Valorisation Database

FoodWasteEXplorer

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List of abbreviations

API	Application programming interface
FCDB	Food composition database
FIPS	Federal Information Processing Standard
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
SRS	Software requirement specification
WCAG	Web Content Accessibility Guidelines

1   Executive Summary

Background

Identifying the most appropriate edible and inedible food waste streams for valorisation, regarding robustness of supply, quality and composition, is important in helping stakeholders build a more sustainable and secure food system. Part of the outputs of the REFRESH project is a compositional database "FoodWasteEXplorer" that provides users with ready access to the biochemical composition of agri-food chain waste streams to support research and development that can aid valorisation and identification of market opportunities.

The FoodWasteEXplorer can be accessed at https://ws.eurofir.org/foodwasteexplorer and is free-of-charge. It can be used by researchers, government agencies and industry including SMEs, and the general public to explore how food waste might be better used. Filters can be applied to retrieve subsets of data, such as side streams (e.g. peel, stalks, seeds) and component groups (e.g. vitamins, minerals).

Data available in FoodWasteEXplorer

Initially, a list of 75 prioritised waste or co-product streams was prepared, based on the most environmentally challenging foods of large volume, e.g. spent grains (alcoholic beverages). Using this list, peer-reviewed publications and existing databases were identified, and composition data added to an Excel-based database. More than 25,000 data points were collected. These included proximates (fat, protein, etc.), inorganics (sodium, potassium, etc.), vitamins (carotene, vitamin E, etc.), undesirable components (toxins, bacteria, etc.), bioactives (anthocyanins, polyphenols, etc.) and other compounds relevant to valorisation processes (volatile content, biogas composition, etc.).

Functionality

A software requirement specification (SRS) for FoodWasteEXplorer was developed to manage the compositional data collected for food waste streams. It was designed to handle food waste streams that are linked to a large set of compositional data and allow both searching by users and data entry by database managers. It is composed of a backend for database managers (i.e. a cloud server where data are stored and processed) and a frontend for users.

Usability testing was undertaken to determine whether FoodWasteEXplorer was fit-for-purpose. Once the REFRESH project ends, FoodWasteEXplorer will be hosted and maintained by EuroFIR AISBL.

2   Background

Approximately one-third of foods fit for human consumption are wasted globally (ca. 1.3 billion tonnes annually) (FAO, 2011). Identifying the most appropriate edible and inedible waste streams for valorisation, with respect to robustness of supply, quality and composition, is important in helping stakeholders build more sustainable and secure food systems. Efficient handling of food waste is an important part of maximising value from foods.

One aspect of REFRESH was to produce a compositional database that helps to improve use of unavoidable waste (e.g. peel). Some of the most common food products (e.g. apples) and their associated sides streams (e.g. apple pomace) were identified, based on how much is eaten and the environmental impact of production. This information was used to develop FoodWasteEXplorer, supporting productive use of these natural resources.

FoodWasteEXplorer provides information on the composition of waste food products that have the potential for valorisation and currently contains ca. 26,000 data points, representing nutrients, bioactives and toxicants, collected from a variety of sources, including scientific (peer-reviewed) papers, manufacturers' data (grey literature) and other data sources. This work is on-going, and more data will be added with time.

FoodWasteEXplorer is free-of-charge for researchers, government agencies and industry including SMEs, and the general public. It is a tool for those exploring how food waste might be better used, e.g. citrus peel limonene can be used to make medical plastic. Potentially, a fruit juice producer could use FoodWasteEXplorer to identify this and start the process towards alternative uses. Filters can be applied to retrieve selected subsets of data, such as side streams (e.g. peel, stalks, seeds) and component groups (e.g. vitamins, minerals) and search results can be exported for further offline analysis. FoodWasteEXplorer can help stakeholders identify waste streams that are appropriate to valorise, enable innovators to accrue appropriate waste-related composition knowledge, and support policy-makers with identification and implementation of improvements in legislature.

QIB leads this task with support from EuroFIR and JSI. FoodWasteEXplorer was designed from scratch, based on the type of data collected and inspiration from other databases containing similar data structures. It can be found at: https://ws.eurofir.org/foodwasteexplorer.

2.1 Objectives

The objective of this work was to develop, test and populate a compositional database that will provide users with ready access to the biochemical agri-food chain waste streams in order to aid identification of market opportunities. This included:

- Evaluation of databases currently available
- Development of a new database structure to enable data population
- Design of a food waste composition database to serve the needs of maintenance, exploration, and exploitation of compositional structured and unstructured data on specific food waste streams
- Population of the database with inputs from other databases (compostion tables, bioactives, safety e.g. COMBASE), literature reviews, valorisation approaches and where appropriate compositional analysis

2.2 Waste streams

75 waste (and co-product) streams were identified as the basis for identifying suitable compositional data. These have been determined to be appropriate for valorisation by food waste and valorisation researchers in previous REFRESH research activities. For further details see Moates et al 2016.

Table 1 shows the top waste streams and number of collected data points for each. A list of all waste streams currently linked to data within FoodWasteEXplorer can be found in Annex 2.

Table 1. Prioritised list of 75 waste streams with number of collected data points

Food Product	Waste Stream	Number of data points collected
Apples	Pomace, single pressed	363
Apples	Pomace, double pressed	
Apples	Pectin extracted fruit	15 (relating to pectin, not pectin extracted fruit)
Juices	Pressings (pits, seeds, pulp, grape lees, peel)	1,390 (including various fruits and vegetables)
Oranges	Peel, seed, membrane residue after juice extraction	121
Oranges	Citrus zest and peel	239 (includes all citrus fruit)
Oranges	Citrus molasses	71
Tomatoes	Pomace (skin, pulp & seeds)	97
Potato	Fibre from potato starch production	18
Potato	Protein from potato starch production	0
Potato	Concentrated fruit juice from potato starch production	0
Potato	Peelings	60

Frozen potato products	Peelings (steam-peeling)	0
Frozen potato products	Peelings (abrasion peeling)	0
Rice	Rice husks	81
Wheat milling products	Wheat middlings	26
Wheat milling products	Wheatfeed	2
Cheese	Whey	154
Cheese	Whey concentrate	0
Cheese	Whey permeate	0
Beef, fresh & frozen	Blood	21
Beef, fresh & frozen	Carcass fat	0
Beef, fresh & frozen	Bones	0
Eggs	Egg shell waste (shell)	121
Fish/seafood, chilled, canned & frozen	Mollusc shell / shell particles	9 (relating to crab shell)
Lamb, fresh	Category 3 - slaughter	24 (including hooves, rumen content, wool meal)
Lamb, fresh	Category 3 - cutting	
Lamb, fresh	Category 3 - imports	
Lamb, fresh	Blood	75
Pork, fresh	Blood	0 (information collected on general animal blood)
Pork, fresh	Head	0
Pork, fresh	Hooves	0
Pork, fresh	White offal	0
Pork, fresh	Red offal	15
Pork, fresh	Bones	0
Poultry, fresh & frozen	Blood	81
Poultry, fresh & frozen	Feather	109
Poultry, fresh & frozen	Head	8
Poultry, fresh & frozen	Feet	8
Poultry, fresh & frozen	Guts	0
Poultry, fresh & frozen	Giblets/offal	96
Poultry, fresh & frozen	Bones	0
Poultry, fresh & frozen	Poultry skin	0
Poultry, fresh & frozen	Fats	1
Poultry, fresh & frozen	Feet	8
Crisps	Vegetable peelings	0 (Data collected for potato but not specifically for crisp manufacturing)
Crisps	Peel and trim	
Crisps	Primary sludge (uncooked) / feed-grade starch	0
Margarine	Stalks, leaves, hulls	0 (Information collected for vegetable oils)
Sugar	Sugar beet pulp	398
Vegetable oil	Crude press cake	577
Vegetable oil	Olive stones	72
Vegetable oil	Extracted press cake or spent meal	36
Vegetable oil	Gums	0
Vegetable oil	Distillate	0
Vegetable oil	Wastewater	50
Ales	Malting by-products (malt powder, malt culms, malt residual pellets	0
Ales	Barley screenings	12
Ales	Spent grains	272
Ales	Grains pressings	0
Ales	Spent hops	160
Ales	Surplus product / ullage	0
Ales	Hot trub	0
Ales	Yeast	144

Cider/perry	Pomace	0
Lager	Spent grains	0
Lager	Trub and yeast	0
Light wines	Pomace (skin and seeds)	456
Light wines	Grape skins	159
Light wines	Grape seed	160
Spirits	Organic wastes, mash from grain, fruit or potato	17
Spirits	Spent grain (draff)	627
Spirits	Pot ale (still residue post-distillation)	17
Spirits	Distillers dark grain	Included in spent grain

Publication and data searches focused on the top 75 waste streams. Data counts relate precisely to what is described in the waste stream column. Large amounts of data relating to similar but different waste streams (e.g. tomato residues, tomato stems, tomato oil cake) were also collected. If a publication contained data for a waste stream outside the scope of the top 75 waste streams, these were also included in FoodWasteEXplorer to make a more comprehensive dataset.

3   Design of the Database

3.1 Design scope

FoodWasteEXplorer (https://ws.eurofir.org/foodwasteexplorer) is free-of-charge and can be used to investigate information on the composition of some of the most common products (e.g. apples) and their associated side streams (e.g. apple pomace).

The scope of FoodWasteEXplorer was to accommodate large sets of compositional reference data for food chain co-products and waste streams (outlined in section 2.2) in a standardised manner for user online access.

FoodWasteEXplorer has been designed to enable data entry (by database managers only), maintenance and validation as well as exploration and export, again in standardised ways. It has been designed for use as a reference source for researchers and early stage process developers, REFRESH project managers, and data compilers. Standardisation followed the *food data structure and format standard* (BS EN 16104:2012), prepared by EuroFIR AISBL, GS1 and others.

An initial discussion was held to determine the assessment criteria needed for FoodWasteEXplorer and included considerations such as:
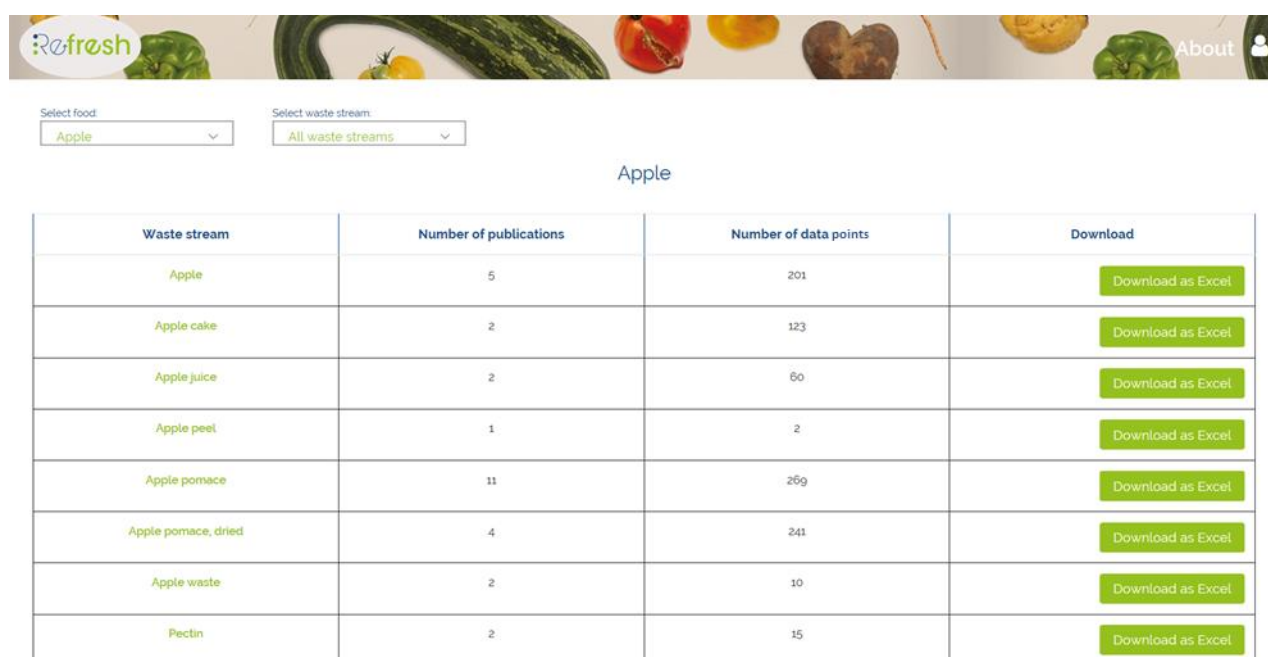
- Name and design – What name would describe the database well and how can the database appeal to users
- End users – Who would this be and how many would use the tool
- Main components and functionality – What is needed? Backend for maintenance, cloud server for storage and frontend for users, what should each of the components do and what does the database need to do
- Operating environment – Which browsers need to support it, which language should it be in, is registration required, which cloud server should be used and how will it be integrated into the REFRESH website
- Data model – how do the foods, waste streams, data etc. link within the tool
- Thesauri – which thesauri should be used for units, components, value types etc. and what about new components/matrix units
- Search tool – how will the user want to search and what will they want to search for
- Data analysis and validation – how should the quality of data, including outliers and missing values, be monitored
- Data exports – who will perform data exports and which information would be required
- User interfaces – what type of data is shown in which part of the screen, what are the aesthetic and functional aspects, are users happy with their interface

- Examples – examples of other available databases with similar information can help identify methods used to solve some of these issues

A technical description of the database structure can be found in Annex 1.

3.2 FoodWasteEXplorer screen shots
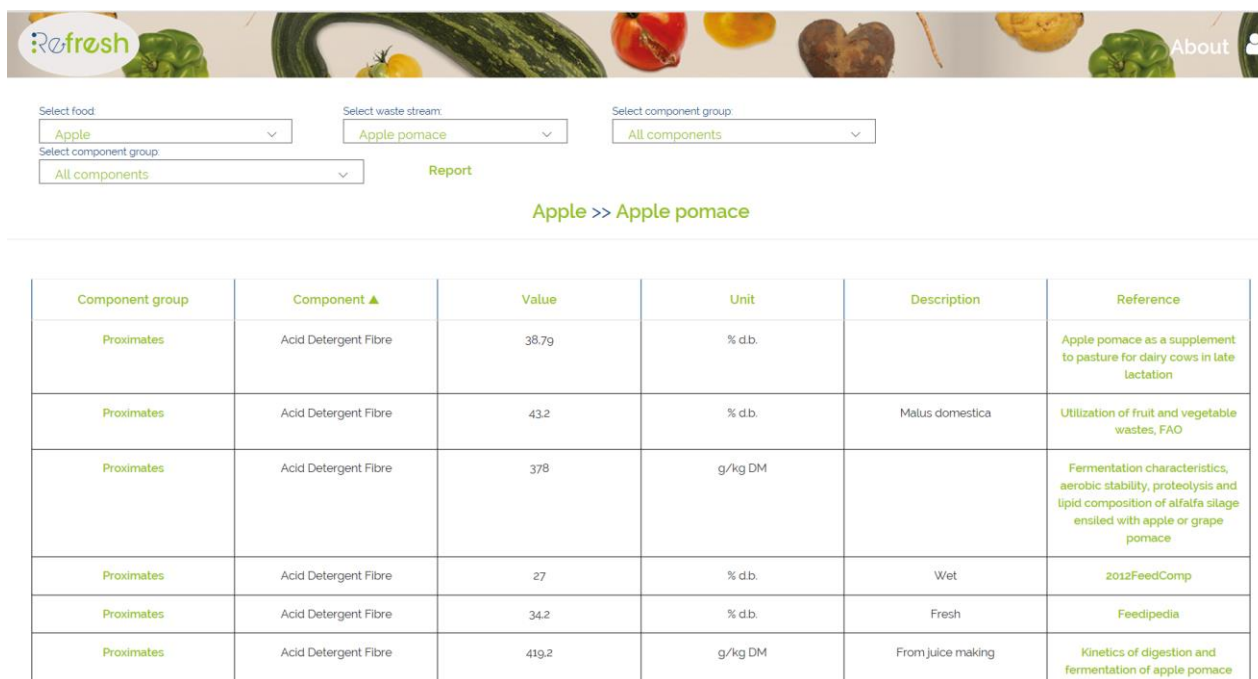
Figure 1 shows an example of waste streams found when selecting the food 'apple'. The user first selects a food from the drop-down list. This brings up the available waste streams linked to that food. The number of publications and data points collected for each waste stream is shown. The user can choose to download all the data for a particular waste stream into Excel or click on the waste stream for further data exploration.

Figure 1. Screenshot of FoodWasteEXplorer showing apple waste streams

Figure 2 shows the resulting output of choosing 'apple pomace' for further data exploration. Every collected data point can be seen with the associated component type, unit, reference and further description. Each column can be sorted alphabetically. The user can choose to make further selections using the drop-down lists at the top of the page.

