

Understanding Consumers' Attitudes towards a Smartphone Application to Reduce Food Waste

Julia Marie Senge
University of Hohenheim, Germany
julia.senge@uni-hohenheim.de

Ellen Mielinger
University of Hohenheim, Germany
ellen.mielinger@uni-hohenheim.de

Marie Catherine Wendt
University of Hohenheim, Germany
mariecatherine.wendt@uni-hohenheim.de

Ramona Weinrich
University of Hohenheim, Germany
ramona.weinrich@uni-hohenheim.de

Christian Krupitzer
University of Hohenheim, Germany
christian.krupitzer@uni-hohenheim.de

Abstract

This paper explores a novel approach to address the problem of food waste in private households through a smartphone application. Employing a design science approach, an app prototype was developed as an instantiation with basic functionality. The prototype was evaluated by conducting a usability test and a consumer survey (N=520) to understand consumers' needs and requirements to increase their willingness to use such applications. Our findings reveal that younger generations are more likely to use the app and are more open to sharing and trusting information about real best-before dates of food products than older generations. Furthermore, the app concept resonates more with men than women. Feedback from consumers highlights a significant interest in a feature that could determine the shelf life of unpacked goods and new features, e.g., a chatbot to analyze food freshness.

Keywords: food waste, design science approach, smartphone application, food supply chain, consumer behavior

1. Introduction

In Germany, around 12 million tons of food are wasted yearly. Alarmingly, private households contribute to 59% of this waste (Federal Statistical Office, 2022). The origin of this excessive food waste can be attributed to several factors, most importantly: 37% was due to the perception that the product was spoiled, 15% because it seemed unsavory, and 6% because of an expired best-before date (BBD) of which almost half is disposed in unopened packaging (Schmidt et al., 2019). Disposing of unopened packaging with past BBD can be correlated with mistaking the BBD for

the use-by date. While the BBD relates to a potential decrease in food quality, the use-by date mentions the latest consumption date without health risks. Besides saving resources, reducing food waste can save millions of tons of CO_2 -equivalent greenhouse gas emissions. The economic implications of this food waste are profound, especially considering the recent inflationary trends and the growing global population. Some consumers are uncertain about the food's freshness and safety for consumption (Richter, 2017). Without clear information, such uncertainties can lead to the premature disposal of edible food, i.e., food waste.

Consumers are limited to their senses when assessing food quality since they often lack easy-to-use tools or knowledge. To tackle this, we propose a design approach for a smartphone application to reduce food waste by enhancing consumers' confidence in their decision-making regarding the expired BBD for packed products. The app distinguishes itself from existing applications by focusing on food items that consumers already possess. Users can scan products and receive feedback regarding the real BBD based on reviews from other users. Further, the app offers information about the optimal storage conditions. Lastly, the usability of the app prototype and the acceptance of an app as a tool to reduce food waste were investigated with user studies and evaluated regarding future research possibilities. By using this consumer-informed approach, we aim to refine the app in the future to align with user expectations and increase the potential of daily use to contribute to the pressing issue of food waste.

The remainder of this work is structured as follows: Section 2 explains fundamentals related to the food supply chain, consumer behavior, the shelf life of food products, and current smartphone applications. Section 3 provides an overview of the potential use case

of the app, the app design approach, and information about the studies conducted on consumer acceptance. Subsequently, Section 4 presents the results of the user interface (UI) and user experience (UX) analyzed in a qualitative study and the acceptance of an app to reduce food waste in a quantitative consumer study. Afterward, Section 5 discusses the functionality gaps, the target demographics, the determinants for app engagement, the willingness to use such an app to reduce food waste, and the threats to validity. Finally, Section 6 concludes the findings of the paper.

2. Background

In the following, we describe the principle of the Food Supply Chain (FSC), and we explain consumer behavior, the definitions and differences of the best-before and use-by dates, and the available apps on the market having the aim of reducing food waste.

2.1. The Food Supply Chain

A supply chain, in its foundational sense, represents the entire life cycle of a product, from raw material to its final delivery to consumers. While this applies universally across industries, the food supply chain is particularly complex due to the perishable nature of its products (Henrichs et al., 2022). The food journey from farm to fork encompasses a series of multifaceted stages, each with unique challenges. While food waste is a concern across all these stages, it is at the consumption stage, particularly within private households, where the issue becomes most pronounced (cf. Fig. 1).

