by manually maintaining data of purchases and consummations in information systems. However, data privacy is important and personal data should be kept as closely as possible. The paper provides findings to better understand aspects of household IS adoption in the specific context of smart food waste management in Switzerland. Whether these findings may be applicable to a wider European or other regional contexts may be fruitful research.

Considering the technical implementations outlined in Section 2.6 it turned out that prototypes dealing with mobile app technology [15], [16], [30], [31], RFID sensors (IoT) [32] or VR [28], can highly benefit from a stronger consideration of data privacy. However, our study revealed that reward systems and social interaction in IT systems are considered not so powerful supportive tools on food waste avoidance as believed.

Future research could dive deeper into a differentiation by age groups as well as exploring in more detail the aspect of managing the household more efficiently. It could show new opportunities for using IT in reducing food waste in selected segments, like age groups and genders. In addition, better knowledge of the requirements for managing quantity and of expiry information on food items is key and important to explore in more detail as well as the data, households are especially concerned to keep private. Another aspect of further exploration could much stronger focus on more radical innovations. As Hebrok and Boks [5] point out, food storage is a category that is surprisingly underexplored and most suggestions on using technology for reducing food waste are set on the construct how the food's journey and the used tools (e.g. fridge, other food storage in households, etc.) look today. Therefore, future research may also focus on more radical concepts like just-in-time delivery (e.g. Uber eats) or zero inventory in Swiss households. Technologies like autonomous driving, flying autonomous vehicles, 3D printing, connected home, internet of things or machine learning could be cornerstones of a digital transformation in food, food storage and food waste reduction and may contribute to reduce the food stock in Swiss households itself.

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