Figure 2. Screenshot of FoodWasteEXplorer showing a selection of data for apple pomace

Figure 3 shows the optional Excel download of all data relating to the waste stream 'apple pomace'. It is possible for users to download several food wastes in Excel and combine them, therefore enabling them to search several waste streams at once.

	A	B	C	D	E	F	G	H
1	Food Product	Waste Stream	Description	Compound Group	Compound	Level	Unit	Reference
2	Apple	Apple pomace	Fresh	Proximates	Acid Detergent Fibre	34.2	% d.b.	Feedipedia
3	Apple	Apple pomace		Proximates	Acid Detergent Fibre	38.79	% d.b.	Apple pomace as a supplement to pas
4	Apple	Apple pomace		Proximates	Acid Detergent Fibre	378	g/kg DM	Fermentation characteristics, aerobic
5	Apple	Apple pomace	Malus domestica	Proximates	Acid Detergent Fibre	43.2	% d.b.	Fruit waste as feed paper
6	Apple	Apple pomace	Malus domestica	Proximates	Acid Detergent Fibre	43.2	% d.b.	Utilization of fruit and vegetable wast
7	Apple	Apple pomace	Wet	Proximates	Acid Detergent Fibre	27	% d.b.	2012FeedComp
8	Apple	Apple pomace	From juice making	Proximates	Acid Detergent Fibre	419.2	g/kg DM	Kinetics of digestion and fermentatior
9	Apple	Apple pomace	From puree making	Proximates	Acid Detergent Fibre	315.3	g/kg DM	Kinetics of digestion and fermentatior
10	Apple	Apple pomace		Inorganics	Ag	<0.1	ppm d.b.	NOSHAN
11	Apple	Apple pomace		Inorganics	Al	15.55	ppm d.b.	NOSHAN
12	Apple	Apple pomace		Proximates	Alanine	2.4	mg/g dry matter	NOSHAN
13	Apple	Apple pomace		Proximates	Alanine	1.42	% D AA	NOSHAN
14	Apple	Apple pomace		Proximates	Arabinose	73	Non covalent-bor	NOSHAN
15	Apple	Apple pomace		Proximates	Arabinose	67.2	Covalent-bound p	NOSHAN
16	Apple	Apple pomace		Proximates	Arginine	1.52	mg/g dry matter	NOSHAN
17	Apple	Apple pomace		Inorganics	As	<0.1	ppm d.b.	NOSHAN
18	Apple	Apple pomace	Fresh	Proximates	Ash	2.5	% DM	Feedipedia
19	Apple	Apple pomace		Proximates	Ash	3.76	% DM	NOSHAN
20	Apple	Apple pomace		Proximates	Ash	24	g/kg DM	Fermentation characteristics, aerobic
21	Apple	Apple pomace	Malus domestica	Proximates	Ash	2.6	% DM	Fruit waste as feed paper
22	Apple	Apple pomace	Malus domestica	Proximates	Ash	2.6	% DM	Utilization of fruit and vegetable wast
23	Apple	Apple pomace	Wet	Proximates	Ash	3	% DM	2012FeedComp
24	Apple	Apple pomace	Wet	Proximates	Ash	0.9-1.4	%	Handbook of poultry feed from waste
25	Apple	Apple pomace	From juice making	Proximates	Ash	25.2	g/kg DM	Kinetics of digestion and fermentatior
26	Apple	Apple pomace	From puree making	Proximates	Ash	37.8	g/kg DM	Kinetics of digestion and fermentatior
27	Apple	Apple pomace		Proximates	Asp	6.88	% D AA	NOSHAN
28	Apple	Apple pomace		Proximates	Aspartic acid/Asparagi	4.58	mg/g dry matter	NOSHAN
29	Apple	Apple pomace		Undesirable components	Aspergillus spp	0	cfu/25g	NOSHAN
30	Apple	Apple pomace		Inorganics	Au	<0.1	ppm d.b.	NOSHAN

Figure 3. Screenshot of Excel download from FoodWasteEXplorer

4 Data searching and entry

Information (e.g. nutrients, bioactives and toxicants) has been collected from a variety of sources, including scientific (peer-reviewed) papers, manufacturers' data (grey literature) and other data sources and can be used to explore how food waste might be better used. Filters can be applied to retrieve selected subsets of data, such as fibre in apple pomace and the search results can be exported for further offline analysis. Data has been collected for 90 different foods, including 633 different waste streams and over 25,000 data points.

4.1 Literature research and data extraction

4.1.1 Food description and classification

Clear, unambiguous food description is essential to enable users to identify and select foods correctly, as well as to facilitate interchange of data, for any purpose. The European Food Safety Authority (EFSA) has developed a standardised food classification and description system, FoodEX2. It was designed specifically for unique and universal identification of food items for use in exposure studies. The system consists of descriptions of a large number of individual food items aggregated into food groups and broader food categories in a hierarchical parent-child relationship. Central to the system is a common 'core list' of food items or generic food descriptions that represent the minimum level of detail needed for intake or exposure assessments.

LanguaL (*Langua alimentaria* or language of food) is based on the concept that any food can be described systematically through a combination of characteristics and the characteristic categorised and coded for computer processing for retrieval. It is a multilingual thesaural system using facetted classification. Each food is described using a set of standard controlled terms chosen from facets characteristic of the nutritional and/or hygienic quality of a food, e.g. biological origin, methods of cooking and conservation, and technological treatments.

These systems were designed for European food composition databases and edible parts of foods. They could be applied to some of the foods found in FoodWasteEXplorer (e.g. spinach) and linked with other databases containing the same classification/ description systems, the number of waste streams containing edible foods is very low. Most food entries in FoodWasteEXplorer relate to inedible parts and, therefore, cannot be coded in the same way. In addition, there are other waste streams where even the top level of coding would be unavailable, e.g. straw. In order to link food waste, an extension of an existing system or development of another coding system including inedible parts of food would be needed.

4.1.2 Identification of relevant data sources

An assessment of currently available food waste composition databases was undertaken. This involved identifying existing databases containing compositional data from other relevant EU projects or by a simple internet search. The assessment provided an overview of available data sources that could be added to FoodWasteEXplorer and an evaluation of the potential to link the information to the tool including NOSHAN <http://www.noshan.eu/index.php/en/>, Cropgen <http://www.cropgen.soton.ac.uk/deliverables.htm>, Co-product Feeds book, <ISBN: 1-897676-35-2>, and feed manufacturer websites <https://www.kwalternativefeeds.co.uk/>.

COMBASE <https://www.combase.cc/index.php/en/>, an online database, contains quantified microbial responses in diverse food environments. Until recently, it was hosted and maintained by QIB (UK) and, therefore, it was suggested this could be linked to data within FoodWasteEXplorer. COMBASE is now no longer hosted at QIB but the University of Tasmania (AU) which has caused some difficulty in linking the data within FoodWasteEXplorer following relocation of this resource. However, even if COMBASE was still located at QIB, linkage with FoodWasteEXplorer's fixed (reference) data are not compatible with the range of variable data outputs COMBASE models. These are dependent user input of various parameters into the COMBASE user interface. So instead, Information about COMBASE and links to it will be (in the next version of FoodWasteEXplorer) created in relevant section(s) of FoodWasteEXplorer, so that users can utilise this important resource. Quantities of microbes have been added to FoodWasteEXplorer where available.

Some of the established databases identified were produced by other EU-funded projects but the number of compounds, units used, and waste streams varied. Some of these databases are no longer being updated and linking automatically to these resources would be difficult without classification and description systems.

Within REFRESH, reviews were carried out to identify literature that contained the composition of the prioritised waste streams to be added to FoodWasteEXplorer. The searches aimed to source and extract data from peer-reviewed publications and other data sources containing relevant composition data. Initially, searches *ad hoc* were performed using the food product name, waste stream descriptor and other general waste terms. In house subscriptions to journals and ScienceDirect were used as the main search tools. Some of information identified was published recently (ranging from years 1995 to 2016); 445 journal articles contained relevant compositional data. Of these, 96 publications or databases have been reviewed to date, and the data added to FoodWasteEXplorer.

All publications were stored in a dedicated SharePoint site as named PDFs and the titles added to a SharePoint Excel spreadsheet. Other folders within this site included those for the data entry evaluators; publications were moved to this folder

after the data had been added into the FoodWasteEXplorer Excel template, preventing duplication of data entry. Once data from a publication had been entered, the data entry evaluator marked it as completed in the Excel spreadsheet.

4.1.3 Population of Excel template with composition data for key waste streams

Data selection criteria

As previously outlined in section 2.2 the compositional datasets collated have been based on a list of food chain materials identified by Moates et al (2016). Data has been obtained from sources with consideration of experienced food compositional data scientists to be as reliable as far as possible. This has been through:

1) Prioritising obtaining data from published peer reviewed journals
2) Including data from established waste composition datasets
3) Checking as part of the data selection process has been carried out as part of the researcher's competence and experience
4) Ensuring data relates to composition of side streams, rather than composition of specific animal diets or digestibility
5) Excluding erroneous or incorrect data, e.g. if there are obvious errors such as banana skins containing 100% water
6) Outliers were not identified in the data selection criteria. As FoodWasteEXplorer is comprehensive, a user can review several data points for the same compound in the same waste stream therefore showing any outliers
7) Including only geographically representative side streams in FoodWasteEXplorer was not considered important as each data point contains a description which will include geographical location if available
8) If a publication contained data for other waste streams outside of the prioritised list, these were also added as it was convenient to do so and meant FoodWasteEXplorer would be more complete for users
9) Where a publication only contained data for waste streams that were outside of the prioritised list, the publication was deemed unsuitable and data was not added to FoodWasteEXplorer

Disclaimer: All sources have been referenced within FWEXplorer and users should check sources and make appropriate conclusions at their own risk as to the quality of the data. For this reason many sources have been provided for similar materials to allow users to gain a perspective on the variability or data quality and follow up reference sources where necessary.

Processing and standardisation

Publications that were saved within the SharePoint folder were selected one-by-one by data entry evaluators and data were assessed to make sure they were suitable for FoodWasteEXplorer. If the publication did not include compositional data that related to one of the top waste streams, it was discarded and moved into the 'unsuitable' folder. Unsuitable publications are then reviewed by a database manager to double-check they agree with the decision before they are deleted.

Initially, composition data for the top 75 waste streams were extracted and added into an Excel template because the online database was not ready; once it had been built data were added directly. The structure of the Excel template was similar to the UK food table dataset (CoFID). All values and units were input as described in the publication or data source to avoid any recalculation errors and additional columns were added where necessary (for units or compounds that were not already in the Excel template). It is desirable to express data in a standard unit for comparison in a database that contains several values for the same compound and food/ by-product. However, recalculating values from some publications, to a standard unit, would be difficult, e.g. converting dry matter into wet weight or *vice versa* would require a moisture value, which is not always available.

To maintain consistency and allow entry by others (including REFRESH colleagues and students), an SOP was drafted. Figure 4 shows the process of adding data to the Excel template or FoodWasteEXplorer.
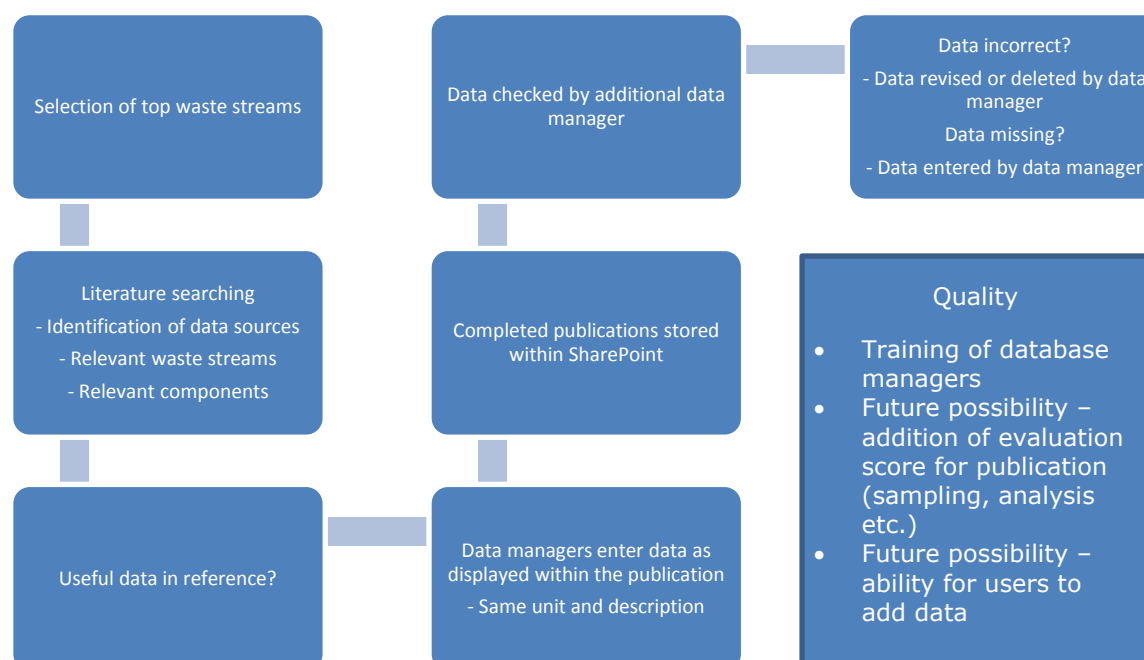
Figure 4. Work flow of data entry into FoodWasteEXplorer

4.2 Organisation of data for import

In order to upload data in the Excel template to FoodWasteEXplorer the structure had to be reorganised, specifically food wastes had to be grouped using a unique number and linked to each value as well as the reference.

4.3 Training and quality control

Data were added by two colleagues in REFRESH: Hannah Pinchen (QIB, UK) and Angelika Mantur-Vierendeel (EuroFIR AISBL, BE). Results from the publication searches were stored within the SharePoint folders and information about the publications added to the central Excel document to avoid duplication. Once the data had been added to the Excel template, they were double-checked to make sure there were no errors in the values or units, and the correct waste stream and food had been chosen. Contact between the data compilers was maintained throughout input, and any queries were discussed by EuroFIR AISBL and QIB and resolved. During June and July 2018, a student at QIB was also adding data to FoodWasteEXplorer.

An SOP was drafted to aid entry of data; this SOP can be revised for future maintenance of the database. Now that FoodWasteEXplorer has been finalised, further data can be added directly into the database. This reduces the potential for errors, such as entering data onto the incorrect line or overwriting other information. For future data entry, training will be needed (one-to-one, workshops or practical sessions) and the data thoroughly checked (e.g. double-entry checking).

4.4 Future plans

4.4.1 Compositional data

Other publications have been saved within the SharePoint folder since the initial upload from the Excel template, ready for input directly into the tool. The additional searches aimed to fill gaps for missing waste streams or nutrients (e.g. bioactives).

Some waste streams (e.g. beef bones) have been difficult to find and consultation with REFRESH experts in that field are needed. In addition, searches have been completed on the following, in order to complement the Food Valorisation Quiz completed in WP7, pectin in apple pomace, limonene in orange peel, casein in milk, inulin in chicory roots, resveratrol in grape pomace, pectin in apple pomace and limonene in oranges. These data will be added to the database, enabling the link between the quiz and FoodWasteEXplorer.

A basic search was performed to start populating FoodWasteEXplorer. Subsequently, titles from the results were used to develop a more comprehensive search strategy for additional searching. The search design consisted of three groups of search terms: food or food product; waste stream descriptor; and valorisation process or waste term. These can be combined within Web of Science using the OR Boolean operator, and the three areas combined with the AND Boolean operator (see Figure 5). Thus, literature will only be returned by the search engine if it contains one of the designated food/ food product terms AND one of the waste stream descriptor AND one of the valorisation processes or waste terms. It can be modified by searching using only the first two descriptors (e.g. just searching using the food product and waste stream descriptor). However, the number of publications retrieved to begin with can help identify whether this is necessary, i.e. if an extremely large number of results is retrieved, the search may need to be modified. In addition, there are other ways to limit large searches, such as publication year or discipline, or using the NEAR operator.

Each waste (e.g. pork) can be completed independently and the initial results screened by reviewing titles and abstracts, and the screened results saved in – for example – Endnote. Once in Endnote, the publications without full text or data, and also those that are not relevant, can be removed.

