



Consumption Habits for Eliminating Waste

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Introduction

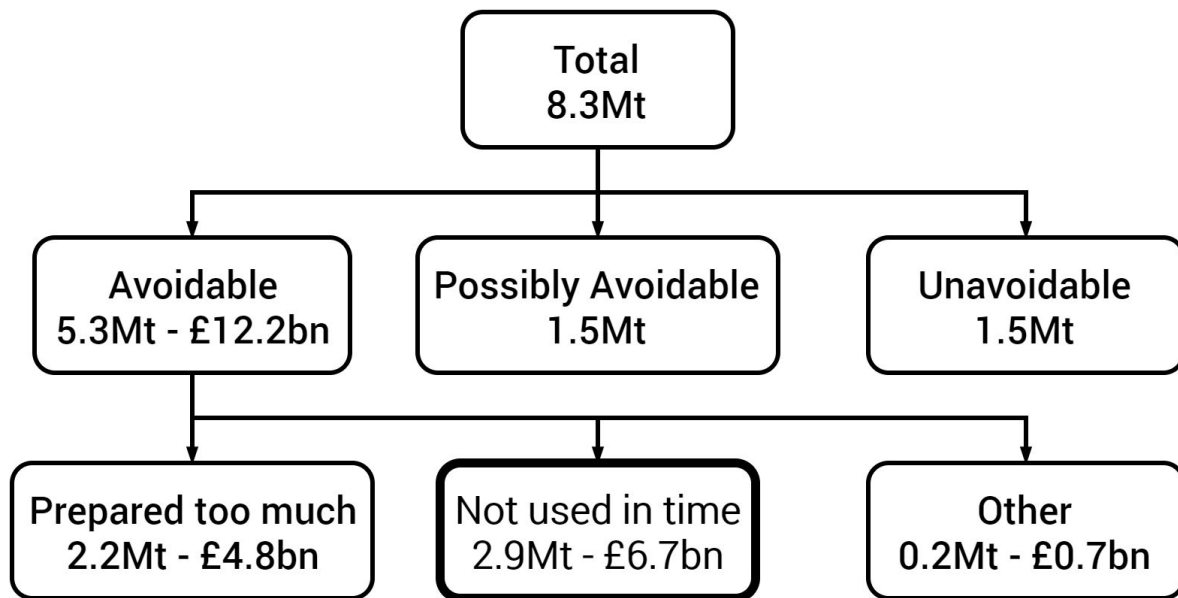


Figure 1: UK household food waste breakdown, by weight and cost (Parfitt et al., 2010)

There is a lot of food waste:

The current high levels of food waste across the entire food supply chain have significant consequences both economically and environmentally. Because of the number of steps in the supply chain, with waste possible at each step, total food waste across the chain can be up to 60%. For high-income countries, waste mostly occurs towards the end of the supply chain, in large part with the consumer. (Gustavsson, 2011). The problem seems to be increasing, as US citizens now waste more than 150% of the food they did in 1974 (Hall et al., 2009).

Food waste is expensive:

A prime example is the UK, which wastes approximately 14 million tonnes (Mt) of food annually, 8.3Mt of which is from households alone. Of this, 5.3Mt is thought to be avoidable, which currently costs £12.2 billion (Figure 1; Parfitt et al., 2010).

Food waste is environmentally damaging:

In the USA, "food waste now accounts for more than one quarter of the total freshwater consumption and ~300 million barrels of oil per year." (Hall et al. 2009:1). This is in addition to the methane produced by food rotting in landfills, which is 25 times worse for global warming than the CO₂ that would have been produced if the food had been eaten (Hall et al., 2009).

Existing solutions and opportunities

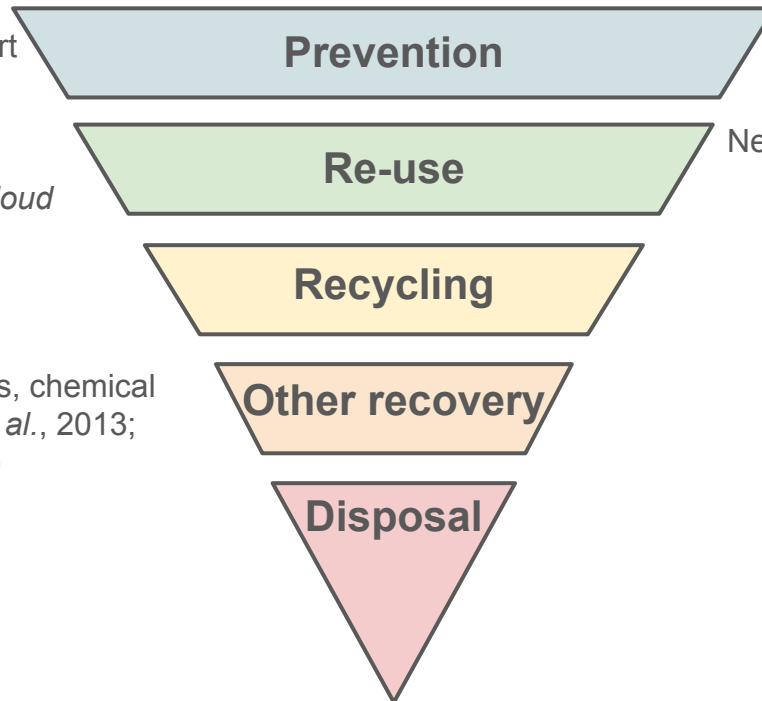
Producers

Hygienic transport
Selling 'rejects'

Giving to food
charities: *FoodCloud*

Valorization: fuels, chemical
extraction (Lin *et al.*, 2013;
Shin *et al.*, 2004)

Landfill
Incineration



Individuals

***Nothing obvious
fills this gap***

Neighbourhood food-sharing:
OLIO
Feeding pets

Council food recycling
(Some) Composting

Landfill
(Most) Composting

Figure 2: Solutions at different stages of the waste hierarchy (adapted: Lin *et al.*, 2013)

Solutions across the supply chain

There are existing attempts to address the problems of food waste at multiple different stages across the food supply chain. These range from better, more hygienic production and transport methods early on, to extraction of chemicals for use by other industries. (Figure 2).

Solutions for individuals

As explored earlier, most food waste is caused by households as end-consumers. Given that the largest segment of avoidable waste is caused by food not being used in time, this appears to be the level at which a solution should be made. Existing apps, such as Olio, have the aim that "surplus food... can be shared, not thrown away" (OLIO, 2017). These operate at the individual level, but similar solutions exist for retailers (FoodCloud, 2017).

Opportunities for improvement

There is an implicit assumption with these apps that use-by dates are remembered in time to deal with foods. This may be true for retailers/producers, but probably fails more often for individuals, as food waste is unlikely to be highly prioritised by people with busy lives. There seems to be a large potential gap for improvement higher up the waste hierarchy, by prevention of spoiling at the individual level.

Initial Concept

With the aim of prevention of food not used in time at the individual level, and operating under the following general premise, a collection of solutions were suggested (Figure 3).