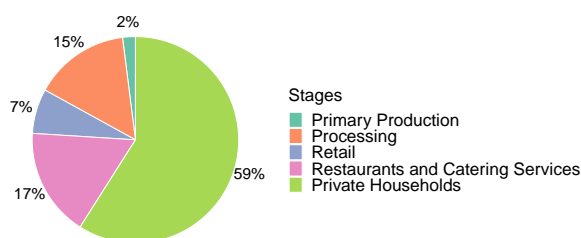


Figure 1. Amount of food waste within the food supply chain (Federal Statistical Office, 2022).

The production stage involves the cultivation or farming of food. Here, approximately 2% of total food waste is produced. In processing, the raw food undergoes defined treatments to be transformed into consumable products. Those treatments range from

simple heating steps to fundamental changes leading to different textures, flavors, or colors. In this stage, around 15% of food waste is produced. In retail, only 7% of food waste occurs, e.g., foods that cannot be sold anymore due to deviations from consumer expectations or past BBDs. Consumption itself happens at the end of the supply chain. This step can be split into two categories when discussing food waste. One is the food waste produced outside the household, e.g., eating out, which makes up 17% of food waste. The amount of food waste produced in private households is the most significant. 59% of the food waste can be traced back to the consumer level (Federal Statistical Office, 2022). Over half of the food waste originates from private households, which indicates that while systematic changes in the food supply chain are essential, addressing wasteful behaviors at home can make the most significant impact.

2.2. Consumer Behavior

Consumer behavior is a crucial factor in food waste, influenced by a complex interplay of understanding, perception, and individual experiences. One of the foremost reasons consumers discharge food relates to its perceived durability. For some consumers, the cost of a potentially bad experience outweighs the economic value of the food. For instance, products might be discharged preemptively to avoid any perceived health risk, irrespective of their actual condition.

A significant factor contributing to food waste is the misunderstanding of the BBD. Many individuals, influenced by prior negative experiences such as food poisoning, dispose of food mainly based on the expiration date. Psychologically and biologically, this phenomenon is explained as an “adaptive system” whereby individual responses change due to an individual’s experience, shaped by their personality and knowledge, and by effects regarding cultural differences such as norms about manners (Curtis et al., 2011). The adaptive system’s origin is within a person’s environment and is influenced by socio-demographic variables like age, gender, place of residence, education, and own experiences (Zielińska et al., 2020).

Referring to the study by Richter (2017), careless food wasters (32%), as the name suggests, frequently discard food without much thought or consideration - often, those dispose of food based on the BBD without assessing its edibility. This behavior contributes significantly to food waste and indicates a clear knowledge gap that our app should address.

2.3. Best-Before Date vs. Use-By Date

A contributing factor to food waste is misunderstanding the food labeling, precisely the terms BBD and use-by date (Zielińska et al., 2020). The EU-Regulation No. 1169/2011 provides guidelines for the date labeling of food items (EU Parliament, 2011). The BBD indicates the date up to which the food maintains—provided it is stored appropriately—its specific properties, such as color, texture, vitamin content, aroma, and taste. An expired BBD does not imply a health risk but indicates a potential decline in food quality (Plasil, 2022). Products bearing the BBD are, for example, dairy products, noodles, and flour.

The use-by date is reserved for products that pose a potential health risk due to rapid microbiological spoilage (EU Parliament, 2011). For instance, raw meat and fish typically come with a use-by date.

Some products have an extended shelf life and do not require a date label. Examples include solid sugar and table salt. Understanding and appropriately interpreting these date labels is crucial to reducing unnecessary food waste and ensuring consumer safety.

2.4. Current Smartphone Applications on the Market

Different smartphone applications on the market share similarities regarding the food waste topic of the proposed app in this study.

These applications can be classified into distinct categories based on their primary functionalities.

The first category describes apps focusing on near-expiry food distribution (e.g., Too Good to Go). These applications emphasize selling foods nearing their BBD and fresh produce, such as bakery items or restaurant meals, for a reduced price. They play a central role in bridging the interaction between retailers and consumers, ensuring that foods are consumed rather than wasted as they expire. These applications reduce food waste on the retailer's side, not for the consumers.

The second category depicts food-sharing applications (e.g., foodsharing). These platforms ease the exchange or distribution of foods near expiration among private households, targeting the consumers directly. They focus on community-driven approaches to food redistribution.

The third category is apps that support food consumption at home (e.g., KptnCook). These applications come equipped with a recipe database tailored to available ingredients. They guide consumers in creating dishes based on what they have at home, regardless of the proximity to the food's BBD, thus promoting efficient food consumption.