A test run on 'apple' was completed and brought up 550 publications which shows the potential for adding more data and making FoodWasteEXplorer more complete. The process was extremely easy with good results.
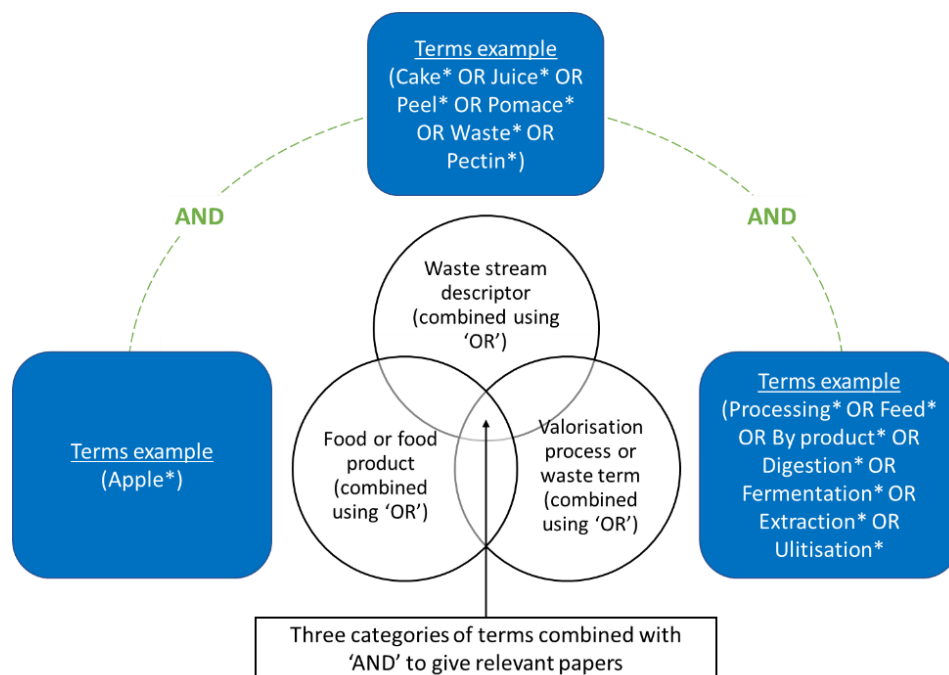

Figure 5: Search Design

4.4.2 Valorisation approaches

General descriptions of valorisation approaches identified in WP6 have been compiled and will be included in pop-up guides next to relevant waste streams, however not all waste streams have relevant valorisation information. Future work could allow valorisation approaches to be linked to waste streams within FoodWasteEXplorer, with similar pop-up text boxes that can easily be modified. Finally, a further feature, using stars or similar icons, could be added to indicate (and filter) approaches that have been added recently. This would be of interest to other users, to identify new approaches, and allow the database to maintain a relevant/actively used appearance. These features would require either self-moderation, or an organisation to support FoodWasteEXplorer with active moderators. Either way some relevant experience in valorisation applications may be required to validate the quality of new user entries, and its value as a reliable resource.

However, following a WP6 side meeting (Bologna, September 2018), REFRESH partners have questioned the usefulness, within a compositional database of: a) associating a database field or list of valorisation approaches with specific materials or components of materials, or b) the relevance of any particular geographical association to specific materials and components.

Instead, an idea was put forward to provide a separate general description of key (commercially relevant) factors for successful food waste valorisation, perhaps using some case study information for context. This could be on the same website (page) as the tool, providing general users or researchers with an overview of the potential importance of e.g. geography or valorisation methods etc. on processing costs or environmental improvements. In particular, this can help outline key considerations for laboratory focussed researchers seeking to demonstrate commercially relevant approaches for valorising food waste for new and sustainable products.

4.4.3 Quality evaluation

Knowing the quality of a value is an important aspect for some users. In the future, FoodWasteEXplorer could include a critical evaluation of data, based on food name/ description, sampling, sample handling, compound identification and sample preparation method. This evaluation could lead to a scoring system identifying high quality values that would help users identify whether data can be trusted.

5 Usability testing

5.1 Initial plans and resources for usability testing

Usability testing of FoodWasteEXplorer is essential to ensure it is fit-for-purpose (i.e. functions well in a logical way). The testing helped identify if participants were able to complete specific tasks, whether they were satisfied with the tool, and also identified changes required to improve performance and satisfaction.

Scenarios for the testing were developed by EuroFIR AIBSL and QIB using the User Experience Honeycomb, based on guidelines from http://usability.gov. This included considerations based on the following:

Useful: Do they use any other resources that fill their needs; do they get a good overview of the waste at first glance; are the waste streams described well?

Desirable: Do they like the look of the website; does it make them want to use it?

Valuable: Can they normally find the information they need easily; does it contain useful information; would they use it again?

Accessible: It won't be useable for those with impaired vision as there are no audio features. Colours need to be carefully chosen

Credible: Are they happy with the data direct from data sources; would they value data quality information; do they trust the values have been added correctly; is it easy for them to go to the data source and confirm the value?

Findable: Can they find the tool? What about if they don't have the name, does it appear at the top of the search engine?

Usable: Can they navigate around the website easily; can they find what they are looking for; would images help?

It was envisaged that four different targeted user groups (researchers, animal nutrition experts, consultants and industry) would use FoodWasteEXplorer and, therefore, usability testing aimed to include equal number from these user groups.

Figure 6 shows potential uses of the tool in the four user groups.
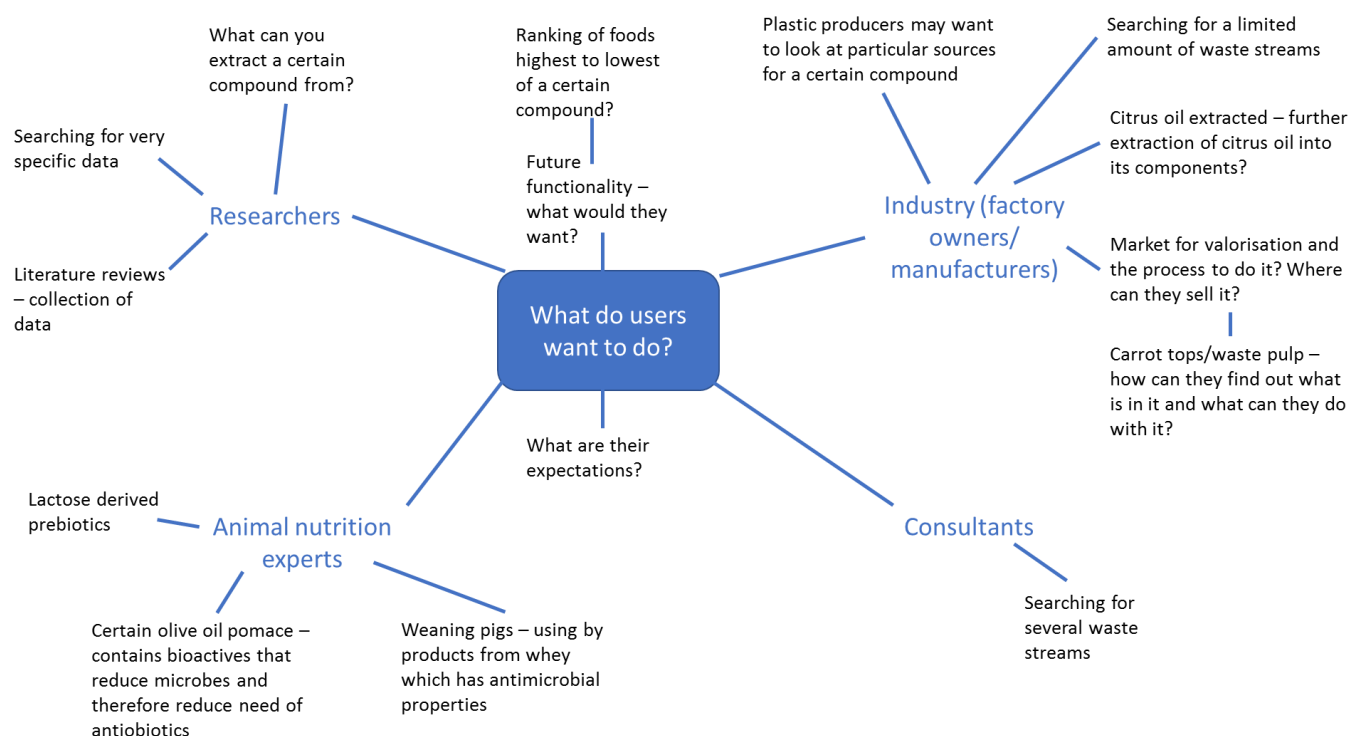
Figure 6. A spider diagram showing the potential uses of the tool

Usability testing included full scale scenarios (including steps), elaborated scenarios (story details) and a goal or task-based scenario (an unlimited option, allowing the tester to make up their own scenario).

Details of the scenarios can be found in Annex 3.

5.2 Usability testing interviews

The usability testing was disseminated widely via EuroFIR AISBL social media channels, the REFRESH and EuroFIR websites, and through project beneficiaries as well as direct email contact with potential users from industry, research and software developers. Over 200 individuals were contacted directly via email, with 17 agreeing to participate (ca. 8.5%). Initially, more sessions were scheduled, but some of the participants did not attend or respond to further contact.

Table 1Table 2 shows the areas of work and interests of the participants.

Table 2. Profile of participants

Professional background	Area of food waste interest
1. Dietetics student 2. BcS Technology Engineering, PhD Biotechnology 3. Chartered Biologist 4. Preliminary LCA of food products 5. Scientific Innovation Manager 6. Researcher 7. Engineer 8. Researcher 9. Knowledge management 10. Research associate, waste managem life cycle assessment 11. Exercise & Nutrition Scientist (and IT software development) 12. Food Science 13. Chemical engineer, researchers 14. food science 15. Science communication 16. Chemistry and Life Cycle Assessment 17. Researcher	1. Research 2. Research and Innovation; Isolation of valuable components from food waste 3. Composting, AD and fibre production 4. Avoidable and unavoidable food waste 5. General, link to retail and food production - sustainability 6. By-products of production of vegetables on field and in greenhouses 7. Food waste measurement and food waste valorisation 8. Bioactive compounds 9. No specific area 10. Elementary composition, calorific value, of products and wastes in a uniform format 11. Cost of food waste, food waste recycling 12. Food waste in general; no specific area 13. Environmental and techno-economic sustainability of valorisation routes 14. Research and innovations 15. Public policy 16. Measurement, prevention and valorisation 17. Valorisation

All usability testing participants were asked to sign a confidentiality agreement, which stated the online tool was part of REFRESH. In some cases, this requirement prevented participants from further participation.

One-on-one sessions with volunteers ran over a period from the beginning of July 2018 until the end of August 2018. Each interview was facilitated using GoToMeeting and lasted 30-45 minutes, depending on the issues encountered. Each respondent was asked to perform nine scenarios designed by EuroFIR AISBL and QIB to allow identification of any technical issues and user satisfaction.

5.3 Usability testing results

A questionnaire was prepared for participants to identify any problems and determine satisfaction with FoodWasteEXplorer. All participants were required to complete the questionnaire to facilitate analysis of the findings. Based on the questionnaire, EuroFIR AISBL was able to:

- Learn if participants were able to complete specified tasks (Annex 3) successfully

- Identify how long it took to complete the tasks

- Find out how satisfied participants were with FoodWasteEXplorer

- Identify changes required to improve user performance and satisfaction

- Analyse the performance to see if FoodWasteEXplorer met the usability objectives

The questionnaire consisted of open questions, grading scale questions (Q4 to Q39), and closed questions. For each open question, users were asked to input free text and, for each grading scale question, they were asked to rate them on the scale from 1 to 10, where 1=strongly disagree, and 10=strongly agree. Low average scores (those below 6) from the grading scale and their possible solutions can be seen in Table 3.

Table 3. Low average scores (below 6) in the grading scale questions

Question	Average score	Possible solution
10. It meets my needs	5.5 (range: 1-10)	The score may be low due to some of the participants having a different area of interest. Alternatively, it may be due to no links to the valorisation approaches for each waste stream – this is currently being addressed
11. It does everything I would expect it to do	5.7 (range: 1-10)	It is likely that users need to have links to the valorisation approaches. This is being addressed.
15. It is easy to find the information I need	5.5 (range: 1-10)	This is most likely due to grouping of the food waste streams. Options could be to group the wastes into larger areas of interest (e.g. wine production) and categories (e.g. fruit)
17. I don't notice any inconsistencies	5.7 (range: 1-10)	All inconsistencies will be solved when addressing the usability testing comments
24. I can effectively complete my work using this system	5.4 (range: 1-10)	The score may be low due to some of the participants having a different area of interest. Adding a link to valorisation approaches and

		addressing the inconsistencies should solve this
32. I like the aesthetics of the tool	5.2 (range: 5-10)	Aesthetics are a personal preference, however improving the registration background and potentially adding some category boxes to the home page could increase this score
34. Overall, I am satisfied with it	5.9 (range: 1-10)	Addressing the collected comments should increase this score
39. This system has all the functions and capabilities I expect it to have	5.7 (range: 1-10)	Adding a link to the valorisation approaches should increase this score

Two of the open-ended questions were, '*Do you have any suggestions or comments regarding the errors encountered?*'; and '*Do you have any suggestions or comments on how to improve the tool?*'. Comments were collected and can be found in Table 4. Potential actions relating to these comments have been compiled and the next steps will be to rank them in accordance with importance. Once this has been completed, work will begin to action the solutions.

Table 4. Open-ended responses obtained in the usability testing

Do you have any suggestions or comments on how to improve the tool?	Solutions
Registration	
Add link to activation page in email with code	Add link to activation page in email for registration
When I registered, it took me to an "inactive" token page, even though I had not entered a token	Once the registration process has been resolved, check if this 'inactive' error still occurs
The login page is too dark and has too many box outlines which add no value	Decide whether to remove the background or change boxes to solid white background
Home page	
No home button	The REFRESH logo in the top left corner links to the home page but add another home button on each page
Put a home button in the first page when one is navigating the about, contact, etc.	
No obvious home button	
You get the impression you can click on "foods", "Waste streams" and "components", but you can't. Is it under construction?	Remove the arrows to stop them looking like they have a link
No link to the REFRESH website to find out more about the project	Add a link to the REFRESH website
Is there a reason that there is no link to the REFRESH project page anywhere? Of	

course, social media buttons are great, but the website is useful too	
Why is there an about page link in the top right and bottom left?	Remove one 'about' link
The REFRESH logo in the top left returns you to the search screen which is fine but it should be listed that it will do this because it is not obvious	State that REFRESH logo in top left returns a user to the search screen
Searching	
Search function: google-like and tree-based	Add in a free text search function that searches food, waste stream and description
A search function would be useful, sorting of products consistently (either by product or process or product group but not mixed)	
I think you could add a search engine to add key words. I think the list of food/waste streams is not always very intuitive, which add time for looking and trying.	
Problem with the drop down - an open search and repeat use of the same category would be nice	
The type function in the search bar is ineffective.	
add a search function	
The search bar is not fully functional. Typing option only works if you type exactly what you want quickly, a pause between typing the letters effectively restarts the search. E.g. search for CORN, type C (goes to products starting with C), pause, type O (goes to products starting with O. It is then not possible to delete the search	
The possibility of searching for food components - for intolerance by restaurants or individuals would have utility. Components of the diet like Cr for daily intake assessment and absorption studies	Add a search option for component on the home page
To include a reverse search option: search a bioactive/mineral/nutrient and provide the list of food waste containing it	
Put a search field	
Multiple options for area of interest	Include an option to select by 'wine production', 'ale production', etc.?
There needs to be a search/go/click button rather than clicking the text in the search bar.	Add a search/go button
Not obvious there is a second page of information as the button is too small and discreet, could be improved by showing a button of "showing X entries".	Increase the size of the page numbers
The lines on the tables in the results sections are different colours. Some are grey, some are black. It would be better to have all one colour (preferably not black as	Change the colour of the results table borders

it doesn't feature anywhere else in the design)	

Waste classification

The list of waste streams is not always easily understandable. For instance, in the case of "Citrus" there are too many options (e.g. citrus peel, pulp) and it is not clear how to differentiate between lemon and orange (peel, pulp etc etc)	Citrus group has been renamed to orange, lemon, lime etc.
The list of foods to explore is not very clear - or you put everything in a big list or you make more subdivisions, now not always knew where I had to search for a certain product	
Food descriptions need to be vastly improved- it was the only thing that would really put me off using this tool. When trying to locate types of wine in the wine section, or types of orange peel, you are met with a multitude of vague leading words that doesn't accurately describe the food type (e.g. Citrus peel being used to describe orange, lemon, lime peel.) A better method would be to lead with the most detailed description and follow it with the food group (e.g. Mandarin peel, dried > Mandarin peel > Citrus peel). Overall, this tool is quite intriguing and bar the issue with food descriptions, it is very easy to use.	Could group them into larger groups, e.g. 'vegetables', 'fruit'. Discussion on how to deal with this, especially things like wine (which contains grapes and lees) is needed. For example, if grouping grapes into fruit, relating lees from the wine process would become lost.
I would prefer general groups of products like in food databases	
The classification of the wastes is not very coherent for example in the oranges exercise sometimes you have oranges and others citrus and then oranges within brackets	
suggestion to organise products to more general groups in search (for example in dairy group I would expect to find milk, yogurt, cheese, butter) but not to look in separate place	
I do not understand the categories. For example, Brassica and Cauliflower are listed separately when cauliflower is a brassica, yet Citrus is a huge category and would benefit from being split up. Grouping categories in this way assumes that all users understand the categories fully which is not wise. Furthermore, there is no consistency.	