General premise: If people are aware their food is about to go off, they are more likely to use it in time.

If expiry date information for perishable food can be gathered in one place (conceptualized here as 'The Cloud'), then individuals can be warned in advance in one (or many) of a number of ways. This raises obvious questions of how to gather the date information and how to provide feedback. Figure 3 explores some possibilities.



Figure 3: Initial ideas for a service that keeps users informed of their food's use-by dates

Related Literature

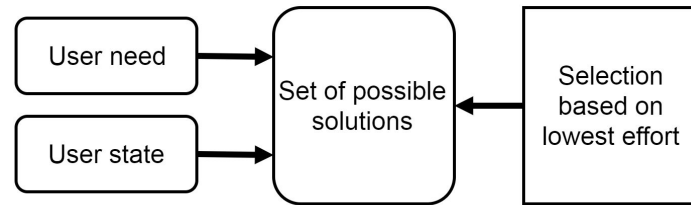


Figure 4: Lazy user theory of solution selection (Tétard & Collan, 2009)

Unsurprisingly, in general users opt for solutions that require the least effort (Figure 4), so solutions should require as little input as possible. The importance of this has been demonstrated in use for a weight loss food-tracking app, where common reasons for stopping use included that it was tedious or not easy to use (Figure 5).

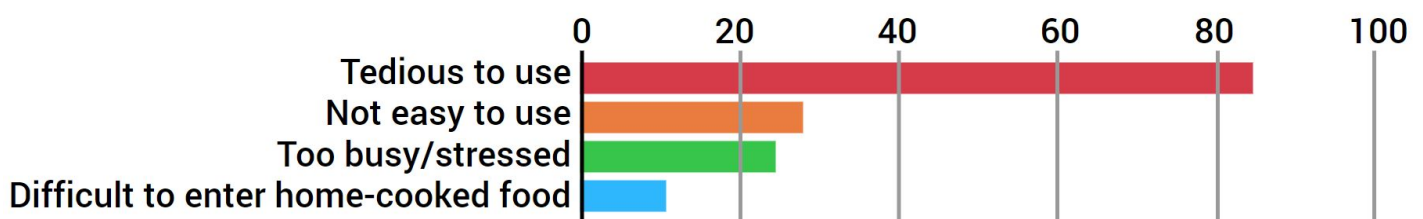


Figure 5: Reasons for stopping food app use (% of drop-outs) (Laing et al. 2014)

Also notable was that users found home-cooked food difficult to enter. This could be an issue for the current solution, as it should be possible to include non-barcoded items, such as from a market. Time and cognitive overhead are also key metrics to minimize.

Target market

For maximum impact, this solution should target those who waste the most and those who influence how food is used. Parfitt *et al.*, (2010:3077) suggests that “young people waste more than older people”, with a general negative correlation between age and quantity of waste. This project shall thus primarily focus on younger potential users. Lewin (1943) describes in detail food use of the era, where the ‘gatekeepers’ to change in food habits were women, but this appears to no longer be the case (Hertzler & Bruce, 2002), as male and female students are able to cook at similar levels.

Computer Vision & Machine Learning

After being taught to recognize visual patterns on a corpus of existing images, machine learning algorithms have been demonstrated to be capable of identifying food (Zhang *et al.*, 2016) and assessing food quality (Du & Sun, 2006). As the computationally-expensive procedure is the training (e.g. Williams *et al.*, 2006), including machine-learnt algorithms may be possible for apps.

Gamification

Although currently popular, Stawarz *et al.* (2015) suggests that positive reinforcement decreases intrinsic motivation, so this may not be a good long-term strategy where habit formation is desired.

User Research

Focus group

A small focus group was used to better contextualize the issues in terms of real potential users with rich quantitative data.

Participants

4 Loughborough University students (2 male, 2 female, ages 20-23) were chosen as representative of the target market.

Procedure

Participants were informed of the purpose of the study, and sat down together with the researcher after consenting to take part (Appendices A & B). In a semi-structured format (Robson, 2011), they were asked about their general attitudes towards food, food waste, and technology, with an emphasis towards determining useful questions for a later questionnaire. Key points were noted down as the session progressed.

Results

- Did not know what to do with waste food: 3/4 were unaware food could be recycled in their area.
- Provided lots of reasons why they might throw away food (see Appendix C)
- Forgetting about food was a common cause for throwing it away, and efforts would be made to use it if remembered in time. This validated the premise of the study/proposed solution, encouraging further exploration.
- A key concerns with the app was that it might take too much time and effort to use.

Questionnaire

A questionnaire was created and distributed to acquire quantitative data from a wider sample.

Participants

20 participants (12 female, 8 male, ages 18-54) were convenience sampled, mostly as students from Loughborough University. As a broader study, middle-aged adults were purposively sampled to provide insight into whether attitudes were different across ages. Age distribution is shown in Appendix D.

Procedure

Questions were created based on key themes from the focus group. They were restricted to topics that would influence the design of the solution, under the headings of 'Food Waste', 'Food Use' and 'Notifications'. See Appendix C for specific questions. These were compiled using Google Forms and distributed digitally. Results were collated and analysed descriptively. The questionnaire was piloted with 3 users to ensure the questions were suitably worded.

Questionnaire Results

(See Appendix D for more.)

Food Waste

- Estimated food thrown away ~ 3x/month. This appears low considering Parfitt *et al.* (2010).
- Most waste is uncooked.
- Very little is recycled.
- Most common reasons for food waste are forgetting about the food or its use-by date (Figure 6).

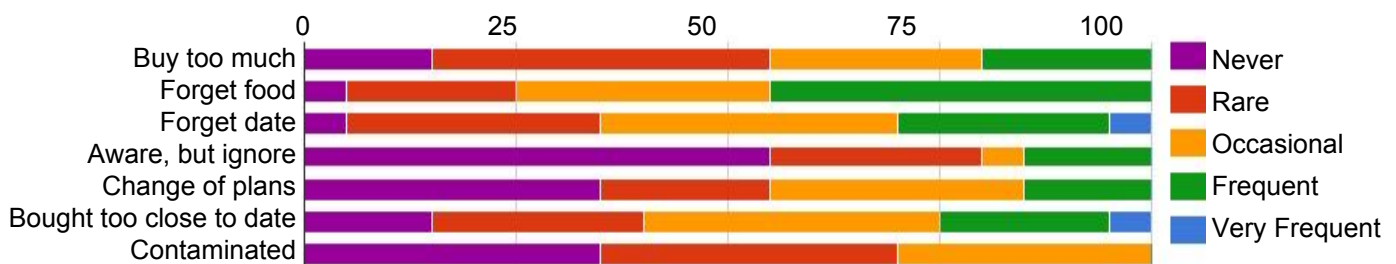


Figure 6: Reasons for wasting food by frequency (% respondents)

Food Use

- Meal plans span from many days in advance to spontaneous (high proportions of each) - recipe suggestions should account for this.
- Most people plan 1-2 meals at once, but some more than 10 (known as ‘meal-prepping’).
- Vegetables, meat & bread are commonly wasted (as Parfitt *et al.*, 2010; Gustavsson, 2011).
- Supermarkets are used most. Markets/food specialists are moderately used (no barcodes), as are online retailers.