The fourth and last category is the food storage assistance applications (e.g., HNGRY). These apps offer a digital representation of available food at home, providing crucial insights into optimal storage techniques. They assist users in maximizing the shelf life of their groceries by emphasizing the importance of proper food storage.

Interestingly, the literature on those types of apps is limited. Researchers neither propose similar systems nor provide user studies on such apps. Research is rather focused on studying wasteful behavior (e.g., Richter, 2017; Schmidt et al., 2019; Zielińska et al., 2020).

3. Methodology

In this work, we followed a Design Science approach (Hevner et al., 2004), similar to Peffers et al. (2007). Hence, we designed and analyzed an app prototype's layout and basic functionalities. This section presents the app's use case, the design, and the studies conducted. The data is available at [10.5281/zenodo.13772955](https://zenodo.org/record/13772955).

3.1. App Use-Case in the Food Supply Chain

The app emphasizes consumers' fundamental role in the food supply chain, especially concerning food waste. Figure 2 accompanies this description and shows the food supply chain, with our app distinctly positioned at the final consumer stage.

This approach assumes that the app is connected to a data repository through a server. This repository stores data provided by producers (product information) or retailers (discount promotion) and collects and aggregates consumer feedback on the BBDs. As a result, consumers can access product details and potential discount promotions, ensuring they remain informed and engaged. While companies can retrieve and utilize this valuable consumer feedback, they also have the option, respecting data sovereignty, to share it with other institutions such as consultancy firms or research facilities. This symbiotic relationship underscores the role of the app in enhancing communication and understanding between consumer and producer. Compared to the apps described in Section 2.4, this app offers users knowledge about optimal storage conditions and the ability to share their experience of consumption of food as well as use the experiences of others to gain a fundamental understanding of differences between quality parameters and durability.

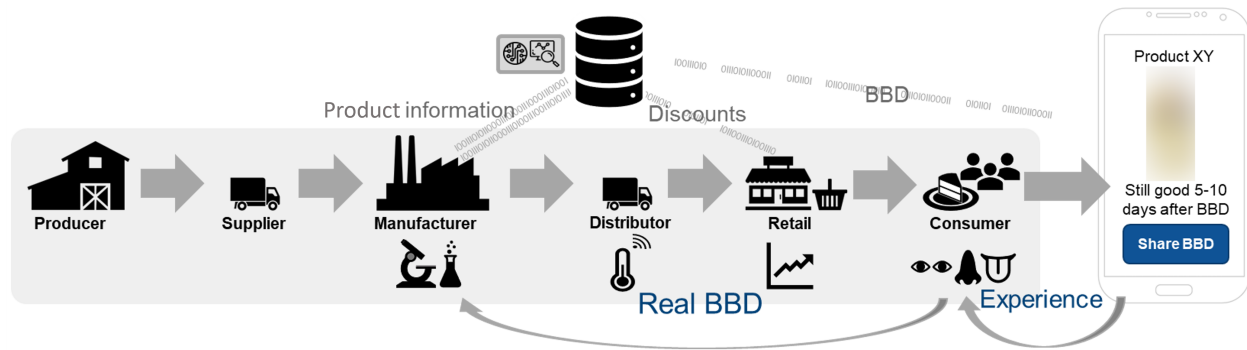


Figure 2. Integration of the app into the food supply chain. Arrows indicate the flow of information, illustrating how feedback from consumers, captured through the app, loops back into the system, benefiting both consumers and producers.

3.2. App Design

The design and development of the app prototype followed a systematic approach based on SCRUM with user studies to ensure it was both intuitive and user-friendly.

The initial app structure embodies the core functionalities within the key pages (home, search, product information, and feedback page). The home screen is a clear and inviting starting point, featuring distinct product categories for easy navigation. The categories provide insights into the ideal storage conditions of products, ensuring the user is informed about maintaining and prolonging a product's shelf life.

The product search functionality on the search page enables users to look for specific products effortlessly in multiple ways:

- Directly entering a product name into the text bar.
- Using the built-in scanner to capture the barcode.
- Snapping a picture of the product package for a visual search.

The product information page directly connects to the search functionality and shows product-specific information. Here, users can check the food's freshness using the app's unique feature: the *Freshlimeter*. A traffic light system provides an intuitive indication of the product's freshness status after surpassing its BBD. The user can input the current BBD of their product to receive a tailored freshness assessment. The assessment via the *Freshlimeter* is based on collective user experiences after products exceeded their BBD. Further, users can find more detailed feedback on this page from other consumers who have rated their consumption of the products after passing the BBD.