It took me a bit of time to work out how to search for specific items. Intuitively, when completing scenario 5 I started looking for orange peel rather than citrus. It might be helpful to add some basic instructions to help users get started. The orange/citrus peel might be a good example showing how some food waste may not be located in the category they initially expect it to be.	Develop a user manual (note: discussion at the WP6 side meeting in Bologna suggested that a manual would not be useful, but information on each page would be)
Waste description	
In cases where for the same food multiple reference sources are provided, giving different amounts of components (for example Ca in orange peel) it would be nice to have some more details on type of food (e.g. origin, etc) so we can understand where the differences are coming from.	Double check the references to make sure all information has been recorded. Prepare a user manual that describes why some values may not have a description (i.e. none provided by publication/reference)
Some waste streams also indicate the source of data e.g. Citrus molasses (Source: United States). Is this relevant, if so, why do only some streams have this information included?	
Components	
Abbreviations full written, one standard per component	Change abbreviated compounds to full names
Expand compound names as well as chemical symbol	
Standardise units of measure where possible so comparisons can be made	
Concentrations should be expressed in standard units where possible, this was a confusing aspect when trying to compare levels of components in a food.	Change all DM values to per kg and all fresh values to per kg
Hard to compare the value when all the units are different.	
When clicking on a component group, it filters the table, but it is not clear it will do this or why.	Add sort function to component group, value, unit, description and reference
Excel download and Report	
The typeface of the excel files are not so clear (e.g. inorganics or proximates).	Amend the compound group text in the Excel download to black and white
Report button moves position depending on the length of the food name	Make report and search buttons static
Search bars keep moving and so does the report button.	
Report should be exportable as a PDF or Excel, or both.	Excel option already exists. Include PDF export function
Cannot download the report making it USELESS.	
Report should be a proper button rather than just hyperlinked text as it is too discreet.	Make report link a proper button

Why is the information in the report presented in a different way to the table on the previous page?	Present report with description next to each value instead of one description at top left. Perhaps only include values in report that are not hidden.
Why is the report having a weird discreet section in the top left which uses terminology not explained elsewhere, e.g. why are distillers grains a waste stream and the maize a description?	
Glossary	
I have difficulties understanding some terms and if they are synonyms (e.g. pomace, bagasse etc.), would it be possible to streamline the terms used? Or offer a glossary?	Add a glossary. Note, these terms would need to be checked with a valorisation expert, e.g. do they differ for different waste streams. Could it introduce errors to try and streamline the terms?
Tooltip to learn more about what a data point means (e.g. pig nitrogen digestibility)	
Other	
Integrate data into Nutritics and for search and recipe development Potential	Probably development for after the project
Ranges should be expressed in one row, rather than having two rows for one component, which I found confusing as it was not expressly stated that it was a range and not two separate values	Not clear which value this relates to as, for example, N-free extract range is expressed on one line in apple pomace, dried
Add a loading bar on interface when processing	Add a loading bar on interface when processing
I was using a mobile (android) and it was difficult to navigate and find the terms on the lists	Test and develop for mobile use
Don't log me out after I update element on my profile	Investigate why the system logs a user out after they update and element in their profile
When you enter "Edit Data" it should not log you out if you haven't altered anything. It's inconvenient when you have to log in again immediately after logging in once.	
Initially I have an error while trying to change my password but then I tried again and worked.	Investigate potential errors when changing password
Not clear after how much inactivity you are logged out.	Investigate time it takes for system to log out when inactive
The black text boxes are basic and ugly	Investigate improving look of text boxes
On the privacy policy page, there are hyperlinks to the mailto but it is not clear it will take you there by clicking these.	Change hyperlink colour
Add 'Database' or 'Explore database' or 'FoodWasteEXplorer database' button to relevant pages such as the 'about' page	Add buttons so that the database is accessible from any part of the website
While the name of the Explorer is FoodWasteEXplorer, I think within the Explorer we should rather speak of food-based side streams, or former food resources, food surplus (or any other non-waste terms) as we actually would like to	Decide on new term for 'waste stream'

change the perspective from waste to resource along circular economy principles	
In main tables amend 'Number of data poits' to 'Number of data points'	Check spelling of 'Number of data poits'
Resolution in progress	
Under the topic "select waste streams" you have sometimes twice or more the same option. What's the difference?	
Waste streams are coded inconsistently: some include the source of data, some list the waste product first and then the food, others have food first then the waste making it impossible to search.	The 'select waste streams' drop down has been streamlined
When the waste stream has a long name, like the sugar cane leaves (higher...), it makes the search bar too long too which distorts the orientation of the page.	
When you hide some information, it still appears in your report.	This has been removed - it was never meant as a function for the user
No registration	
I did not receive the registration mail and therefore was not able to confirm my registration	Registration issues are being investigated
Some recommendation on what to do with the waste components would make it more practical, not just the nutrients in it.	Valorisation approaches are being compiled
Do not put items that have no data (users won't feel bad if they aren't aware of the inexistent)	This has now been resolved and all data has been imported
Make sure the units of each variable and parameter are clearly shown	All values have a unit
Sometimes the components are repeated but with different values, e.g. in scenario 7.	A user guide will be produced to describe that the database is comprehensive and contains multiple values collected from literature. Further work will also include hiding some of the repeated values to allow it to be both comprehensive and simple
The waste streams should be listed alphabetically.	The drop-down lists are now alphabetical
It is already useful	N/A

Note: these solutions are expected to be completed by the end of March 2019

5.4 Recommendations for database changes and impressions from usability testing

Overall, FoodWasteEXplorer was well received among the usability testing participants. Only a few of the users were unsure of the potential for FoodWasteEXplorer and these were the participants without immediately relevant

backgrounds (e.g. software developers, whose input was important because of their IT knowledge and experience, but who didn't necessarily have the nutritional knowledge). Most of the participants liked the idea behind FoodWasteEXplorer. They were not always fully satisfied with functionalities but recognised this is a beta-version. Perhaps most importantly, based on discussions with the testers and the results, whilst FoodWasteEXplorer did not meet expectations [5-6] in terms of usability, it was regarded positively, and interest was high. Similarly, whilst ease of use was average [5], recovery from mistakes was higher [7] and most testers were successful in completing the scenarios [7] and using FoodWasteEXplorer without support [8] (i.e. a manual might not be necessary), and they would recommend it to colleagues. Also, some of the issues with FoodWasteEXplorer were unrelated to functionality, but rather understanding the outputs and how these data might be used most effectively. In general, the main issues were:

1. Food waste and food waste stream terminology

    It was difficult for users to search for specific waste streams in FoodWasteEXplorer. Consultation with REFRESH colleagues is needed to work out the best way of organising names. A harmonious approach is required, but also one that will satisfy both food wastes that are solely linked to the name of the food waste (e.g. lettuce) and food wastes that are linked to a process, and where it makes sense to group them (e.g. wine: grape pomace, lees, holocellulose).

2. Searching

    Searching was identified as a problem within FoodWasteEXplorer, which is probably linked to food waste stream names. However, there are other unrelated areas that can be improved. One option would be to include a free text search box that searches the food, waste stream and description, allowing users to be confident that all relevant waste streams have been retrieved. Users also expressed a wish to search by compound. Adding a compound search option would bring up a list of food wastes where the compound is present. In addition, it was also suggested that the food wastes should be grouped into categories (e.g. fruit, vegetables) or areas of interest (wine production, ale production). However, this approach could add another layer of searching making it more difficult for the user. To avoid this, the same food could be listed in more than one group, e.g. grape pomace in fruit, juicing and wine production. To include a free text search box, different categories and different areas of interest would probably work well. The next steps would be to draft the list of waste streams, linking them to the categories and areas of interest, and test this with REFRESH colleagues to make sure it works well before implementation.

3. Registration

    Registration has been a problem for organisations that have very high spam control for emails. Currently, when someone registers, a token is sent to them to confirm their email address. In some cases, when the security is high, the email does not reach the individual. Communication is ongoing between JSI and SERSO (EuroFIR IT support) to solve this problem. One option would be to remove the need for a token and replace it with a capture box. Once REFRESH ends, and the tool is managed by EuroFIR, newly registered users will be confirmed by EuroFIR and their data entered into the EuroFIR LDAP system, removing the need for tokens.

4. Compounds

    Waste stream data was collected as it appeared in publications, which included both the name and unit. Therefore, some names are abbreviated, and some are not, and units differ (e.g. g/kg Dry Matter, g/100g Fresh Weight, g total solids/g, % dry ash free basis). These were highlighted in the usability testing as something that should be resolved. Amending all compound names to the full name is simple and will be done asap. Using the same unit, however, is not. It might be possible to change all dry matter values into g/ kg dry matter and all fresh weight values into g/ kg fresh weight. Changing fresh weight values into dry weight values is not possible without a moisture value, which might not have been published with the research. The first step will be to amend those values that are easy (e.g. all dry matter and all fresh weight values) and will not introduce calculation errors. Any remaining issues will be reviewed subsequently.

5. User manual and glossary

    A user manual and glossary are essential for any online tool, as these allow the user to be confident in the results they are finding and provide information about the best way to use the tool. It was suggested that the glossary for FoodWasteEXplorer should also contain information about compounds that may not be commonly known ([e.g. nitrogen digestibility, growing pig (note: the term 'compounds' has been used as an umbrella term and may include factors)]. Others suggested that information on synonyms should be included (e.g. whether bagasse and pomace are the same). These would require further investigation and input from a valorisation expert. However, after consultation at the WP6 side meeting (Bologna, IT), there is also some concern about how easy it would be to develop a glossary, as there are minor differences amongst terms when applied to different waste

streams. It was also suggested that it is unlikely a user will take the time to read a user manual and information in pop-ups might be more useful.

6. Report

Currently, all data can be downloaded as an Excel spreadsheet. It was suggested that, to be useful, the report should also be available as a PDF. This is a straight forward addition to FoodWasteEXplorer. However, as similar waste streams are grouped, and the descriptions displayed next to each value, the PDF report needs to follow the same style.

6 Conclusion and next steps

A compositional database called FoodWasteEXplorer has been developed and is available for use free-of-charge by stakeholders such as researchers, government agencies, industry, SMEs and the general public. The database aims to aid users in identifying food waste that can be used in better ways, such as identifying the amount of limonene in citrus peel that could be used to make medical plastic. The database has been designed so that users can search and retrieve data in specific side streams. Retrieved data can also be downloaded so that the user can explore the data. The database is comprehensive and contains multiple values from a variety of sources such as scientific (peer-reviewed) papers, manufacturers' data (grey literature) and other data sources. A comprehensive database allows the user to evaluate a range of data, therefore ensuring that the values they use are suitable. FoodWasteEXplorer is already being used by users, however, several updates have been planned based on the usability testing results which will make the searching and retrieving process easier. It is anticipated that the new version will be available by the end of March 2019 and data will be continued to be added once this is complete.

6.1 Current changes

During the recent REFRESH Governing Council meeting in September 2018, WP6 colleagues met to discuss the usability testing results. Next steps and changes to the database were scored and a prioritised list of actions were agreed (Table 5).

Table 5. Prioritised list of actions to FoodWasteEXplorer

Priority order	Action
1 (highest)	Add free search function that searches food, waste stream and description
2	Sort waste streams into 'areas of interest' and 'categories'
3	Add a search option for component
4	Standardise units where possible
5	Amend registration page (change background)
	Develop help pop-ups (instead of a manual)
	Write abbreviations (for compounds) in full
6	Add home buttons onto each page

7	Add function to enable report to be downloaded into pdf
8 (lowest)	Add a glossary (it was noted that this would be difficult to do as terms can vary for different waste streams)
Change perspective of database from 'waste'?	5=yes, 3=No, 1=unsure Change to **side streams** (3 votes) or by-product (1 vote)

Following discussions between JSI, EuroFIR and QIB, JSI are progressing through the list of improvements suggested above, focussing on those of the highest importance. In addition, smaller changes (as suggested by the testers) are also being included. A second version of FoodWasteEXplorer is expected to be completed by the end of March 2019.

6.2 Possible use cases and user types

5.2.1 Market value of recovered compounds from agricultural wastes

With increased health awareness, bioactive compounds (linked to reduced incidence of age- and diet-related non-communicable diseases) are being used by the food and beverage industry to create functional products and nutraceuticals. Knowing the cost of recovery from waste, and the potential sale value, would provide a good estimation as to whether a compound is low-, medium- or high-value in terms of valorisation. This, in turn, can be combined levels of waste production to determine whether it is realistic extract these compounds from waste. This could be done for all compounds in FoodWasteEXplorer and a star system used to indicate compound value (e.g. 1 star - low, 2 stars - medium and 3 stars - high). However, access to these types of data is difficult and often requires a large fee. It is also likely that the market values will change over time. Further investigation into finding, acquiring and incorporating this information needs to be performed.

5.2.2 Waste geographical location

Food waste is produced all over the world, however some food waste might not be valorised and therefore could be used by others. An ideal feature of FoodWasteEXplorer would be to show where available food wastes are located globally and produced by whom for those wishing to valorise these waste streams. Unfortunately, this information is often confidential and difficult to obtain. As the FoodWasteEXplorer continues to develop, it might be possible to allow food waste

producers to add their details, waste type, amounts and locations to waste streams, allowing others to contact them directly, providing essentially a waste utilisation network. Whether or not this would work in practice is unclear.

6.3 Sustainability and future opportunities

FoodWasteEXplorer will continue to be hosted by EuroFIR once the project has ended in June 2019. EuroFIR will maintain the technical function but adding of newly available data is not planned at this point.

FoodWasteEXplorer is linked to the REFRESH Community of Experts website (www.refreshcoe.eu). The Community of Experts website is a knowledge sharing platform, offering users a dedicated space to find and share information about proven solutions and innovative new approaches to reduce the volume of surplus food generated, feed hungry people, and divert food and scraps to the highest beneficial use. Linking FoodWasteEXplorer to this resource would ensure it is linked to the correct type of user. There would also be potential that interested parties would want to continue updating the dataset. It will also be linked to the Animal Feed Tool.

Figure 7 shows potential for incorporating FoodWasteEXplorer into the EuroFIR structure to enable facilitation of a sustainable future. EuroFIR AISBL is a non-profit Association which was set up in 2009 to ensure sustained advocacy for food information in Europe. Its purpose is to develop, publish and exploit food composition information, and promote international cooperation and harmonisation of standards to improve data quality, storage and access. Incorporating FoodWasteExplorer into the EuroFIR structure would not only ensure that it has a secure future, there would also be potential of EuroFIR documenting the values and therefore allowing exchange of data from other datasets. In addition, future data inputs could be completed by visiting workers.
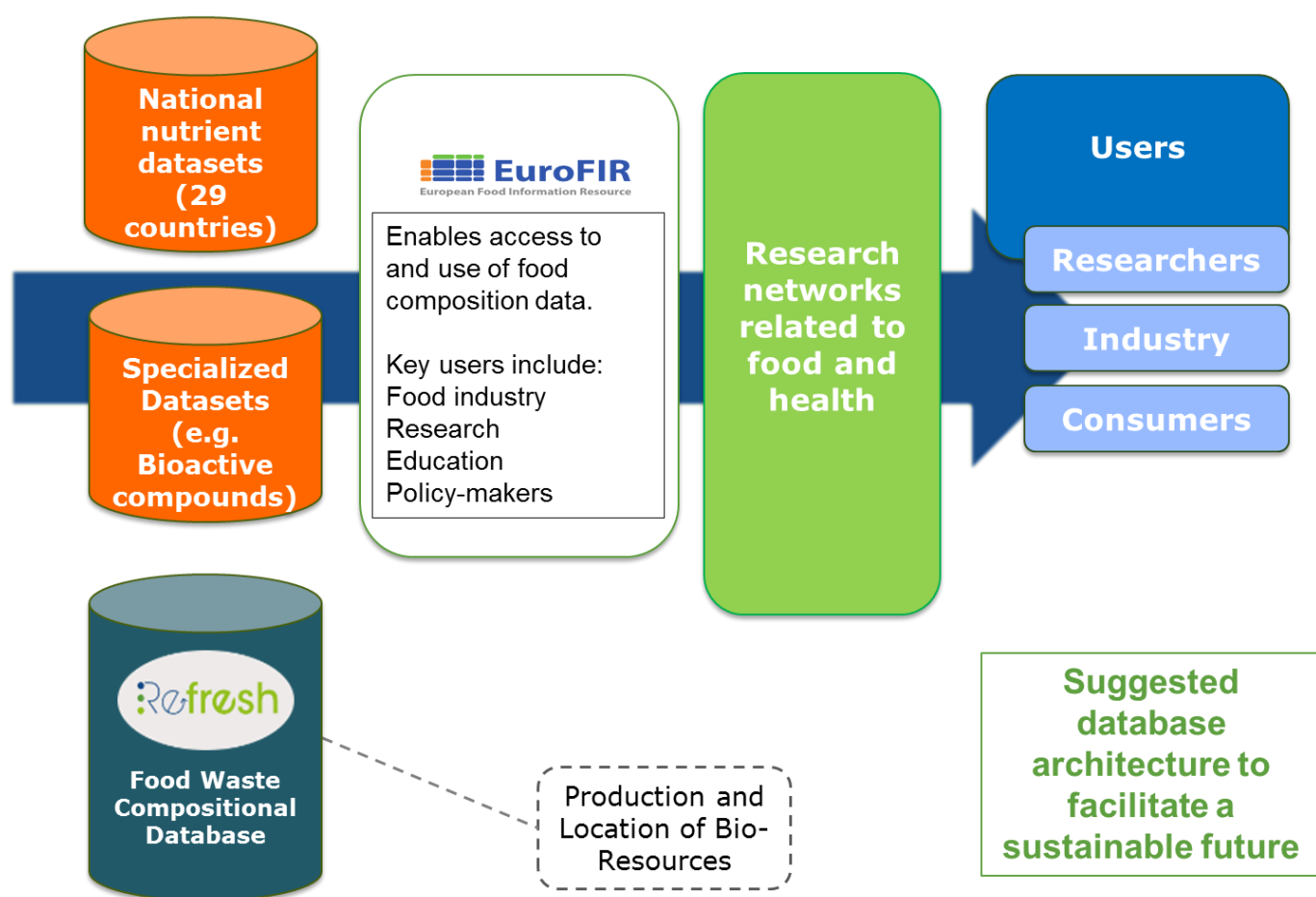
National nutrient datasets (29 countries)

Specialized Datasets (e.g. Bioactive compounds)

EuroFIR
European Food Information Resource

Enables access to and use of food composition data.