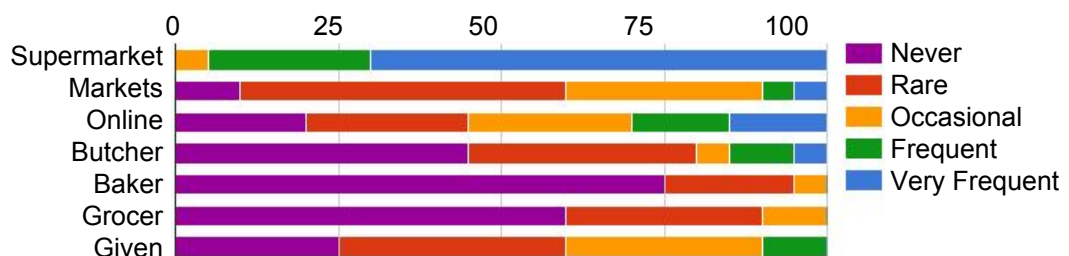


Figure 7: Food shopping methods by frequency (% respondents)

Technology

- A smart technology solution had the most positive response (but 1 thought poor). This was closely followed by notifications, which everyone thought were at least acceptable (Figure 8)
- Suggestion for planning meals.
- Phones used by many for recipes, and notifications had the least negative response, suggesting that making an app may be the best direction.

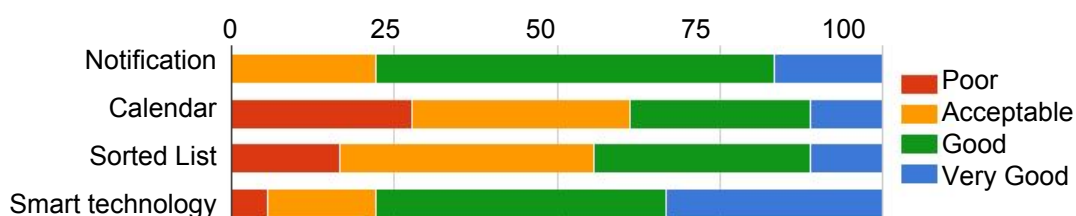
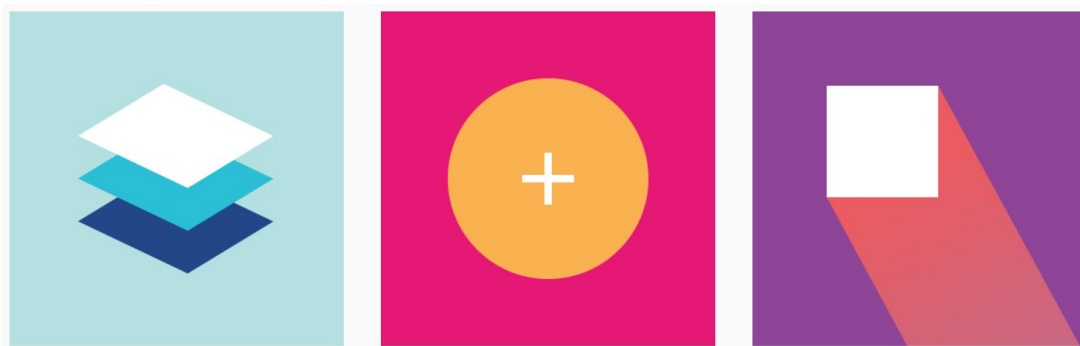


Figure 8: Ratings of different feedback methods (% respondents)

App Design Influences

Android has over 80% of the market share worldwide, and phones with an Android OS are being sold ~460% as fast as iOS. OSes other than those 2 have less than 0.4% market share. (Gartner, 2017). As a result, primary development of the app will be on Android.

Android has a common visual language that designers for the platform are encouraged to use. Employing 'Material' design takes advantage of both user stereotypes and good general design principles: "Surfaces and edges of the material provide visual cues that are grounded in reality. The use of familiar tactile attributes helps users quickly understand affordances". The focus is on "deliberate color choices, edge-to-edge imagery, large-scale typography, and intentional white space... emphasis on user actions" (Google, 2017).



Material is the metaphor Bold, graphic, intentional Motion provides meaning
Figure 9: Principles of Material design (Google, 2017)

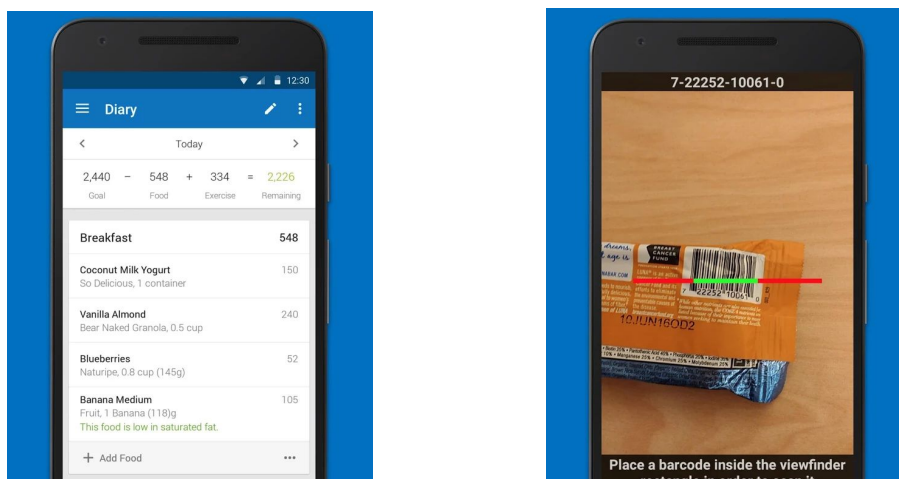


Figure 10: MyFitnessPal: diary view and barcode scanning (MyFitnessPal, 2017)

MyFitnessPal provided a reference for another food based app, and demonstrated the use of (simple) computer vision - using the camera to scan barcodes (Figure 10). Barcodes are not sufficient for the app developed here, as they are not on food from markets (etc), and only input one food item at a time. Technology appears to exist that is capable of finding and identifying multiple foods from a single photo (as described earlier), which requires much less user effort.