Consumer feedback is collected via a standardized form. The form includes information about the product's BBD, consumption date, acceptability, and

specific characteristics, such as taste, smell, and texture. Users also provide information about storage and their overall consumption experience by leaving further comments. This concept encourages user interaction by allowing them to share experiences, review products, and provide feedback. The collected feedback should also be provided to the food producers - however, this feature is out of the scope of this study.

The app was developed in Android Studio using Kotlin. Kotlin is interoperable with Java, offering robustness and flexibility for Android app development.

3.3. Studies on App Acceptance

This section is divided into two components: a qualitative and a quantitative study. The quantitative study evaluated the consumers' views on food waste and their willingness to use an app to reduce food waste at home. Within the qualitative study, we used a semi-structured interview to understand the current potential of the app's functionalities and gain knowledge of further requirements to reach consumer satisfaction. Through different approaches, we endeavor to paint a holistic picture of how end-users perceive and engage with our app. Thereby increasing the rigor of this study.

3.3.1. Qualitative Study To fully understand the user experience and potential areas of improvement for the app, we conducted a usability test. This test aimed not only to assess the current user-friendliness and functionality of the app but also to identify any additional features or modifications that users might desire, resulting in the first two research questions:

- **RQ1:** How user-friendly and intuitive is the app design?
- **RQ2:** Which additional functionalities are requested by users?

The data collection took place in February 2023. Therefore, 10 participants between 21 and 29 years old evaluated the app's functionalities and user-friendliness using a standardized semi-structured guideline interview to gather detailed and structured feedback. This approach ensured that while participants had a clear direction in providing their feedback, they also had the flexibility to express additional thoughts and insights beyond the presented questions.

3.3.2. Quantitative Study An online-based quantitative consumer survey was conducted to check the app's concept acceptance, determine the level of knowledge regarding the BBD, and gain insight into participants' food waste behavior. This approach ensured statistically robust results that could highlight potential motivators, inhibitors, and barriers to using the app. A representative sample (N=520) corresponding to the German population regarding gender and age was generated using a panel provider. Respondents were selected according to standard market practices by the panel provider. The data collection took place in December 2022. The survey answered the following research questions:

- **RQ3:** Who are the primary target groups for the current app approach?
- **RQ4:** What key determinants influence the likelihood of utilizing the app?
- **RQ5:** Are people willing to use the app to reduce food waste in their private households?

Table 1 lists the characteristics of the sample. The sample consisted of 47% male and 53% female participants. The age distribution showed that some generations (Gen Y, Gen X, Gen Boomer, and Gen Silent) were overrepresented compared to the German average. In contrast, younger generations (Gen Alpha and Gen Z) were underrepresented. The respondents in our sample exhibited a higher level of education and a lower net household income compared to the German average.

4. Results

The qualitative study (see Section 3.3.1) shed light on different aspects: the user interface (UI), the user experience of the app (UX), and future requirements for the app to increase its usability. Additionally, we performed a quantitative study (see Section 3.3.2) with a large sample (N=520) to better understand the food waste patterns and derive additional possible features for the app. This section describes the results of the different studies.

4.1. Usability Test

The usability test results were based on analyzing intuitiveness and user-friendliness, focusing on the four primary functionalities of the current app version: the home screen, product search, product information, and adding consumer reviews. With this approach, we aimed to identify the important functionalities.

The home screen was perceived as clear, intuitive, and self-explanatory. 90% were able to navigate to the product information page. For this purpose, 50% utilized the camera function, while the others used the text search. 30% of the participants felt intuitively inclined to click on the relevant category images on the home screen to find information about the product. Although the functionalities were intuitive, the participants suggested an additional symbol for the barcode scanner.

The product information page, on the contrary, was perceived as difficult to understand. 60% felt overloaded by the information of the *Freshlimeter*. In more detail, 70% did not immediately recognize the option to input their products' expiration dates for the tailored freshness assessment due to the general statement that the page was too crowded with information. Further, 20% of the participants mentioned difficulties in understanding the information from the bar chart. In general, the participants demanded a re-organization of the page. 80% of the participants could add information about consumed products by navigating to the feedback page. Additionally, the participants deemed that the handling and input of information were easy to understand and intuitive. A product-specific scale was proposed to enhance the quality of the information from the rating. Participants further suggested uploading pictures of the current state of the food to add visual references for other users to strengthen their decision-making capabilities regarding food quality.

At the end of the interviews, participants stated their main concerns were about the provided data's credibility, data privacy, and potential costs. According to this study, the freshness assessment of unpacked and opened food products is an important addition to the app's future functionality.