Key users include:
Food industry
Research
Education
Policy-makers

Research networks related to food and health

Users

Researchers

Industry

Consumers

Refresh

Food Waste Compositional Database

Production and Location of Bio-Resources

Suggested database architecture to facilitate a sustainable future

Figure 7. Suggested database architecture to facilitate a sustainable future

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Annex 1. Technical description of the database structure

Concept and implementation

Database perspective

FoodWasteEXplorer was developed for specific use cases related to REFRESH. Major components of FoodWasteEXplorer include: a ***backend*** that is aimed at data managers, a ***cloud server***, where data are stored and processed and a ***frontend***, which is for data users. FoodWasteEXplorer can also be integrated with other information tools through Application Programming Interfaces (APIs). An API is a software intermediary that allows two applications to communicate with each other.

User types

FoodWasteEXplorer has been designed for three user types:

1) **Data managers:** access to the backend of FoodWasteEXplorer to enter data, documentation and thesauri definitions as well as maintenance and data validation.
2) **Online users:** use the frontend of FoodWasteEXplorer to explore and export data. It should be noted that data users do not have the ability to enter data.
3) **System administrators:** oversee FoodWasteEXplorer, taking care of the tool and database maintenance including upgrades. They also maintain the food waste stream thesauri; only the system administrators can change the thesauri.

Each user type has specific roles, a set of permissions, and a set of actions, which are distinct but complementary, and do not overlap.

Database functions

The functionality of FoodWasteEXplorer can be split into five categories:

1. **Data management:** data managers use the backend of FoodWasteEXplorer to:

   a. maintain the document repository
   b. maintain thesauri (a controlled vocabulary for FoodWasteEXplorer)
   c. enter new data
   d. search for and modify existing data
   e. analyse and validate data

     f. export reports

2. **Interaction with data users:** data users use the frontend of the tool to:

     a. explore data
     b. export reports

3. **Interaction:** FoodWasteEXplorer has the potential to interact with other information tools through APIs

4. **Administration of the tool:** system administrators use the backend of the tool to perform:

     a. tool monitoring
     b. database maintenance

Operating environment

FoodWasteEXplorer has been implemented as a browser-based application and supports the latest, stable releases of major browsers and platforms. The tool has been deployed on the EuroFIR cloud server and the interface will be integrated with the REFRESH website.

Design and implementation constraints

FoodWasteEXplorer is based on a specific data model that is implemented in a relational database (Figure 9). The language requirement for FoodWasteEXplorer is English. The tool and database have been developed so that localisation for other countries can be performed easily. Both the database and the interface have been secured from unauthorised manipulation. A third party with no access is not able to block legitimate parties from using the resource. Beside prevention (authentication, authorisation, accounting, encryption of sensitive data), detection and reaction have been implemented.

The external API has been implemented as an easy-to-use (lightweight) web-interface which makes application development much easier and faster.

Software requirement specification (SRS)

A software requirement specification is a description of a software system to be developed which lays out functional and non-functional requirements and may

include a set of use cases that describe user interactions that the software must provide. The SRS for FoodWasteEXplorer was prepared by considering the standard, IEEE convention for software requirement specification Std. 830.

External interface requirements

User interfaces

The three user interfaces (for data managers, data users and system administrators) have been designed with respect to standards and guidelines for human computer interactions, namely:

- ISO 9241-part 171: Guidance on software accessibility (ISO 9241-171, 2008)

- ISO 9241-part 20: Accessibility guidelines for information/communication technology (ISO 9241-20, 2008), as well as Web Content Accessibility Guidelines (W3C Recommendations, 2008).

Error messages comply with error messages display standards.

The user interface design follows design of the REFRESH website.

Hardware and software interfaces

FoodWasteEXplorer does not have any hardware interface (internal architecture used to connect two devices together). There is potential to link the database with the EuroFIR (food composition) database(s) and other information systems via APIs. Components in FoodWasteEXplorer that are the same as those found in the EuroFIR database(s) have been coded in the same way. FoodWasteEXplorer shares data about food waste streams but not users.

System features

FoodWasteEXplorer is composed of two main parts: 1) backend (maintenance and data entry) and 2) frontend (interface for users). The backend is further decomposed into two distinct parts for: i) data managers and ii) system administrators.

Figure 8 shows how the backend and interface are connected to the cloud server (note: data entry, i.e. data provider, is only possible through the backend part)
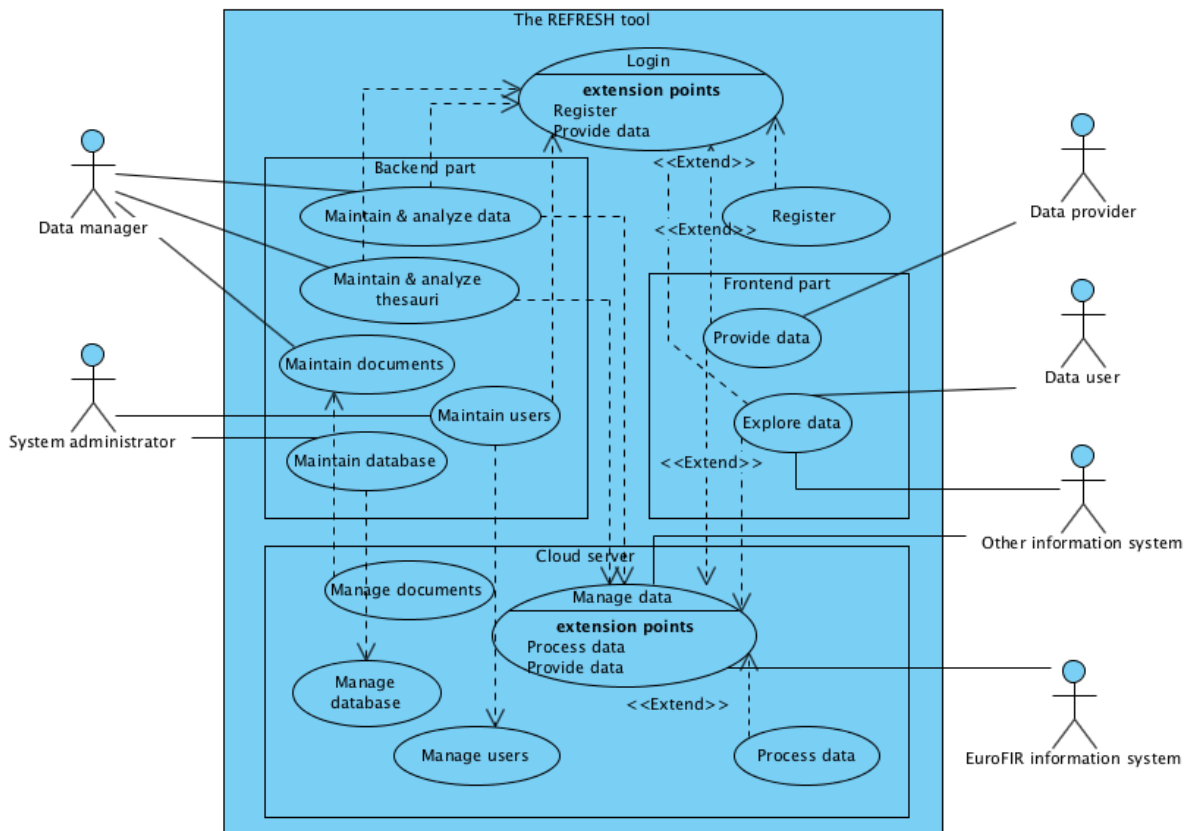
Figure 8. Use case model of FoodWasteEXplorer

Description and priority

The backend for data compilers has a higher priority than the backend part for administrators due to the need for efficient data entry and data validation. System responses to specific user actions and error conditions have been designed and can be found in section 7.3.

The frontend is also of high priority, but lower than the backend for data managers. It makes sense first to develop a database management system that can later be potentially upgraded with user interfaces for end users.

Other non-functional requirements

Performance requirements

FoodWasteEXplorer can handle at least 10 data managers and 100-1000 data users and providers, simultaneously. The cloud server is the only part of the system that is limited in terms of performance and the number of concurrent connections and data saving.

Security requirements

Initially, FoodWasteEXplorer was accessible only by authorised (registered) users, based on safe user accounts and passwords. Due to registration problems, and for the purpose of REFRESH, login and registration will be removed.

At the end of REFRESH when FoodWasteEXplorer is maintained by EuroFIR AISBL, registration and login may be needed. In this case, FoodWasteEXplorer will allow secure transfer and storage of all data. To achieve these requirements, the Spring Security framework for authentication and authorisation will be used. Session management is handled by this framework, which has automatic session expiry after 20 minutes (idle) and logs out the user.

Users' personal data are stored in a relational database and the user password is encrypted, using the BCrypt algorithm. However, only the super administrator user can access and manage user information. Additionally, FoodWasteEXplorer is only accessible via HTTPS, where communication between the client and the server is encrypted.

The database will be backed up regularly in separate data storage in case of backend system failures.

Software quality attributes

In order to prevent any data corruption or loss (during writing, reading, storage, transmission, or processing), measures providing data integrity have been implemented.

No specific technique was used during development, due to the small size of the project, but development process followed the principles of scrum methodology. Weekly meetings and reviews were held during the development phase. Major milestones were set at the beginning of the development. Minor milestones were set during weekly meetings.

Business rules

No specific rules were defined for the tool.

FoodWasteEXplorer database architecture

The main table **wsvalue** stores data (values) about waste stream components. Each waste stream belongs to a food – waste stream descriptions are stored in the table **wastestream**, while information about components is collected in the table **component**. The table **food** stores information about food items and is related to the table **fcdb**, which collects information about food composition databases, as a potential data source for biochemical composition of the food waste streams. Components are classified with respect to component groups and subgroups, and this classification is defined in the tables **compgroup** and **compsubgroup**. For example, the component *leucine* belongs to the component group *proximates* and to the subgroup *indispensable amino acids*. Units for the data values are stored in the table **Units** and references are described in the table **Reference**. Values for units, matrix, acquisition type, reference type, value type, method indicator, and method type have been defined with respect to the EuroFIR Thesauri (EuroFIR AISBL, 2017), and are stored in the corresponding tables: **units, matrix, acquisitiontype**, **referencetype**, **valuetype**, **methodindicator,** and **methodtype**. Other tables (user, role, areaofinterest, searchstatistics, etc.) are aimed to collect information about the database and its users, which is needed to perform analysis.
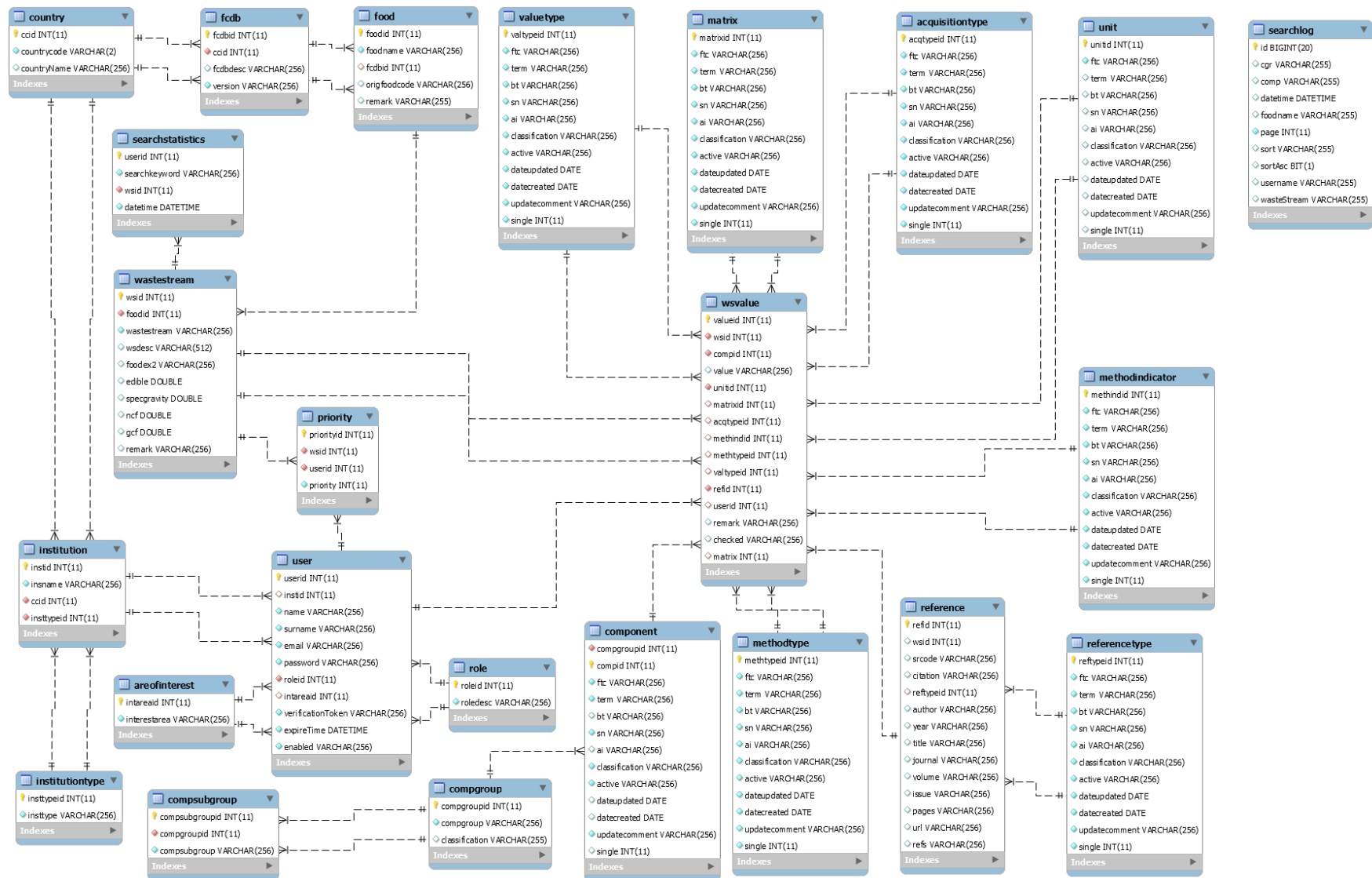
Figure 9. Relational model of the food waste stream database
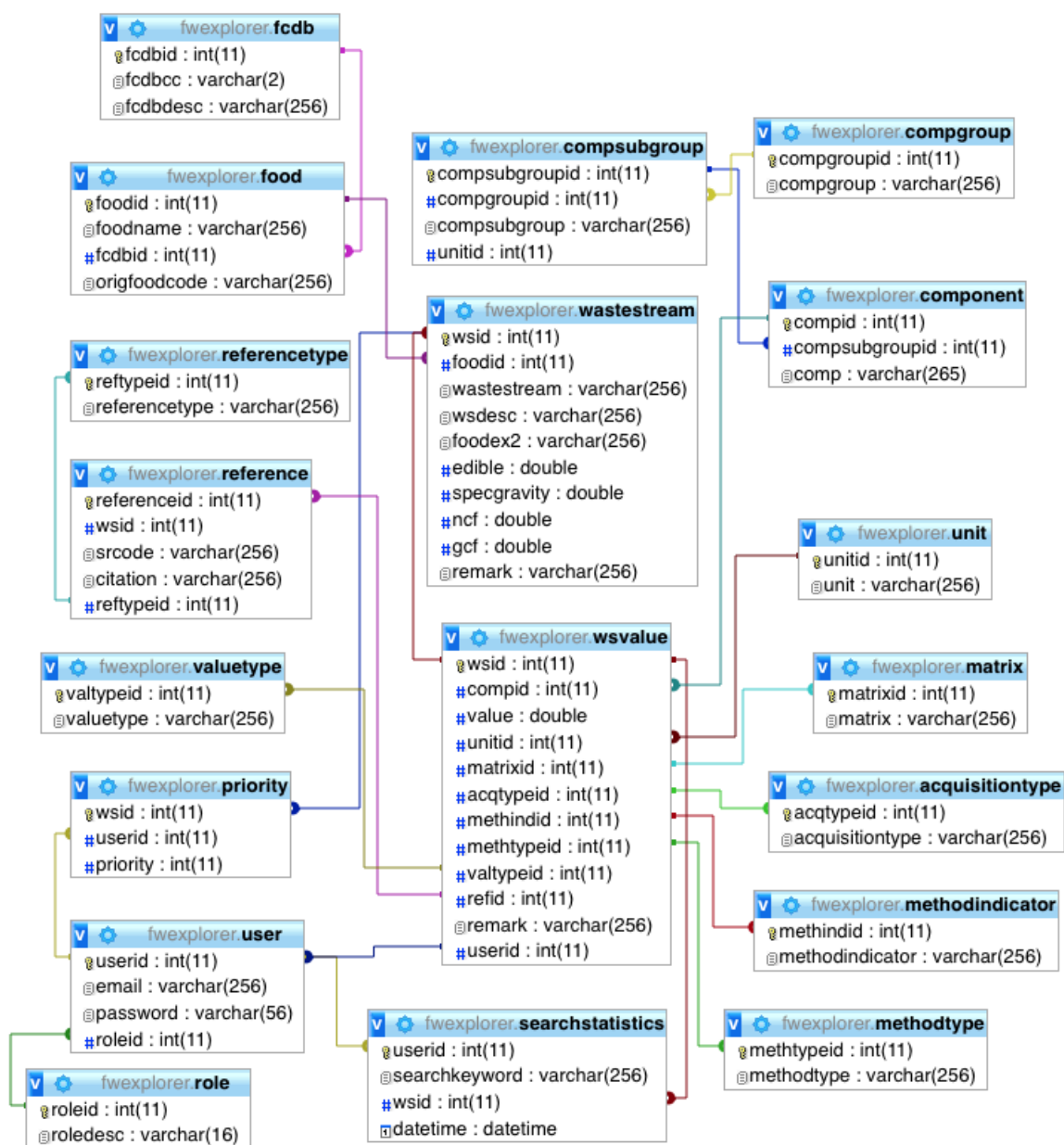
Analysis Models