UX Design

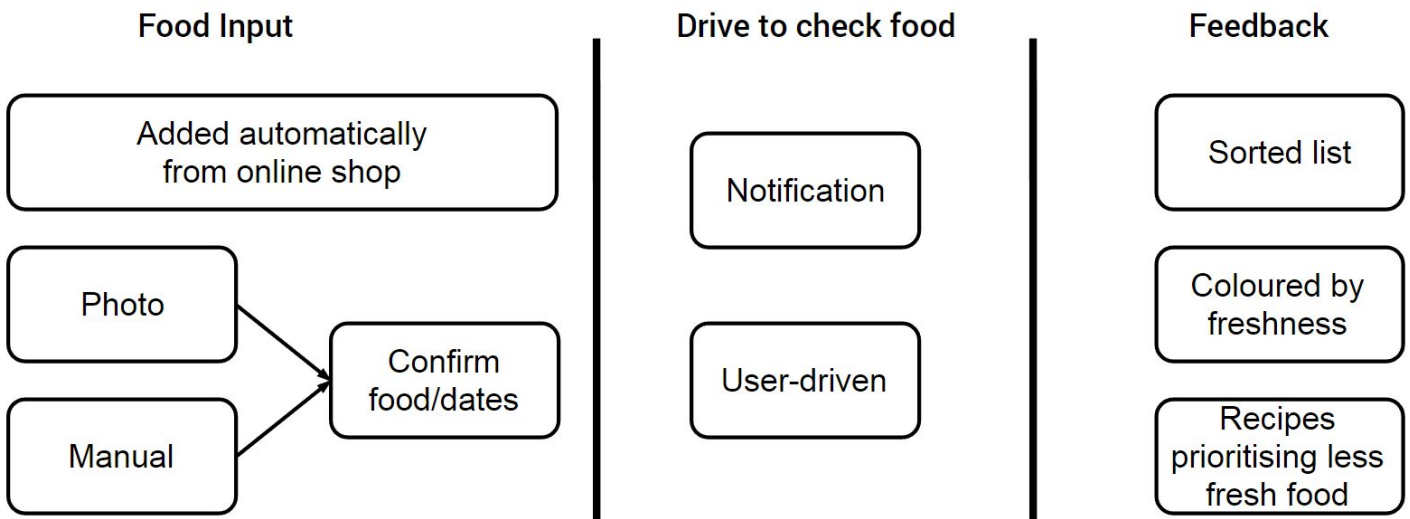


Figure 11: Simplified user interaction with app. See Appendix E for flow chart.

Aims

- Provide flexible inputs and outputs - redundant methods through different types
- Require as little interaction as possible for each user stage

Food Input

- No user effort - Online shop integration
- Minimal user effort - Photo
- Some user effort - Manual product selection
 - Search
 - Browse (similar to self-service checkout - existing stereotypes)
 - Add new food

Determination of best-before date

- Explicitly stated (by user/online shop)
- Estimated based on food & storage type
- Machine-learned algorithm estimates on food, storage type *and* visual characteristics

Feedback timing

- Fixed time(s) before the best-before date.
- Triggered by other actions, e.g. looking at recipes for the following week's meal.
- User-determined (e.g. seeing general overview).

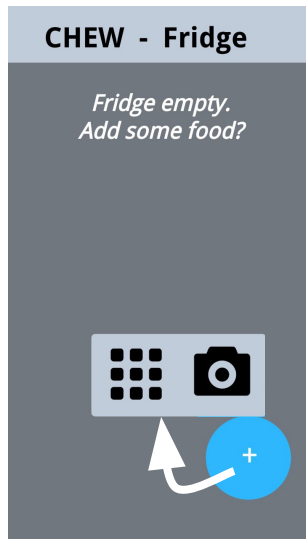
Feedback type

- Simple notification of foods near BB date
 - Email
 - Popup
- Fridge elements listed in date order
- Recipes with items near best before date

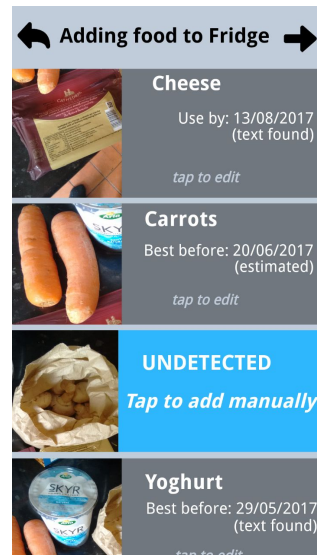
Concept refinement

Procedure

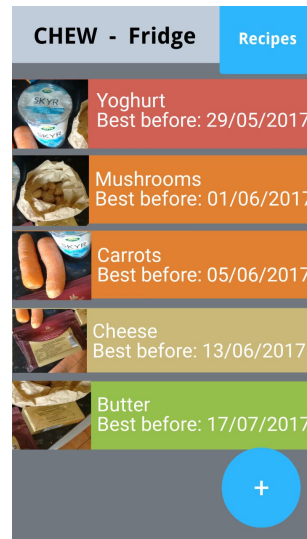
POP - Prototyping on Paper was used to test out the user journey on 4 users, following Nielsen (2000) & Krug (2010). Participants provided feedback on the interface and their understanding of what was going on as they went through the user journey. See Appendix F for all screens and task flow. Key points are mentioned below.



- + Obvious how to start.
- Not obvious that the camera will autodetect food on the first use. Even though more effortful, participants use the manual entry option, as this is familiar.



- + Useful seeing how the dates had been determined (e.g. text read vs estimate).
- + Information architecture easy to follow (through manual processes).
- + Foods requiring user action are obvious.
- Individual foods take up too much real-estate - size as with fridge (right).



- + Colour-coding is meaningful.
- + Sorted list useful.
- + Good as homepage
- + 'Interaction' vs 'food' colours well distinguished.
- Food colours are bland/need tweaking.
- Ensure 'out of date' food is distinguished.



- + Coloured dots with numbers understood as how many ingredients at each freshness stage were used in a recipe.
- Couldn't tell which ingredients immediately.
- Wanted more info on recipe (time required).
- Wanted to be able to sort recipes in other ways.

General comments

Some would prefer as standalone app, some would prefer integration into a calorie-counting or recipe app, so that foods do not have to be added multiple times. This may also allow for better triggering of notifications: when a user is planning meals for the following week, recipes that use up low-freshness food are suggested. It could also integrate into existing social networks for adding and rating recipe suggestions.

Participants liked the idea of food being automatically added from an online shop.

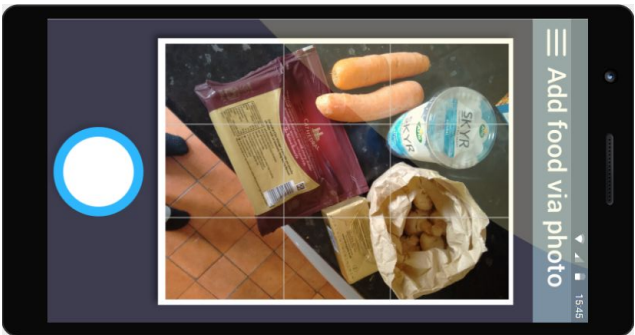
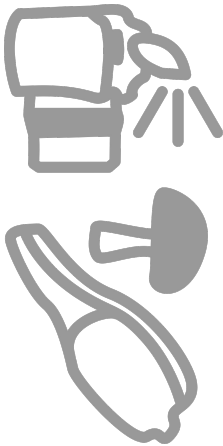
The photo scanning was thought to be a very easy input method.

A representation of money saved/impact achieved was wanted.