4.2. Consumer Survey

The data from the quantitative study reveals insightful trends in food disposal habits in German households. Fruits and vegetables, leftovers, bread and pastries, and dairy products emerged as the most frequently discarded food categories (Fig. 3). On the contrary, there is a lower tendency to dispose of canned

Table 1. Overview of sample distribution and comparison group distribution

Variable	Group	Sample [%]	Germany [%]
Gender	Female	52.9	50.7
	Male	47.1	49.3
Age	< 12 (Gen Alpha)	0	12.3
	13 - 26 (Gen Z)	9	14.3
	27 - 41 (Gen Y)	23.3	19.3
	42 - 56 (Gen X)	25.2	19.8
	57 - 66 (Gen Boomer)	25.8	14.8
	67 - 76 (Gen Silent)	15.8	10.1
	77+ (Gen till 45)	1.0	9.4
Education	Without graduation	1.2	7.5
	Secondary education	13.5	28.6
	Advanced Secondary education	36.3	30.0
	A-level	49.0	33.5
Household Net income [EUR]	Lower than 1300	11.3	13.5
	1301-1700	13.1	9.2
	1701-2600	21.2	20.3
	2601-3600	21.3	17.6
	3601-5000	21.9	16.7
	5000 or higher	11.2	22.7

goods, rice and noodles, or sweets.

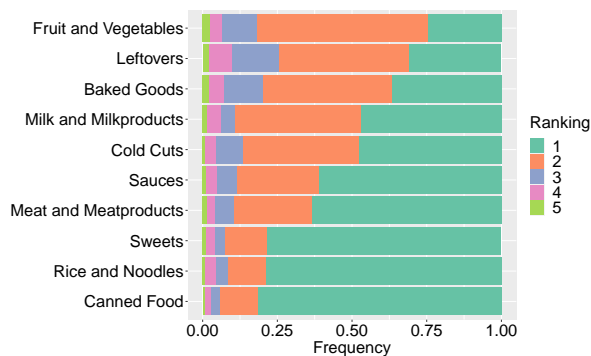


Figure 3. Frequency of food disposed according to consumers; 1=never, 2= 1 per month or less, 3= 1 per week, 4= 2-4 per week, 5= daily.

Further, we investigated the understanding of the BBD. 82% of the respondents agreed that food might be consumable after the BBD. Moreover, 77% would not immediately throw food away when reaching its BBD. Instead, 79% applied the *see, smell, taste* rule to judge the product's edibility.

By addressing the issue of food waste, the study showcases which strategies are actively employed to mitigate it. Precise shopping planning is a common approach, with 72% of the respondents always preparing a shopping list and 79% checking their existing food

stocks before heading to the store. Proper food storage is practiced by 79% of the surveyed individuals.

The study investigated the use of food management apps in a technological dimension. A significant 77% of respondents currently do not use such digital tools. However, there is latent potential, as 40% acknowledged the utility of an app to reduce food waste. Of these, 23% agreed to the app's efficacy in helping reduce personal food waste, while 26% saw value in it as a platform to discuss product shelf life with fellow users. Additionally, 83% confirmed they had the necessary resources to run the app, like a smartphone with internet access. With 78% having technical knowledge and 76% finding it straightforward to operate a new app, the uptake barriers appear minimal.

A strong correlation emerged between one's affinity for technology and willingness to use the app (Kruskal-Wallis test: $p < 0.05$). The different groups and their likeliness to use the app are shown in Figure 4. The significant differences between the groups were analyzed using a Dunn test ($p < 0.025$). Hence, this indicates that people with a higher affinity towards technology are more likely to use an app to reduce food waste. Regarding potential adoption, 28% of the surveyed population expressed openness to using the app, with 21% considering its integration into their daily lives. An interactive aspect of the tool, allowing users to share their experiences with BBD, caught the interest

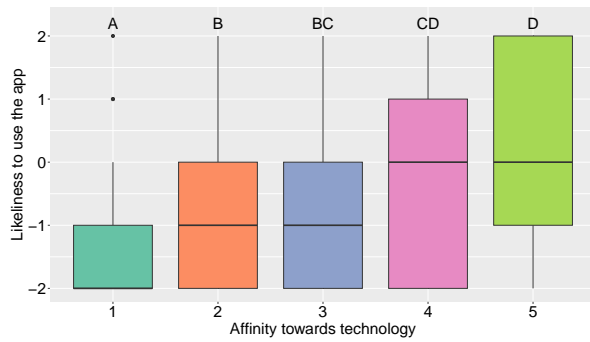


Figure 4. Dependency of ones affinity towards technology and their likeliness to use; x-scale 1: no affinity; 5: high affinity. Differing letters indicate a significant difference (Dunn test: $p < 0.025$) between groups.