Figure 3. Food waste data model

acquisitiontype

Property name	Property ID	Data type	Scope note
Acquisition type identifier	acqtypeid	INT	ID used to identify the acquisition type
Acquisition type	acquisitiontype	STR	Thesauri

compgroup

Property name	Property ID	Data type	Scope note
Component group identifier	compgroupid	INT	ID used to identify the group of components in the dataset
Component group	compgroup	STR	The English name of the component group

component

Property name	Property ID	Data type	Scope note
Component identifier	compid	INT	ID used to identify the component in the dataset
Component subgroup identifier	compsubgroupid	INT	ID used to identify the subgroup of components in the dataset
Component	comp	STR	The English name of the component (Thesauri)

compsubgroup

Property name	Property ID	Data type	Scope note
Component subgroup identifier	compsubgroupid	INT	ID used to identify the subgroup of components in the dataset
Component group identifier	compgroupid	INT	ID used to identify the group of components in the dataset
Component subgroup	compsubgroup	STR	The English name of the component subgroup

fcdb

Property name	Property ID	Data type	Scope note
FCDB identifier	fcdbid	INT	ID of the food composition database
FCDB country code	fcdbcc	STR	ISO 3166-1 alpha-2 country codes
FCDB description	fcdbdesc	STR	Description the food composition database in English

food

Property name	Property ID	Data type	Scope note
Food identifier	foodid	INT	ID used to identify the food in the dataset
Food name	foodname	STR	The food name in English
FCDB identifier	fcdbid	INT	ID of the food composition database
Original food code	origfoodcode	STR	Food ID in the food composition database

matrix

Property name	Property ID	Data type	Scope note
Matrix identifier	matrixid	INT	ID used to identify the matrix in the dataset
Matrix	matrix	STR	Thesauri

methodindicator

Property name	Property ID	Data type	Scope note
Method indicator identifier	methindid	INT	
Method indicator	methodindicator	STR	Thesauri

methodtype

Property name	Property ID	Data type	Scope note
Method type identifier	methtypeid	INT	
Method type	methodtype	STR	Thesauri

priority

Property name	Property ID	Data type	Scope note
Waste stream identifier	wsid	INT	ID used to identify the waste stream in the dataset
User identifier	userid	INT	ID used to identify the food in the dataset
Priority	priority	INT	The user's priority of the wastestream

reference

Property name	Property ID	Data type	Scope note
Reference identifier	referenceid	INT	ID used to identify the reference in the dataset
Waste stream identifier	wsid	INT	ID used to identify the waste stream in the dataset
Standard reference code	srcode	STR	Reference code identifying the reference record (doi or pmi)
Citation	citation	STR	Reference citation in English (Vancouver style)
Reference type indicator	reftypeid	INT	Thesauri

referencetype

Property name	Property ID	Data type	Scope note
Reference type identifier	reftypeid	INT	
Reference type	referencetype	STR	Thesauri

role

Property name	Property ID	Data type	Scope note
Role identifier	roleid	INT	
Role description	roledesc	STR	

searchstatistics

Property name	Property ID	Data type	Scope note
User identifier	userid	INT	ID used to identify the user
Search keyword	searchkeyword	STR	
Selected waste stream identifier	wsid	INT	
Selection data&time stamp	datetime	DATETIME	

unit

Property name	Property ID	Data type	Scope note
Unit identifier	uniteid	INT	ID used to identify the unit in the dataset
Unit	unit	STR	Thesauri

user

Property name	Property ID	Data type	Scope note
User identifier	userid	INT	ID used to identify the user in the dataset
Email address	email	STR	
Password	password	STR	Encrypted password
Role identifier	roleid	INT	

valuetype

Property name	Property ID	Data type	Scope note
Value type identifier	valtypeid	INT	
Value type	valuetype	STR	Thesauri

wastestream

Property name	Property ID	Data type	Scope note
Waste stream identifier	wsid	INT	ID used to identify the waste stream in the dataset
Food identifier	foodid	INT	ID used to identify the food in the dataset
Waste stream	wastestream	STR	The English name of the waste stream
Waste stream description	wsdesc	STR	Description of the waste stream in English
FoodEx2 code	foodex2	STR	Description of the waste stream in FoodEx2
Edible part of the waste stream	edible	NUM	Edible part of the waste stream
Specific gravity	specgravity	NUM	
Nitrogen conversion factor	ncf	NUM	
Glycerol conversion factor	gcf	NUM	
Remark	remark	STR	Any remark related to the waste stream

wsvalue

Property name	Property ID	Data type	Scope note
Waste stream identifier	wsid	INT	ID used to identify the waste stream in the dataset
Component identifier	compid	STR	ID used to identify the component subgroup in the dataset

Value	value	DOUBLE	
Unit identifier	unitid	INT	ID used to identify the unit of the value
Matrix identifier	matrixid	INT	Thesauri
Acquisition type identifier	acqtypeid	INT	Thesauri
Method indicator identifier	methindid	INT	Thesauri
Method type identifier	methtypeid	INT	Thesauri
Value type identifier	valtypeid	INT	Thesauri
Reference identifier	refid	INT	ID used to identify the reference in the dataset
Remark	remark	STR	Any remark related to the waste stream
User identifier	user id	INT	

Stimulus/response sequences of FoodWasteEXplorer

The following tables show the system responses to specific user actions, including responses to specific error conditions. This allows the developers to understand what is required to be implemented.

FoodWasteEXplorer backend

Data managers – specific user actions:

User action	System response
User registers to the system providing user data: name, surname, email address, password, area of interest, institution, institution type and country.	System checks user data, generates a new user profile, and sends a confirmation token to the user. If user data are wrong, an error message is displayed.
User logs into the system providing user data: email address, password.	System checks user data. If user data are wrong, an error message is displayed.
User logs out of the system.	Systems logs out the user.
User searches for existing data about FCDB, food, food waste stream, component, component group or subgroup, reference or value.	Data are searched for and listed on the screen. If there are no hits, a message is displayed.

User modifies existing data about FCDB, food, food waste stream, component, component group or subgroup or value.	Data are modified in the database. If the data verification identifies an error in data, a message is displayed.
User enters new data about FCDB, food, food waste stream, component, component group or subgroup, reference or value.	Data are stored in the database. If the data verification identifies an error in data, a message is displayed.
User searches for existing data about thesauri (tables: component, compgroup, unit).	Data are searched for and listed on the screen. If there are no hits, a message is displayed.
User modifies existing data about thesauri.	Data are modified in the database. If the data verification identifies an error in data, a message is displayed.
User enters new data about thesauri.	Data are stored in the database. If the data verification identifies an error in data, a message is displayed.
User requires data analysis and validation.	Data analysis and validation is performed and the results are displayed. If data analysis cannot be performed, a message is displayed.
User requires an export of data.	A report is created and its exportation (in Excel format) is enabled. If report cannot be generated, a message is displayed.

Data managers use cases – specific error conditions:

REQ-1: data maintenance

Potential error conditions / invalid inputs	System response
The data manager enters a wrong value.	There is a warning and the data is not stored in the database.

REQ-2: thesauri maintenance

Potential error conditions / invalid inputs	System response
There is a missing thesauri parameter.	The user cannot select it. However, the system administrator can manually add it for further use.

REQ-3: data analysis & validation

Potential error conditions / invalid inputs	System response
None identified	N/A

REQ-4: exporting reports

Potential error conditions / invalid inputs	System response
The user has not installed MS Excel on his/her computer.	The report can be stored as an Excel document. This can be either open on some other computer, which has installed MS Excel, or convert in another format.

System administrators – specific user actions:

User action	System response
User registers to the system providing user data: name, surname, email address, password, area of interest, institution, institution type and country.	System checks user data, generates a new user profile, and sends a confirmation token to the user. If user data are wrong, an error message is displayed.
User logs in the system providing user data: email address, password.	System checks user data. If user data are wrong, an error message is displayed.
User logs out of the system.	
User requires analysis of user activities.	Analysis is performed and the results are displayed. If analysis cannot be performed, a message is displayed.
User requires an export of user activities.	A report is created and its exportation (in Excel format) is enabled. If report cannot be generated, a message is displayed.
User requires database diagnostics.	If database diagnostics cannot be performed, a message is displayed.
User imports new data from Excel spreadsheets.	Data is imported in the FoodWasteEXplorer database.
User restores the database.	

System administrator use cases – specific error conditions:

REQ-1: tool monitoring

Potential error conditions / invalid inputs	System response
None identified	N/A

REQ-2: database maintenance

Potential error conditions / invalid inputs	System response
Data is wrongly stored.	The application does not display this data.

FoodWasteEXplorer frontend (interface)

Data users – specific user actions:

User action	System response
User registers to the system providing user data: name, surname, email address, password, area of interest, institution, institution type and country.	System checks user data, generates a new user profile, and sends a confirmation token to the user. If user data are wrong, an error message is displayed.
User logs in the system providing user data: email address, password.	System checks user data. If user data are wrong, an error message is displayed.
User logs out of the system.	
User searches for existing data about FCDB, food, food waste stream, component, component group or subgroup, reference or value.	Data are searched for and listed on the screen. If there are no hits, a message is displayed.
User requires an export of data.	A report is created and its exportation (in Excel format) is enabled. If report cannot be generated, a message is displayed.

Data user - specific error conditions:

REQ-1: exporting reports

Potential error conditions / invalid inputs	System response
The user has not installed MS Excel on his/her computer.	The report can be stored as an Excel document. This can be either open on some other computer, which has installed MS Excel, or convert in another format.

Annex 2. Food Product Wastes currently in FoodWasteExplorer

The Table below shows a list of all the food products and related wastes that are linked to data within FoodWasteEXplorer.

Food Product	Food Product Waste
Ales	Barley grain screenings
Ales	Barley rootlets
Ales	Beer yeast
Ales	Brewer's grains
Ales	Brewer's grains and yeast
Ales	Brewer's grains or draff (23% DM)
Ales	Brewer's yeast
Ales	Brewing cake
Ales	Hop leaves
Ales	Hop vine silage
Ales	Hops
Ales	Malt sprout meal
Ales	Malted barley germs
Ales	Malted sorghum sprouts
Ales	Sorghum bran and milling offal
Ales	Sorghum germ oil meal
Ales	Sorghum gluten feed
Ales	Sorghum gluten meal
Ales	Sorghum grain
Algae	Chlorella
Algae	Spiruline
Almond	Almond hulls
Animal	Abattoir raw effluent
Animal	Abattoir waste water
Animal	Abattoir, bore holes
Animal	Abattoir, hand dug wells
Animal	Abattoir, receiving streams
Animal	Animal fats
Animal	Blood
Animal	Blood meal
Animal	Bone meal
Animal	Greaves
Animal	Leather meal
Animal	Liver meal
Animal	Meat and bone meal
Animal	Meat compost

Food Product	Food Product Waste
Animal	Meat powder
Animal	Meat waste
Animal	Rinds
Animal	Slaughterhouse flotation tailings
Animal	Slaughterhouse grease trap residues
Animal	Slaughterhouse rumen contents
Animal	Slaughterhouse rumen press water
Animal	Slaughterhouse screenings
Animal	Slaughterhouse wastewater
Apple	Apple
Apple	Apple cake
Apple	Apple juice
Apple	Apple peel
Apple	Apple pomace
Apple	Apple pomace, dried
Apple	Apple waste
Apple	Pectin
Apricot	Apricot stones
Aubergine	Aubergine plant
Babassu	Babassu husks
Bakery	Bakery and viennoiserie by products
Bakery	Bakery product, dried
Bakery	Bakery residues
Bakery	Bakery waste
Bamboo	Bamboo shoot shells
Bamboo	Biochar from bamboo stems
Banana	Banana
Banana	Banana bunch
Banana	Banana flour
Banana	Banana fruits
Banana	Banana fruits, cooked
Banana	Banana fruits, dried
Banana	Banana fruits, ensiled
Banana	Banana leaves
Banana	Banana leaves, dried
Banana	Banana peel
Banana	Banana pintoza
Banana	Banana pseudo stems
Banana	Banana shoots
Banana	Banana stalks
Barley	Barley
Barley	Barley bran
Barley	Barley feeding meal
Barley	Barley grains

Food Product	Food Product Waste
Barley	Barley, total plants silage
Bean	Bean plant
Beef	Blood meal, dried
Beef	Cattle hoof and horn meal
Beef	Cattle manure
Beef	Cattle manure, dried
Beef	Dissolved air flotation sludge
Beef	Liver meal
Beef	Mixture of paunch, dissolved air flotation sludge and soft offal at annual production ratios
Beef	Paunch
Beef	Rumen content
Beef	Rumen content, dried
Beef	Rumen microbes
Beef	Soft offal
Beef	Solid cattle slaughterhouse wastes
Beetroot	Red beet
Blueberry	Blueberry pomace extract
Bran	Bran and cereal strip waste (70:30)
Bread	Bread by product
Bread	Calcium carbonate
Brussels sprouts	Brussels sprouts
Butter	Buttermilk, dried
Cabbage	Abyssinian cabbage
Cabbage	Cabbage
Cabbage	Cabbage leaves
Cabbage	Cabbage meal
Cacao	Cacao
Cacao	Cacao hulls
Cacao	Cacao shell parts, shoots
Cacao	Cacao shells
Carrot	Carrot
Carrot	Carrot pomace
Carrot	Carrot pulp
Carrot	Carrot tops
Carrot	Carrot waste
Carrot	Carrot, dried
Cassava	Cassava meal
Cassava	Cassava starch
Cauliflower	Cauliflower
Cauliflower	Cauliflower leaves
Cauliflower	Cauliflower stem
Cereal	Cereal strip waste
Cheese	Cheese
Cheese	Whey