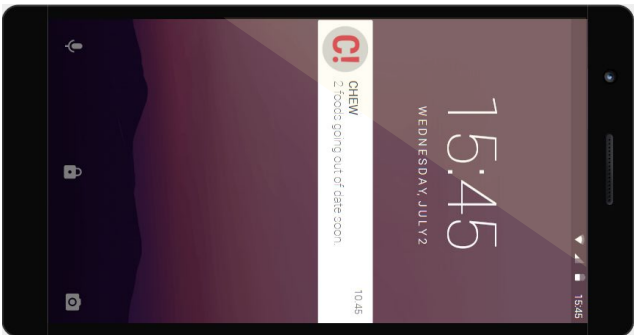
Final Concept

Save food and money with minimal effort. Normal use involves only a few steps:

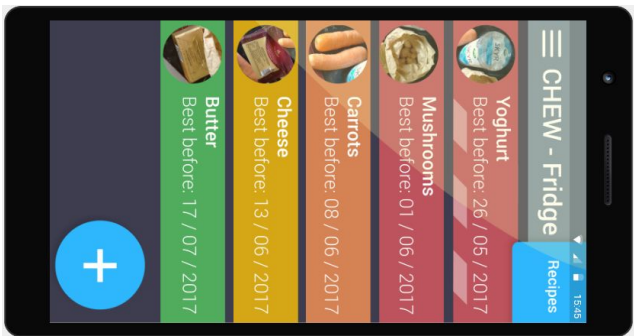
1) Photo your food



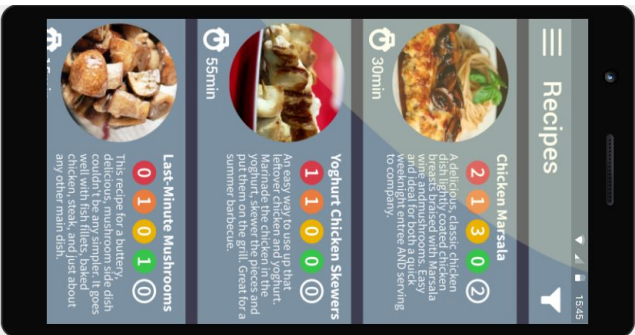
2) Get notified that food is about to go off



3) See foods sorted by freshness



4) Get recipe ideas for the foods about to go off



(Example recipes/photos from AllRecipes, 2000; Hungry Girl, 2011; Magill, 2005)

Discussion

Technical feasibility

Although similar technology appears to exist, it might be difficult to train the algorithm for detecting all the various possible foods ahead of time. It may be possible, however, to provide an initial annotated corpus, and improve the interpretations based on user corrections and active learning with web-based food images (Sivaraman & Trivedi, 2014).

Managerial feasibility

Integration with online shops is not necessary for the app to function, however it eliminates effort required on the food input side. It is uncertain whether multiple online food shops would be willing to associate themselves with each other via connection with the same app, however they may be able to present it publicly as putting aside their differences for a higher cause.

Solution format

Apps such as this require user motivation to input food and (to a lesser extent) to pay attention to the warnings provided. This has been minimised as much as possible with the proposed graceful degradation/fallback procedure (automatic online-shop integration to photo recognition of multiple items to manual entry), however friction still exists. The initial proposition of a fridge with image detection and coloured highlights for food going out of date may fit into a user's life with less effort, which is likely to improve continued use. This idea was strongly liked by some, but disliked by others. As a result, multiple formats may be better than one that tries to please everyone.

User acceptability

Some participants suggested that this would be a product they would actually use. Some said they would prefer if it were incorporated into an app that they already used, such as a 'real' recipe app or food-tracking app. This could also provide a social element (which Thomas *et al.* (2008) suggested may improve user retention), and allow contextually-timed notifications.

Extent of solution

The solution does not account for food going out of date at a different time. Continual visual contact (i.e. with cameras in a fridge) may be better at predicting off food. There may be legal issues with encouraging eating outside of use-by dates, and there are contradictory opinions on whether this should be done (Food Standards Agency, 2017; Gustavsson, 2011). Recipe generation methodology has not been explicit thus far. A technique similar to Ueda *et al.* (2011) for personalized cooking recipe recommendation could be readily employed with additional weighting on foods close to their use-by/best-before date. This would be best if preferred meals for users were already known: again suggesting that incorporation into a fully-fledged recipe app may be the best direction.

Methodological Limitations

Results based on students as participants may not generalise to others, even of the same age. Further research is required to explore any differences that may exist in different populations.

Conclusions

Through literature research and user involvement, a need was found relating to decreasing the large amount of avoidable food waste: users forget about their food until it is too late.

Suggestions for addressing this need have been made, and one was followed through to a successful proof-of-concept prototype app based on a simple task flow and Android Materials guidelines.

Key Results

Students either underestimate the amount of food they waste or waste less than expected. Forgetting about food or its use-by dates are the most common reasons for throwing it away.

Waste food is mostly uncooked.

Computers and phones are both used a lot for finding recipes.

Most students make 1-2 meals at a time, which are approximately equally likely to have been planned many days before, the day before, or the day of preparation.

The supermarket is the most used food source in the population sampled.

UX testing led to some small changes, but overall confirmed the utility and usability of the app: participants engaged with the app, and suggested both that they would use it, and that it would address their food-waste-reduction need.

Future Developments

Machine-learned algorithms for detecting food need to be developed for this specific purpose.

Online food retailers may need convincing to link to this app.

Smart technology (particularly fridges) may be a better long-term solution, but is less easily implemented.

Automatically generate infographics for the amount of food and money saved by users.

Incorporation with a recipe app may encourage user adoption and persistent use.

The other major source of avoidable household food waste - too much food being prepared - should also be addressed.

Concluding Remarks

Prevention of food waste at the individual level is both important and feasible. The proposed app appears to be a partial solution to this problem. Some (discretionary) technical and social challenges remain to be overcome, but the app, and the service it provides, look like a promising solution to this food waste problem.

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Appendix A: Participant Information Sheet

Food Waste Reduction – User Research Participant Information Sheet

What is the purpose of the study?

This research is one of a number of steps to provide a product (app) that reduces food waste. The aim is to inform users of how close their food is to the best before/use by date and so encourage/remind them to eat it before it goes off.

What will I be doing?

Answering questions about food use, food waste, and technology use.
Going through a prototype app and providing feedback.

Who is doing this research and why?

This study is a part of a student coursework assignment by Andrew Reece
a.z.m.reece-14@student.lboro.ac.uk.

Once I take part, can I change my mind?

Yes. After you have read this information and asked any questions you may have, I will ask you to complete an Informed Consent Form. You can withdraw at any time, for any reason before the work is submitted and you will not be asked to explain your reasons for withdrawing.

How long will it take?

This study should not take more than 20 minutes.

What personal information will be required from me?

None

Will my taking part in this study be kept confidential?

Yes

What will happen to the results of the study?

Extracts from the user research including photos will be presented within the coursework submission but all extracts will be anonymous. Personal details (name, address etc.) will not be passed on to anyone.

What if I am not happy with how the research was conducted?

Contact the module leader Diane Gyi, Loughborough Design School
d.e.gyi@lboro.ac.uk

The University has a policy and procedure relating to Research Misconduct and Whistle Blowing which is available online. If you require access to this document, please search online for 'Loughborough University Whistleblowing'.