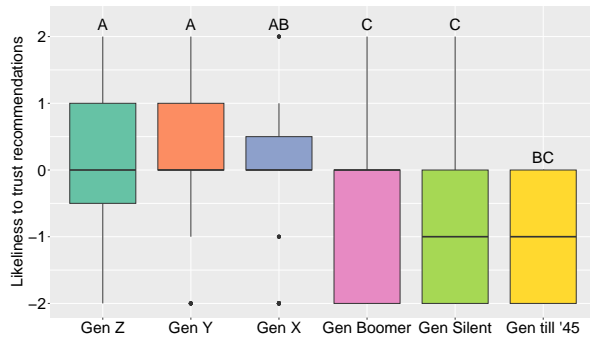


Figure 5. Likelihood to trust recommendation of an app depending on generation. Differing letters indicate a significant difference (Dunn test: $p < 0.025$) between groups.

of 29% of the respondents. The data further highlighted more demographic correlations. The likeliness to use the app regarding gender showed that men would tend to use the app more than women (tested with Kruskal-Wallis test: $p < 0.05$ and Dunn test $p < 0.025$). Figures 5–7 show the differences (tested with Kruskal-Wallis test: $p < 0.05$ and Dunn test $p < 0.025$) between generations towards their trust regarding recommendations of an app, their likeliness to use the app, and their willingness to share the BBD via an app. The results of the Dunn test revealed that younger generations have a higher probability of trusting recommendations of the shared BBD, are more likely to use the app, and show a greater tendency towards sharing their experiences of the BBD.

5. Discussion

This section discusses the app's applicability based on the previously mentioned results. Further, we

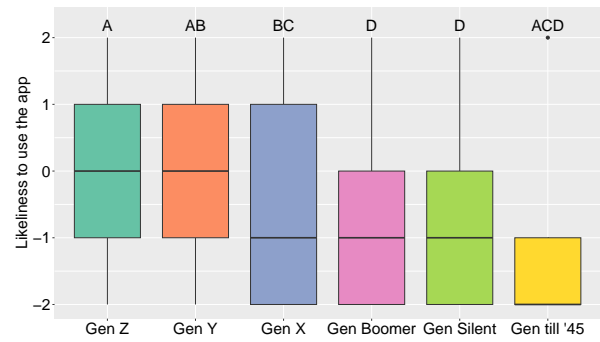


Figure 6. Likelihood to use the app depending on generation. Differing letters indicate a significant difference (Dunn test: $p < 0.025$) between groups.

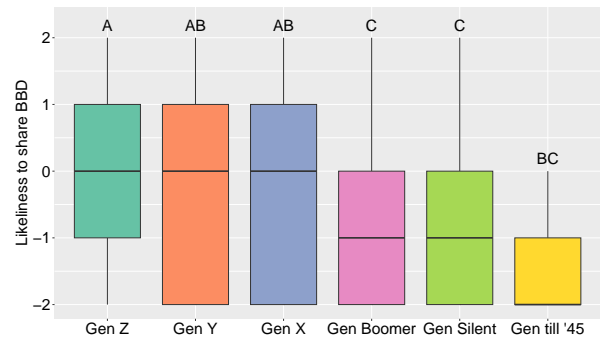


Figure 7. Likelihood to share the BBD via an app depending on generation. Differing letters indicate a significant difference (Dunn test: $p < 0.025$) between groups.

describe identified threats to validity.

5.1. App Intuitiveness and Functionality Gaps

User interaction with apps hinges on two fundamental aspects: User Experience (UX) and User Interface (UI). While UX delves into how the use of a product feels, UI is about how it looks and functions. Through the usability test, we have gained insights into how users perceive and interact with the basic prototype of the app. These insights can guide refinements for the future design and the final functionalities of the app, ensuring the user's experience and interface interactions are optimized for clarity, ease, and satisfaction.

The home screen was perceived as clear and intuitive. Hence, the information about optimal food storage is easily accessible and self-explanatory, helping users to prolong the shelf life of their food.

All different pathways of the product search were

used, proofing its intuitiveness. However, despite having an included barcode scanner functionality, its representation must be distinguished from the camera symbol in the future design. Given the barcode symbol's familiarity with other existing apps, the separated integration can enhance the UX through quick and straightforward product searches.