Food Product	Food Product Waste
Cheese	Whey, dried
Cherry	Cherry pits
Chocolate	Cocoa hulls
Chocolate	Cocoa oil meal
Chocolate	Cocoa pod husks
Citrus (unspecified)	Citrus
Citrus (unspecified)	Citrus meal, dried
Citrus (unspecified)	Citrus molasses
Citrus (unspecified)	Citrus pulp
Citrus (unspecified)	Citrus pulp silage
Citrus (unspecified)	Citrus pulp, dried
Citrus (unspecified)	Citrus seed meal
Citrus (unspecified)	Citrus, dried
Coconut	Char from coconut shell
Coconut	Coconut cake
Coconut	Coconut cake/expeller
Coconut	Coconut coir dust
Coconut	Coconut copra
Coconut	Coconut fibre
Coconut	Coconut fibre dust
Coconut	Coconut husk
Coconut	Coconut meal
Coconut	Coconut pith
Coconut	Coconut shell
Coffee	Coffee grounds
Coffee	Coffee hulls
Coffee	Coffee husk
Coffee	Coffee leaves
Coffee	Coffee oil meal
Coffee	Coffee parchment
Coffee	Coffee pulp, dried
Coffee	Instant coffee by product
Coffee	Malt coffee marc
Corn	Corn bran
Corn	Corn gluten meal
Corn	Corn silage
Courgette	Courgette plant
Cranberry	Cranberry pulp meal
Cucumber	Cucumber
Cucumber	Cucumber peel
Cucumber	Cucumber plant
Date	Date palm
Date	Date palm flower stems
Date	Date palm fruits

Food Product	Food Product Waste
Date	Date palm leaves
Date	Date palm leaves, dried
Date	Date palm pedicels
Date	Date palm pits
Date	Date palm, pulp
Eggs	Eggshells
Fish/seafood	Bolti fish
Fish/seafood	Crab meal
Fish/seafood	Crab meal, dried
Fish/seafood	Crab shells
Fish/seafood	Crab waste meal
Fish/seafood	Crawfish waste meal
Fish/seafood	Fish
Fish/seafood	Fish hydrolysate
Fish/seafood	Fish liver meal
Fish/seafood	Fish meal
Fish/seafood	Fish oil
Fish/seafood	Fish processing waste
Fish/seafood	Fish protein concentrate
Fish/seafood	Fish protein isolate
Fish/seafood	Fish silage
Fish/seafood	Fish solubles
Fish/seafood	Fish solubles, dried
Fish/seafood	Freshwater fish silage
Fish/seafood	Freshwater fish waste
Fish/seafood	Saltwater fish silage
Fish/seafood	Saltwater fish waste
Fish/seafood	Shrimp heads
Fish/seafood	Shrimp heads, dried
Fish/seafood	Shrimp waste
Fish/seafood	Shrimp waste meal
Fish/seafood	Shrimp waste, dried
Fish/seafood	Shrimps, dried
Fish/seafood	Squid meal
Fish/seafood	Starfish meal
Fish/seafood	Tilapia filleting residue
Fish/seafood	Tilapia residue silage
Food (unspecified)	Food leftovers
Food (unspecified)	Grocery by-product waste
Frog	Frog meal
Frog	Tadpole meal, dried
Fruit and vegetables (unspecified)	Market waste, fruit and vegetables
Fruit and vegetables (unspecified)	Pectin residue

Food Product	Food Product Waste
Grain	Grain dust
Grain	Grain screenings
Grapefruit	Grapefruit
Grapefruit	Grapefruit peel
Grapefruit	Grapefruit peel silage
Grapefruit	Grapefruit pulp
Grapefruit	Grapefruit pulp silage
Grapefruit	Grapefruit pulp, dried
Grapefruit	Grapefruit skin char
Green waste	Biochar from green waste
Green waste	Biochar from greenhouse waste
Green waste	Biochar from greenhouse waste
Juices (unspecified)	Juice pomace
Lamb	Lamb hooves
Lamb	Rumen content
Lamb	Slaughterhouse blood
Lamb	Wool meal
Leek	Leek
Lemon	Lemon
Lemon	Lemon peel
Lemon	Lemon pellets
Lemon	Lemon pulp
Lemon	Lemon pulp, dried
Lemon	Lemon, dried
Lemon	Sweet lemon pulp
Lettuce	Lettuce
Lime	Lime
Lime	Lime peel
Lime	Lime peel silage
Lime	Lime pulp, dried
Lime	Lime seeds
Maize	Maize gluten feed
Maize	Maize starch
Maize	Maize strip waste
Melon	Melon
Melon	Melon plant
Melon	Melon seeds
Melon	Muskmelon, peels
Melon	Watermelon
Melon	Watermelon plant
Melon	Watermelon, hulls
Melon	Watermelon, peels
Melon	Watermelon, seeds
Milk	Milk, dried

Food Product	Food Product Waste
Millet	Millet husk
Mushrooms	Mushrooms
Mustard	Mustard husk
Nuts	Char from peanut shells
Nuts	Nut bagasse, dried
Nuts	Nut cake/expeller
Nuts	Nut crop residues
Nuts	Nut crop residues, dried
Nuts	Nut extraction meal
Nuts	Nut hulls
Nuts	Nut kernels
Nuts	Nut meal
Nuts	Nut oil meal
Nuts	Nut seedcoat
Nuts	Nut shell oil
Nuts	Nut shells
Nuts	Nut skins
Nuts	Peanuts
Nuts	Peanuts, with shells
Onion	Onion
Onion	Onion hulls
Orange	Orange
Orange	Orange by-product, dried
Orange	Orange peel
Orange	Orange peel silage
Orange	Orange pressings
Orange	Orange pulp
Orange	Orange pulp silage
Orange	Orange pulp, dried
Orange	Orange seeds
Orange	Orange skin char
Pea	Pea hull
Pea	Pea starch
Peach	Peach pits
Pears	Pear
Pears	Pear pomace
Pepper	Pepper plant
Pineapple	Pineapple
Pineapple	Pineapple bran
Pineapple	Pineapple canning byproduct, dried
Pineapple	Pineapple greenchop
Pineapple	Pineapple leafy shoot
Pineapple	Pineapple leaves
Pineapple	Pineapple peels

Food Product	Food Product Waste
Pineapple	Pineapple presscake
Pineapple	Pineapple waste
Plantain	Plantain banana fruits
Plantain	Plantain banana fruits, dried
Plantain	Plantain banana leaves
Plantain	Plantain banana peel
Plantain	Plantain banana shoots
Plantain	Plantain banana trunk
Pork	Hog hair meal
Pork	Liver meal
Pork	Piggery effluent
Potato	Arabinan
Potato	Arabinogalactan
Potato	Buffer insoluble solids
Potato	Hot buffer soluble solids
Potato	Liquid potato feed
Potato	Polygalacturonic acid
Potato	Potato
Potato	Potato aerial part
Potato	Potato amniotic fluid (starch production)
Potato	Potato chips
Potato	Potato fibres
Potato	Potato flakes
Potato	Potato leaves, dried
Potato	Potato mash
Potato	Potato peel
Potato	Potato press water
Potato	Potato process water
Potato	Potato pulp
Potato	Potato pulp, dried
Potato	Potato skin
Potato	Potato starch
Potato	Potato vine silage
Potato	Potato vines
Potato	Potato waste
Potato	Potato waste, dried
Potato	Potato, aerial part
Potato	Residue from pressed potato fibres
Potato	Supernatant from pressed potato fibre
Potato	Sweet potato
Potato	Sweet potato leaf protein concentrate
Potato	Sweet potato, aerial part
Potato	Sweet potato, aerial part, dried
Potato	Sweet potato, dried

Food Product	Food Product Waste
Potato products	Chip fat
Poultry	Blood
Poultry	Blood meal
Poultry	Feather meal
Poultry	Feathers
Poultry	Feathers, dry
Poultry	Hatchery by product
Poultry	Hatchery waste
Poultry	Liver meal
Poultry	Meat meal
Poultry	Offal meal
Poultry	Offals
Poultry	Poultry by product meal
Poultry	Poultry fats
Poultry	Poultry feet
Poultry	Poultry heads
Poultry	Poultry heads and feet
Poultry	Poultry manure, dried
Poultry	Poultry viscera
Poultry	Pyrolysis char from skimmings poultry processing
Prunes	Prune pits
Rabbit	Rabbit manure, dried
Rice	Char from rice hulls
Rice	Rice bran
Rice	Rice feeding meal
Rice	Rice grain
Rice	Rice hay
Rice	Rice hull
Rice	Rice husk
Rice	Rice husk, dried
Rice	Rice mill byproduct
Rice	Rice polishings
Rice	Rice straw
Rice	Rice straw char
Rice	Rice, aerial part
Rice	Rough rice, paddy rice
Rye	Seed residue
Snail	Snail meal
Sorghum	Sorghum silage
Spinach	Spinach
Spirits	Distillers corn stillage
Spirits	Distillers grain
Spirits	Distillers grain, dried
Spirits	Distillers grains and solubles

Food Product	Food Product Waste
Spirits	Distillers residues
Spirits	Distillers solids
Spirits	Distillers solubles
Spirits	Distillers solubles, dried
Spirits	Distillers, corn
Spirits	Grain, mash
Spirits	Grain, strip waste
Spirits	Oil extracted from distillers dried grains with soluble
Spirits	Pot ale syrup
Spirits	Potato mash
Spirits	Thin stillage
Spirits	Vinasse
Sponge gourd	Sponge gourd fibers
Straw	Straw
Straw	Straw pellets char
Sugar	Bagasse
Sugar	Bagasse pith
Sugar	Bagasse, dried
Sugar	Molasses
Sugar	Pressed beet-pulp
Sugar	Sugar beet
Sugar	Sugar beet feed
Sugar	Sugar beet leaves
Sugar	Sugar beet leaves and tops
Sugar	Sugar beet molasses
Sugar	Sugar beet molasses
Sugar	Sugar beet molasses residues
Sugar	Sugar beet pulp
Sugar	Sugar beet pulp, dried
Sugar	Sugar beet root
Sugar	Sugar beet scraps
Sugar	Sugar beet taproots
Sugar	Sugar beet tops
Sugar	Sugar beet tops, dried
Sugar	Sugar beet, dried
Sugar	Sugar cane
Sugar	Sugar cane bagasse
Sugar	Sugar cane forage
Sugar	Sugar cane juice
Sugar	Sugar cane leaves
Sugar	Sugar cane leaves, dried
Sugar	Sugar cane molasses
Sugar	Sugar cane molasses, dried
Sugar	Sugar cane mud

Food Product	Food Product Waste
Sugar	Sugar cane stalks
Sugar	Sugar cane straw
Sugar	Sugar cane tops
Sugar	Sugar cane trash
Sugar	Sugar cane, syrup-off
Sugar	Sugar for feeding
Sugar	Sugar, feed grade
Sugar	Trash
Sugar	Wastewater
Sweets	Residue from production of sweets
Tea	Bergamot peel
Tea	Medicinal tea
Toad	Toad meal
Tomatoes	Biochar from a blend of greenhouse waste (tomato leaves and stems) and clean wood
Tomatoes	Tomato
Tomatoes	Tomato cake
Tomatoes	Tomato meal
Tomatoes	Tomato oil cake
Tomatoes	Tomato peel
Tomatoes	Tomato plant
Tomatoes	Tomato pomace
Tomatoes	Tomato pomace, dried
Tomatoes	Tomato residues
Tomatoes	Tomato residues, dried
Tomatoes	Tomato seed
Tomatoes	Tomato seed oil
Tomatoes	Tomato skin
Tomatoes	Tomato, leaves
Tomatoes	Tomato, stems
Vegetable oil	Argan fruit pulp, dried
Vegetable oil	Argan leaves, dried
Vegetable oil	Argan oil cake
Vegetable oil	Babassu cake
Vegetable oil	Canola cake
Vegetable oil	Canola meal
Vegetable oil	Castor hulls
Vegetable oil	Castor oil meal
Vegetable oil	Castor seed cake
Vegetable oil	Char from olive husks
Vegetable oil	Char from olive pits
Vegetable oil	Coconut water
Vegetable oil	Cotton leaves
Vegetable oil	Cotton stalk
Vegetable oil	Cotton straw

Food Product	Food Product Waste
Vegetable oil	Cottonseed
Vegetable oil	Cottonseed cake/expeller
Vegetable oil	Cottonseed extraction meal
Vegetable oil	Cottonseed hulls
Vegetable oil	Cottonseed husks
Vegetable oil	Cottonseed meal
Vegetable oil	Crambe meal
Vegetable oil	Flax cake/expeller
Vegetable oil	Flax chaff
Vegetable oil	Flax extraction meal
Vegetable oil	Flax hay
Vegetable oil	Flax seed hulls
Vegetable oil	Flax shives
Vegetable oil	Flax straw
Vegetable oil	Flax, aerial part
Vegetable oil	Grape seed oil meal
Vegetable oil	Hemp press cake
Vegetable oil	Isolated lignin from olive tree pruning
Vegetable oil	Juncea canola meal
Vegetable oil	Linseed meal
Vegetable oil	Linseeds
Vegetable oil	Maize germ
Vegetable oil	Maize germ cake/expeller
Vegetable oil	Maize germ meal
Vegetable oil	Mustard oil meal
Vegetable oil	Mustard seeds
Vegetable oil	Oil palm fronds
Vegetable oil	Oil palm fronds, dried
Vegetable oil	Oil palm kernels
Vegetable oil	Oil palm leaflets
Vegetable oil	Oil palm mill effluent, dried
Vegetable oil	Oil seed rape
Vegetable oil	Olive
Vegetable oil	Olive cake
Vegetable oil	Olive cake, dried
Vegetable oil	Olive flesh
Vegetable oil	Olive husk
Vegetable oil	Olive kernels
Vegetable oil	Olive leaves
Vegetable oil	Olive mill effluent
Vegetable oil	Olive mill wastewater
Vegetable oil	Olive oil cake
Vegetable oil	Olive oil pulp
Vegetable oil	Olive oil vegetation water

Food Product	Food Product Waste
Vegetable oil	Olive pits
Vegetable oil	Olive pomace
Vegetable oil	Olive pulp
Vegetable oil	Olive residue
Vegetable oil	Olive skins
Vegetable oil	Olive stones
Vegetable oil	Olive tree pruning
Vegetable oil	Olive waste
Vegetable oil	Orujillo
Vegetable oil	Palm empty fruit bunches
Vegetable oil	Palm kernel cake
Vegetable oil	Palm kernel cake/expeller
Vegetable oil	Palm kernel meal
Vegetable oil	Palm oil mill effluent
Vegetable oil	Palm press fibre
Vegetable oil	Poppy oil meal
Vegetable oil	Pumpkin
Vegetable oil	Pumpkin crop by-product
Vegetable oil	Pumpkin hulls
Vegetable oil	Pumpkin oil meal
Vegetable oil	Pumpkin seeds
Vegetable oil	Rape
Vegetable oil	Rape cake
Vegetable oil	Rape FM
Vegetable oil	Rape forage
Vegetable oil	Rape forage, dried
Vegetable oil	Rape straw
Vegetable oil	Rapeseed
Vegetable oil	Rapeseed cake
Vegetable oil	Rapeseed cake/expeller
Vegetable oil	Rapeseed grains
Vegetable oil	Rapeseed hulls
Vegetable oil	Rapeseed meal
Vegetable oil	Rapeseed press cake
Vegetable oil	Rapeseed straw
Vegetable oil	Rapeseed strip waste
Vegetable oil	Safflower hulls
Vegetable oil	Safflower meal
Vegetable oil	Safflower seeds
Vegetable oil	Sesame meal
Vegetable oil	Sesame seeds
Vegetable oil	Soy protein concentrate
Vegetable oil	Soybean hay
Vegetable oil	Soybean hulls

Food Product	Food Product Waste
Vegetable oil	Soybean meal
Vegetable oil	Soybean straw
Vegetable oil	Soybean, aerial part
Vegetable oil	Soybeans
Vegetable oil	Sunflower
Vegetable oil	Sunflower cake
Vegetable oil	Sunflower cake/expeller
Vegetable oil	Sunflower char
Vegetable oil	Sunflower extracted atmosphere oil
Vegetable oil	Sunflower extracted bagasse
Vegetable oil	Sunflower forage
Vegetable oil	Sunflower heads
Vegetable oil	Sunflower Heinze oil
Vegetable oil	Sunflower hulls
Vegetable oil	Sunflower meal
Vegetable oil	Sunflower oil cake
Vegetable oil	Sunflower peelings
Vegetable oil	Sunflower screenings
Vegetable oil	Sunflower seed hulls
Vegetable oil	Sunflower seeds
Vegetable oil	Sunflower stalks
Vegetable oil	Sunflower stover (stalks and heads)
Whale	Whale meal
Whale	Whale solubles
Wheat	Char from wheat straw
Wheat	Triticale aerial part
Wheat	Triticale grain
Wheat	Triticale straw
Wheat	Wheat
Wheat	Wheat bran
Wheat	Wheat bran extract
Wheat	Wheat feed
Wheat	Wheat forage
Wheat	Wheat germs
Wheat	Wheat gluten
Wheat	Wheat grain
Wheat	Wheat hay
Wheat	Wheat meal
Wheat	Wheat middlings
Wheat	Wheat mill run
Wheat	Wheat screenings
Wheat	Wheat shorts
Wheat	Wheat silage
Wheat	Wheat starch

Food Product	Food Product Waste
Wheat	Wheat straw
Wheat	Wheat straw char
Wheat	Wheat strip waste
Wine	Char from grape residue
Wine	Grape cane
Wine	Grape marc
Wine	Grape marc and lees
Wine	Grape meal
Wine	Grape oil
Wine	Grape oil cake
Wine	Grape peels
Wine	Grape pomace
Wine	Grape pomace, dried
Wine	Grape pomace/marc
Wine	Grape pulp
Wine	Grape seed oil
Wine	Grape seeds
Wine	Grape seeds and peels
Wine	Grape skins
Wine	Grape stalks
Wine	Grape vine
Wine	Grape vine shoot
Wine	Grape waste
Wine	Holocellulose
Wine	Lees
Yoghurt	Yoghurt

Annex 3. Scenarios used in the usability testing

1. Go to the website: https://ws.eurofir.org/foodwasteexplorer/ and navigate to the following pages:
-About
-Contact us
-Privacy Policy
-Terms & Conditions

Check if you understand the information provided on each page.