Appendix B: Consent form

(to be completed after Participant Information Sheet has been read)

The purpose and details of this study have been explained to me.

I have read and understood the information sheet and this consent form.

I have had an opportunity to ask questions about my participation.

I understand that I am under no obligation to take part in the study.

I understand that I have the right to withdraw from this study at any stage for any reason, and that I will not be required to explain my reasons for withdrawing.

I understand that all the information I provide will be treated in strict confidence and will be kept anonymous.

I am willing for unnamed photos of me to be shared within Loughborough Design School.

I agree to participate in this study.

Your name _____

Your signature _____

Researcher signature _____

Date _____

Appendix C: Questionnaire

Questionnaire - Food Waste

Food waste

The purpose of this questionnaire is to determine how people prepare and waste food, in order to develop a product (most likely an app) for reducing food waste.

By participating you confirm that you are over 18, and you understand that:

- Your participation is voluntary
- Your data will be anonymised

What is your age? (in years)

Your answer

What is your gender?

- ☐ Male
- ☐ Female
- ☐ Prefer not to say
- ☐ Other: _____

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How many times a month do you throw away food because it is out of date/going off?

Your answer

Of the food you throw away, what proportion of it have you already cooked?

0 1 2 3 4 5 6 7 8 9 10

None cooked (e.g. all as raw ingredients) ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ All cooked

Of the food you throw away, what proportion of it do you recycle/compost?

0 1 2 3 4 5 6 7 8 9 10

None ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ All

How frequent are the following causes for throwing away food?

	Never	Rare	Occasional	Frequent	Very Frequent
You buy too much	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
You forget about it	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
You forget the use-by/best-before dates	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
You are aware of date but don't want to eat it anyway	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
You have a sudden change of meal plans (e.g. take out/eat out)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
You bought too close to its use-by/best-before date	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The food is contaminated/damaged (dropped, spilt bleach on...)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other (type below)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

(Other reasons for throwing away food)

Your answer

What types of food do you (more) commonly throw away?

Your answer

Do you have any other comments on how or why you waste food?

Your answer

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Questionnaire - Food Use

How frequently do you acquire food (for your own preparation) from the following?

	Never	Rare	Occasional	Frequent	Very Frequent
Supermarket	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Markets	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Online	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Butcher	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Baker	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Grocer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Given by someone else (e.g. parents)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

How frequently do you use the following for viewing food recipes?

	Never	Rare	Occasional	Frequent	Very Frequent
Recipe books	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Computer/laptop	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Phone	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tablet	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

What's the longest in advance that you typically plan meals?

- ☐ You decide as you add ingredients to the meal
- ☐ You decide immediately before cooking
- ☐ You decide the day of cooking
- ☐ You decide the day before cooking
- ☐ You decide multiple days before cooking (e.g. at the beginning of the week)
- ☐ Other: _____

How many meals do you typically prepare at once?

1	2	3	4	5	6	7	8	9	10
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

(or more)

Do you have any other comments on how you prepare food?

Your answer

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Questionnaire - Notifications

How would you rate the following ways of informing you that food is about to go out of date?

	Very Poor	Poor	Acceptable	Good	Very Good
Notification shortly before the "best before" date	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
"Best before" dates integrated into your calendar	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A sorted list of best-before dates	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Integration with other technology (e.g. smart fridge)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other (describe below)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

(Other ways you'd like to be informed)

Your answer

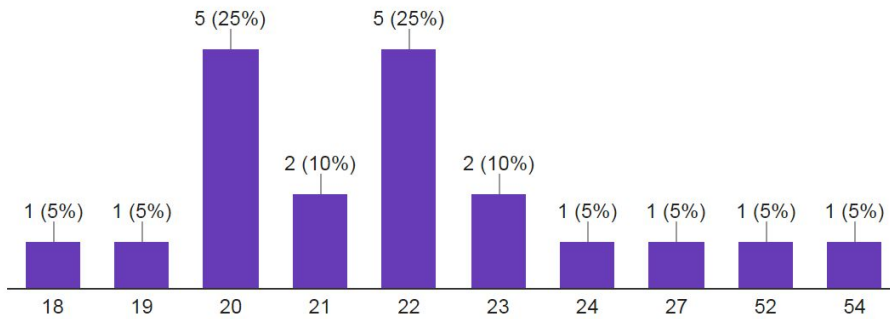
BACK

SUBMIT

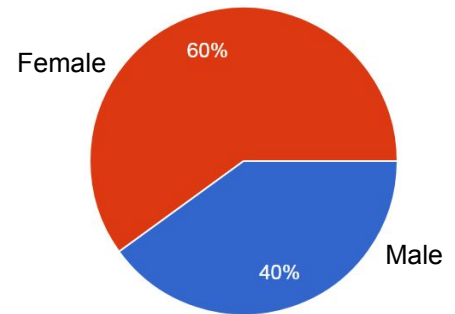
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Appendix D: Key Questionnaire Results

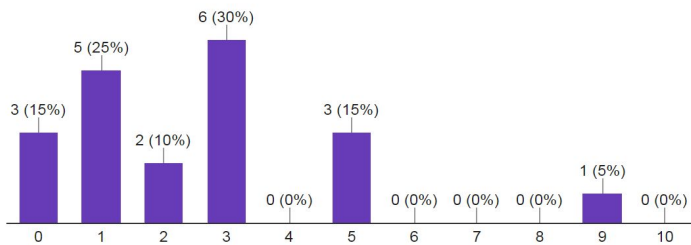
What is your age (in years)



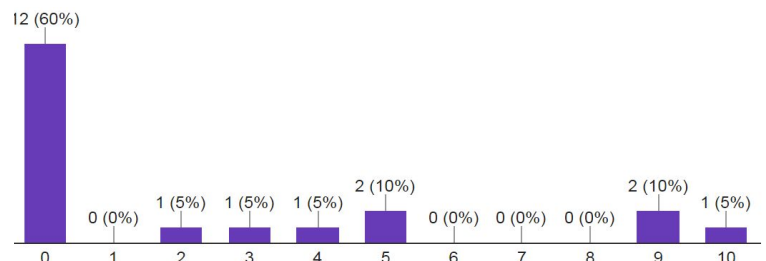
What is your gender?



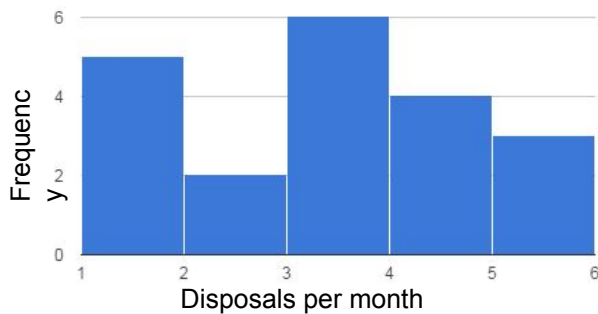
Of the food you throw away, what proportion of it have you already cooked?