The product information page entailed some difficulties among the participants. The interpretation of the *Freshlimeter*, in particular, led to an unsatisfactory UX. Due to the broad range of information on that page, the freshness assessment was not immediately apparent. Enhancing its visibility or positioning it more prominently on the page could ensure that users recognize and utilize it more intuitively. Furthermore, presenting users with both the *Freshlimeter* and a bar chart on the same page made the information feel dense and overwhelming. Given the consistent feedback, prioritizing one of these visualization tools and centering it on the page can improve the UX. Therefore, the app's design will focus on distinguishing this feature from other content and aiming for a more structured layout in the future.

The feedback mechanism was straightforward and intuitive, suggesting that universal symbols (+) can effectively guide user actions without requiring explicit instructions. Furthermore, the collected information was viewed as easy to submit. A camera button must be integrated into the feedback page as an additional function. A visual reference to assess the product quality can help gain more trust in the decision-making process about the durability of food, thereby minimizing the potential risk of having a bad experience. As mentioned in Section 2.2, consumers' perceived durability of food can be influenced by their experiences and knowledge. Hence, an app that enhances the consumers' knowledge using different types of information transfer, e.g., *Freshlimeter*, visual references, or written feedback, can help to reduce food waste.

Further, participants emphasized a distinct need for assessing the freshness of unpacked foods, given their lack of 'best before' indications compared to packed items. Therefore, a chatbot with image recognition capabilities could be introduced, combining the previously mentioned features to receive information and support the freshness assessment of different food types (Senge et al., 2024). Such a chatbot can offer an educated assessment of the food item's freshness by matching user descriptions (e.g., sour taste indicating fermentation) or pictures (e.g., black spots implying decay) with pre-programmed knowledge.

While information about optimal storage conditions, product search, and sharing feedback remain

fundamental features, refining the freshness assessment with a structured approach to cover the consumers' expectations and needs will be essential for future work.

5.2. Target Demographics and crucial Determinants for App Engagement

Our findings revealed that the potential target group for the current app design approach points predominantly towards younger generations. Further, men demonstrated a higher predisposition towards the app's usage than women. This pattern might be attributed to women's traditionally more prominent roles in household management, including grocery shopping or cooking (Federal Statistical Office, 2019). Further, Zielińska et al. (2020) discovered that women check the expiration date more often and tend to eat food past its BBD less often than men. Therefore, it is essential to investigate this observed trend further to design an app that is equally appealing to all genders.

Most notably, younger generations exhibited a more pronounced willingness to share their experiences, especially concerning the BBD of products (Fig. 7). Additionally, younger generations are more likely to trust those recommendations (Fig. 5) in an app, which might be connected to growing up in the digital age and their familiarity with such technologies. A study by Hamilton et al. (2005) indicated that younger individuals discard food more frequently than older people. Such behavioral patterns underline the importance of addressing this demographic with innovative and contemporary solutions to increase their knowledge of proper food storage. This premise is further strengthened by Farr-Wharton et al., 2014, who pointed out that past experiences heavily influence purchase decisions and food waste behavior.

Consumers tend to underestimate the amount of food they waste. Social views influence this perspective, where admitting to wasting food is seen negatively due to perceived social pressures. Often, what is deemed as 'waste' is mischaracterized as 'non-avoidable' (e.g., misinterpreting the BBD), highlighting an informational gap and a potential intervention area. The issue of food waste and its broader implications for the environment and humanity often remains overshadowed. Preparing a list before grocery shopping is an important first step, which was done by most participants (72%). However, overestimating the needs can lead to more food waste, especially when it comes to perishable unpacked food like fruits and vegetables (Fig. 3). Therefore, the future functionalities of the app need to address this issue (5.1).

When exploring the factors influencing the likelihood of app utilization, motivations often pivot

around four central themes: learning, personal, social, and hedonic benefits (Shaikh et al., 2023). The first three showed relevance within this app design approach. The app supports users in learning the best food storage practices and clarifies real BBDs of products, going beyond just their stated expiration dates. Reduced expenses from extended food shelf life and minimized food waste, combined with peace of mind by removing uncertainties regarding freshness, are notable benefits. The ability to share reviews facilitates community engagement, empowering users to benefit from shared experiences and insights. Richter (2017) identified three clusters of food wasters: *guilty food wasters* (26%), *unwitting food wasters* (42%), and *careless food wasters* (32%). Among those groups, two show the potential to benefit from the proposed application: the *guilty food wasters* and the *unwitting food wasters*. The *guilty food wasters* possess an adequate understanding of the implications of food waste but require motivation to take action, i.e., strategies such as financial benefits like coupons. On the other hand, the *unwitting food wasters* lack essential knowledge about food waste, emphasizing the need for targeted educational interventions to raise their awareness. Our app provides the foundations to address both groups.