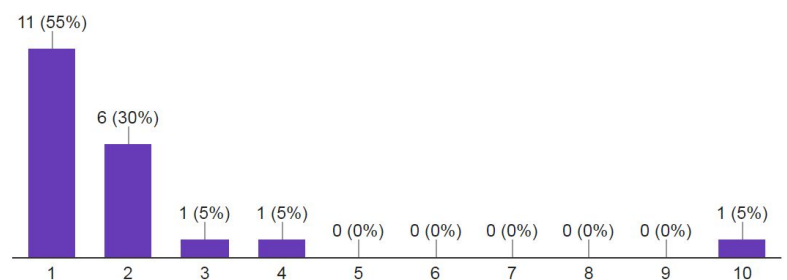
Of the food you throw away, what proportion of it do you recycle/compost?



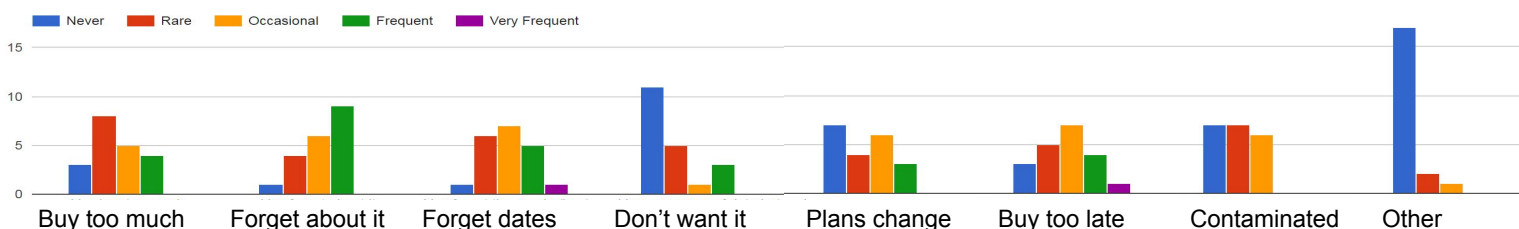
How many times a month do you throw away food because it is out of date/going off?



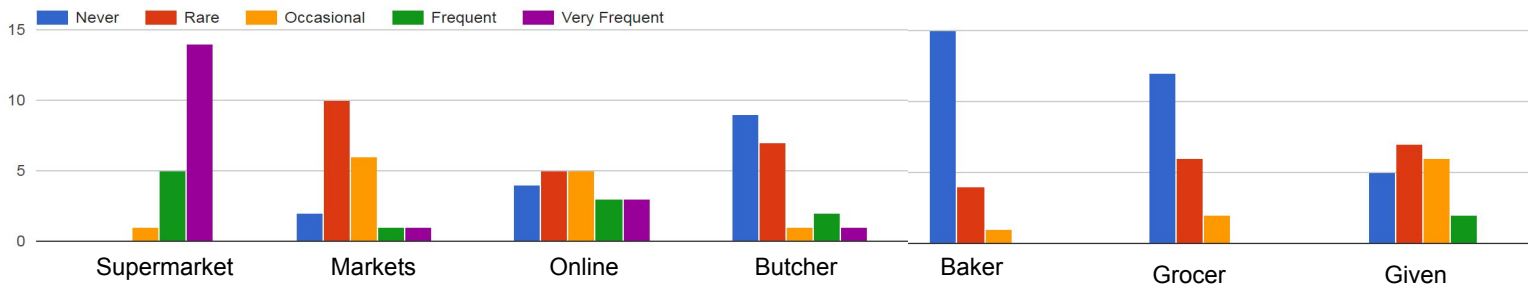
How many meals do you typically prepare at once?



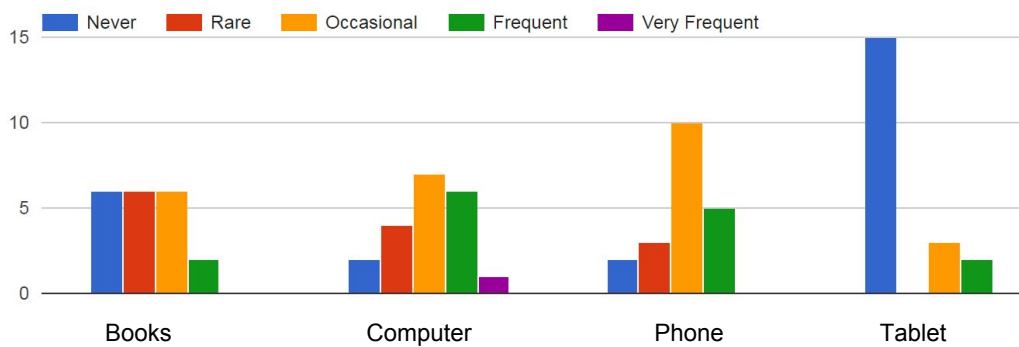
How frequent are the following causes for throwing away food?



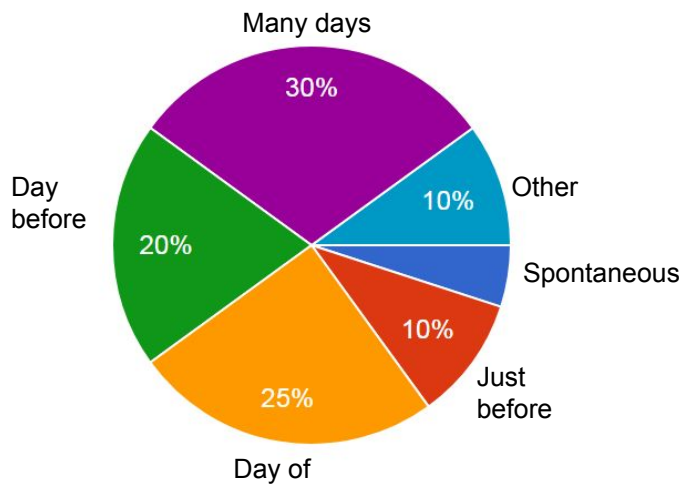
Frequency of food sources



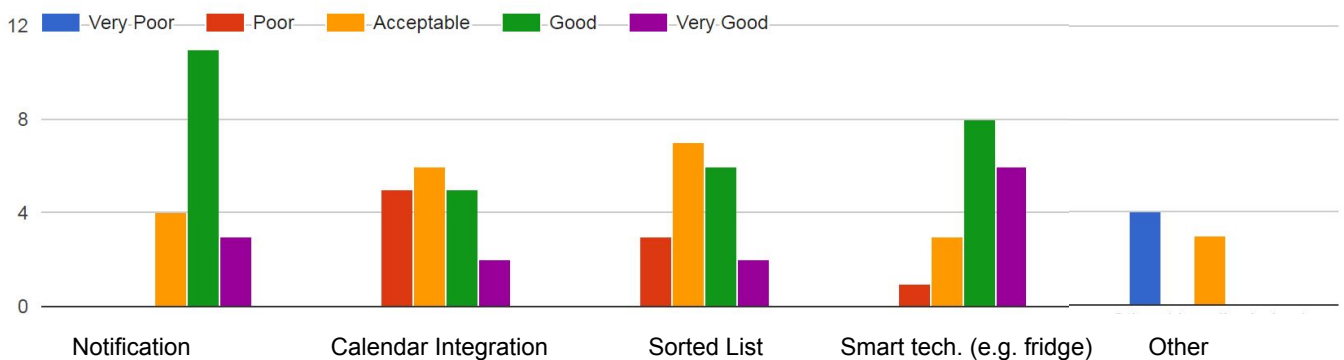
Frequency for viewing food recipes?



How far in advance do you plan meals?

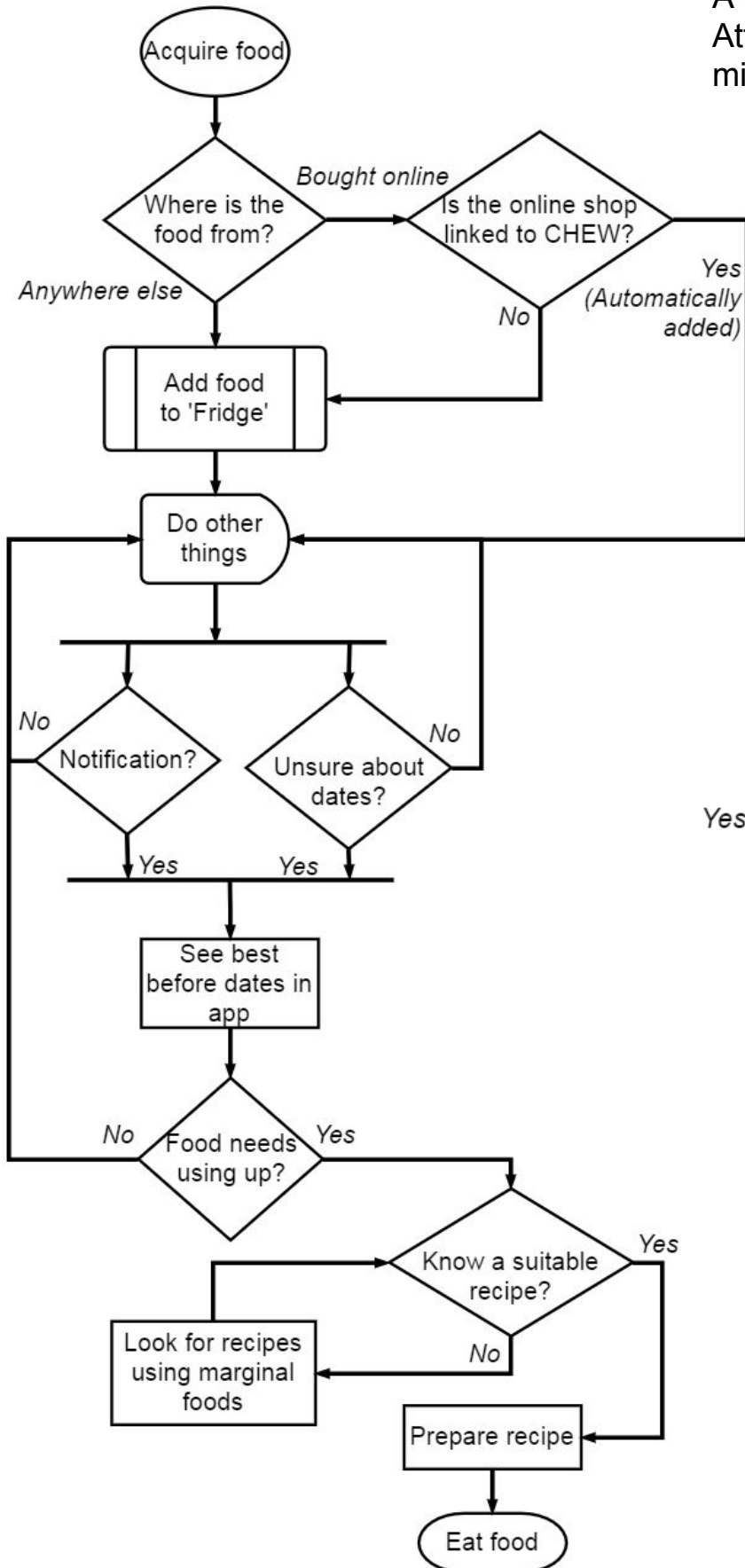


Rate the following ways of informing you that food is about to go out of date:



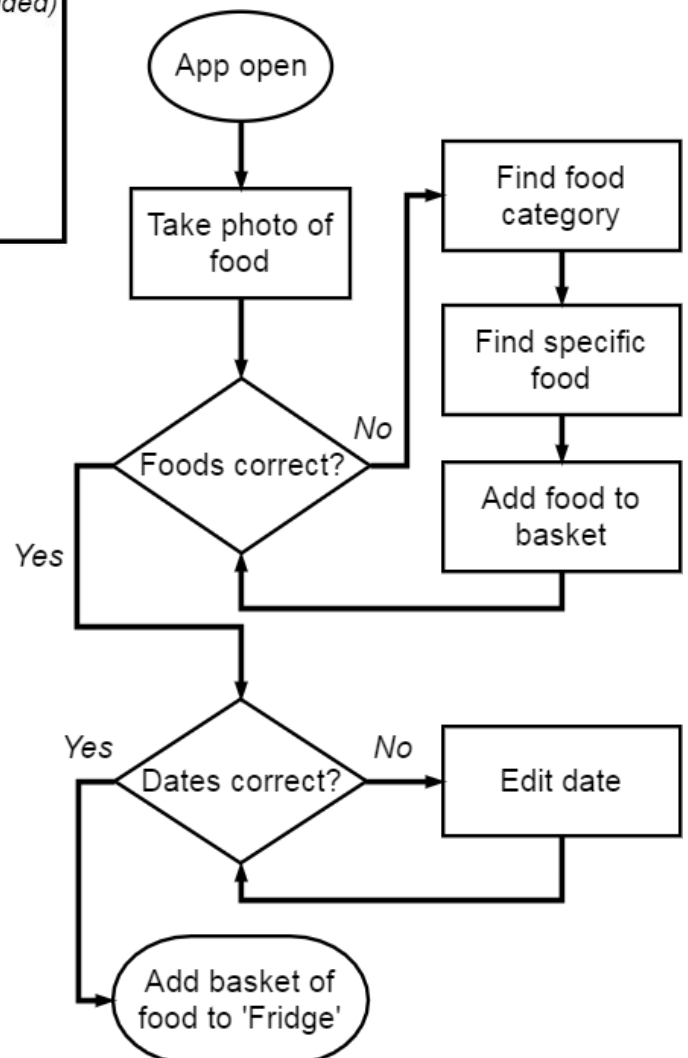
Appendix E: User Journey Flow Charts

General app use:



A key consideration was the Attempted to make these require the minimum input to use.

Add food to 'Fridge':



Appendix F: POP Prototype Navigation

These screens follow the task flow depicted in Appendix E.