5.3. Assessment of Willingness using an Application to Reduce Food Waste

It is of great importance whether individuals are prepared to use an app to reduce food waste in private households or not. This study provides a robust foundation that favors the introduction of such an app. 77% of the participants do not utilize an app to reduce food waste, which might indicate an opportunity. It suggests that, until now, no app has sufficiently addressed the needs of potential users. However, some users mentioned concerns, such as data security and privacy, reviews' authenticity, potential costs, and the integration of unpacked and opened food.

Regarding data security and privacy concerns, a potential solution could be end-to-end encryption for all the data transmitted within the app. Hence, sensitive information is protected at all times. Additionally, any shared data should be anonymized and aggregated to prevent identification of individual users. Especially the trust in shared reviews about the BBD needs to be considered for a revised approach (Fig. 5). A potential method to implement a verification system involves the integration of receipt scanning, ensuring users can only review products they have genuinely purchased. Further, a user rating system can be integrated, allowing users to rate the accuracy and helpfulness of the feedback

they receive. Further, the app could cross-reference the feedback with expert advice or publicly available data on shelf life, enhancing the overall credibility of the information provided.

Another factor influencing the likelihood of using the app is potential costs. Ensuring easy access by offering the app as a free download option will broaden the audience. A different approach to increase the adoption of this app is a partially free usable app. This model would allow users to access the app's core functionalities for free while offering additional premium features, such as advanced analytics. Also, financial rewards, like coupons, are a strong incentive. As mentioned before, expanding the app's database to incorporate a broader range of products would increase the app's use case (Senge et al., 2024).

Increasing the personal and social aspects and addressing the motivation could be the main decision criterion for using the app for *guilty food wasters*.

5.4. Threats to Validity

Several potential threats to validity of our findings emerged while we were conducting our research. Firstly, the group's limited size and age distribution for the usability study may not represent the broader population, potentially introducing selection bias. Secondly, we may have overlooked alternative designs that could yield different user responses or performance outcomes by evaluating only a single app design. Thirdly, users interacting with unfamiliar devices possibly exhibit different behaviors than they would on their personal devices. Lastly, the incomplete implementation of the app's functionality might not reflect the real-world UX of a fully developed product, which can lead to misinterpretations of user feedback and not capture all issues or benefits. Furthermore, the sample for the consumer survey was only representative of gender and age for the German population. While still providing useful insight, a more representative or targeted sample could hold more information about users' expectations and needs.

Although we did not explicitly structure the study using a typical technology acceptance model (such as TAM, UTAUT, etc.), this study explores consumer behavior and app acceptance on a systematic level. Additionally, there is no data available whether the use of the application leads to a reduction in household food waste. We will conduct further usability studies with a broader demographic group to tackle these threats and current limitations. Further, we will revise the app according to the users' proposed limitations and collect data regarding the app's ability to reduce food

waste. Despite these potential threats to validity, it is important to emphasize that the findings of our study remain robust and provide valuable insights into the UX and app concept.

6. Conclusion

This work investigated the use of a smartphone application to reduce food waste. Therefore, a basic prototype of the proposed app was developed. We performed a consumer survey to explore the consumers' likeliness to use an app to reduce food waste at home. Additionally, a usability test was performed to examine the user-friendliness of the designed app layout. While the primary function, was clear and straightforward, some noticeable design elements, such as the missing barcode symbol, must be revised. Moreover, the product information page appeared to be overwhelming for many users. According to the consumer survey, the target group is younger generations who are more likely to share and trust information received via an app. The feedback was diverse when addressing whether people are willing to use the app to reduce household food waste. Data safety, data privacy, the accuracy of the feedback and potential costs were identified as important for users. While a notable proportion, about 28%, expressed a willingness to use the app as currently presented, there was an apparent demand for more concrete motivators, like financial benefits or including a freshness assessment for unpacked food. Given that unpacked food plays a significant role in the uncertainty and gaps in storage knowledge, the app's emphasis on this aspect could increase its adoption.

For this, we proposed to aim future research towards functionalities like a chatbot (Senge et al., 2024). In addition, this approach might be applicable to other stages of the food supply chain, e.g., supermarkets.

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