2. Under "Contact us", try to fill in the contact form/ send an email and see if it's sent properly.
3. Navigate to registration page. Fill in the registration form and activate your account. Once you've activated your account, log in.
4. Once you've logged in, navigate to your user profile and check if you can edit your data and change your password.
5. Imagine you are an orange producer and you want to know what you can find in orange peel. You decide to try and find out what components you can get out of orange peel.
6. Imagine you are an orange producer and you want to know what you can do with your orange pulp. You decide to try and find out what components orange pulp contains.
7. Find out how much carbon there is in sugar cane bagasse.
8. Imagine you are a spirits producer and you want to find out information on distillers grains and solubles. Try and find out what information is available and if you can get a report on it.
9. Perform your own search. Think of something that interests you and try and find the data. It can be something from your work domain/ your industry/ your previous interests etc. It could be something you already searched for in the past in different resources.

Annex 4. FoodWasteEXplorer Usability Questionnaire Results

Q1. What is your professional background?

Legend:
- Research
- Food science
- Engineer
- Science communication
- Food waste & life cycle assessment
- Nutrition
- Biology
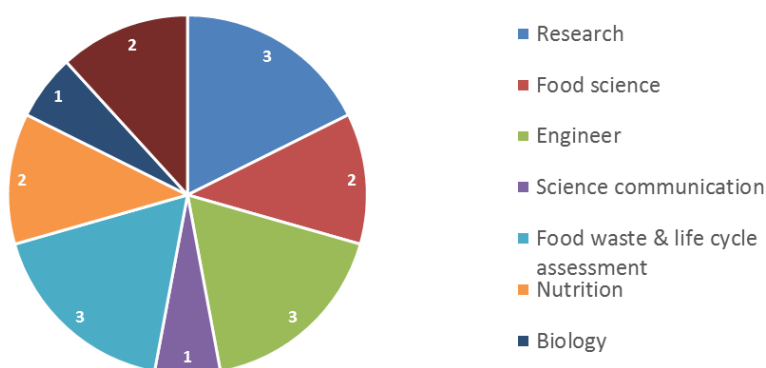
Q2. Which area of food waste are you interested in?

Legend:
- Research & Innovation
- Composting, AD and fibre production
- Avoidable and unavoidable food waste
- Valorization & Sustainability
- Cost of food waste, food waste recycling
- Byproducts of production of vegetables on field and in greenhouses
- Food waste nutritional composition
- Food waste in general
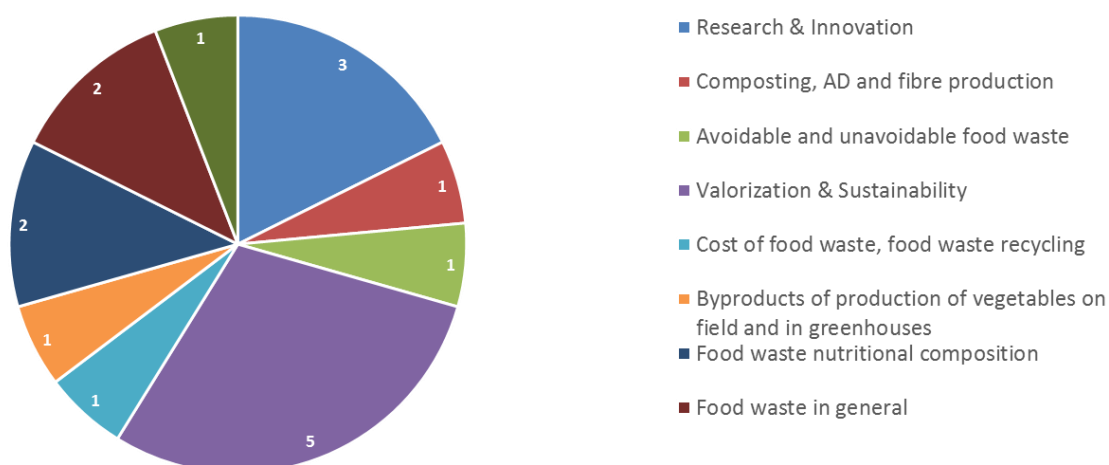
Q3. What would you potentially use the FoodWasteEXplorer for?

- Research & development.
- Pre-screening of data for the planning of new experiments / new product development.
- Looking for hazardous materials, looking for parameters that will effect end application- chloride for growth media, items with fibres or polymers.
- Finding out which waste products can be used for certain applications.
- Signposting industry and researchers who are looking for detailed information on specific food wastes and where they might be able to find specific compounds in food waste.
- Identification of potential sources of bioactive compounds.
- Search for elementary composition and calorific value of food by-products.
- Perhaps integration of the data with Nutritics.
- To obtain data for use in exposure assessment research.
- As input for modelling new food valorisation technologies to produce bioproducts.
- As a policy solution for food waste.
- Technical data for characterisation.

Q4 to Q39 are grading scale questions, rated by the users on the scale from 1 to 10, where 1=strongly disagree, 10=strongly agree.

Q4: I am familiar with online search engines.
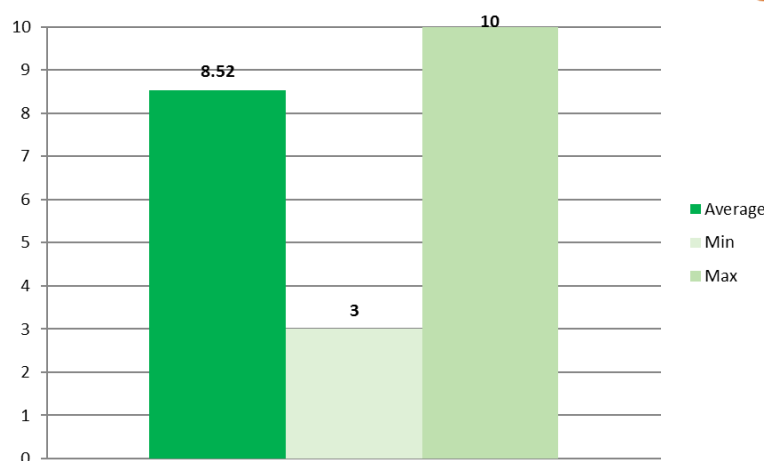
Q5. I understand the food composition topic (nutrient information).

Chart showing: Average 8.7, Min 2, Max 10

Legend: Average, Min, Max
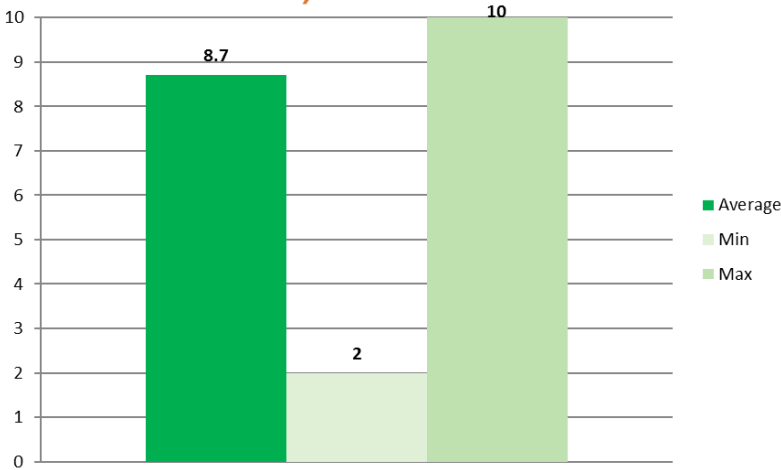
Q6. I am familiar with the food waste topic.

Chart showing: Average 8.05, Min 4, Max 10

Legend: Average, Min, Max
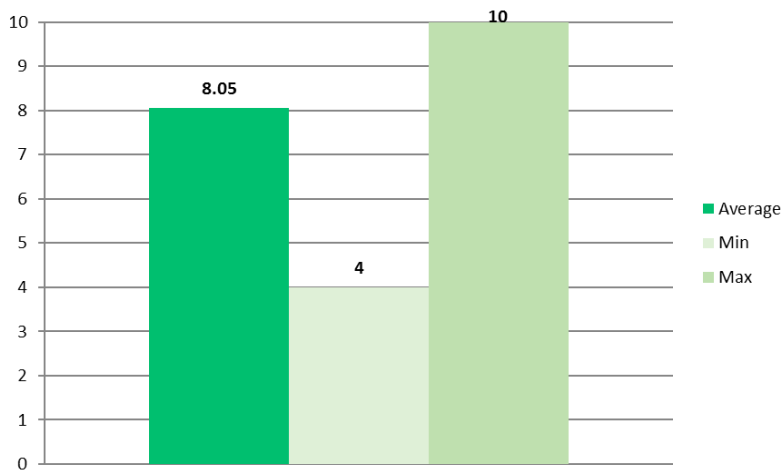
Q7. I am familiar with the concept of reducing food waste across the EU by 30% by 2025 (which amounts to 25 to 40 million tonnes).
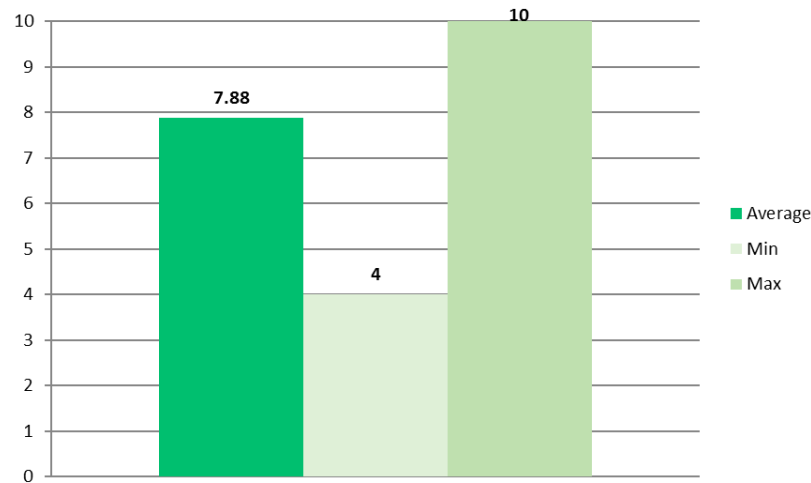
Q8. It (FoodWasteEXplorer) helps me be more productive.
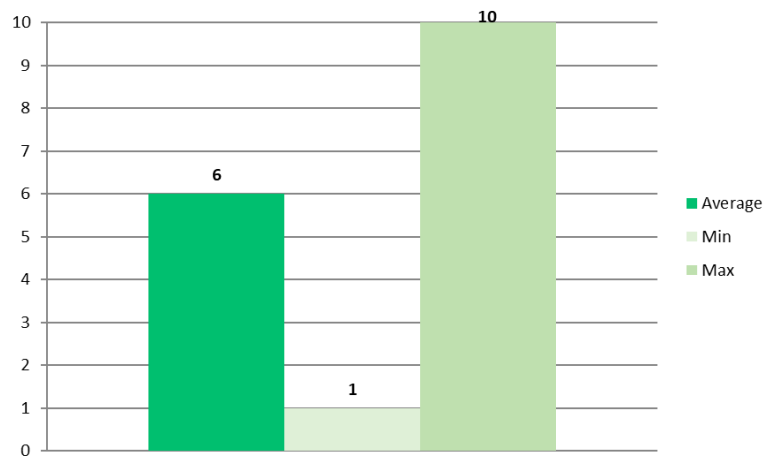
Q9. It (FoodWasteEXplorer) is useful.
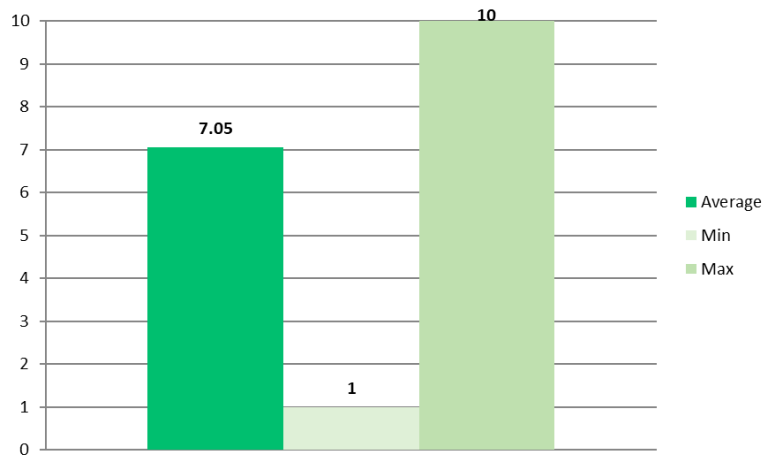
Q10. It (FoodWasteEXplorer) meets my needs.
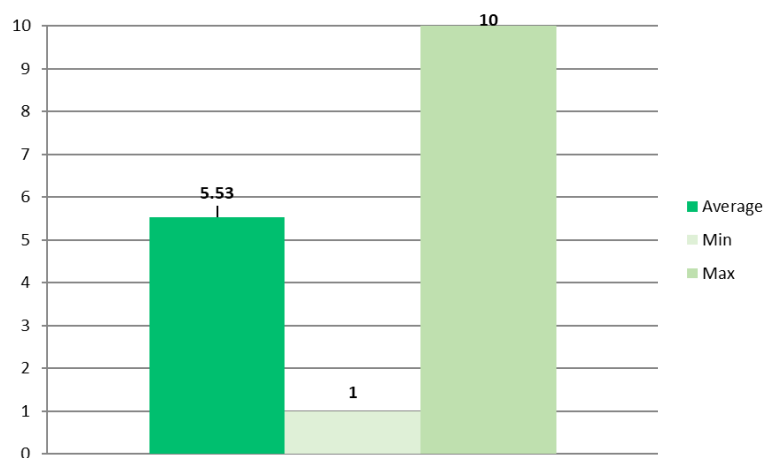
Q11. It (FoodWasteEXplorer) does everything I would expect it to do.
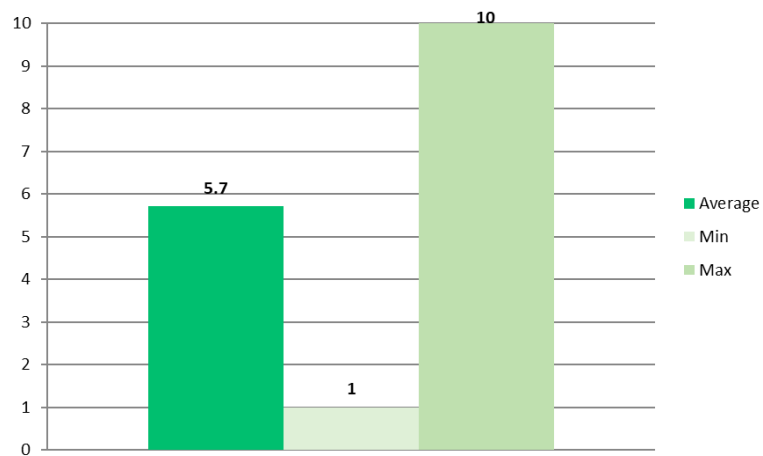
Q12. I find the tool and the available data interesting.
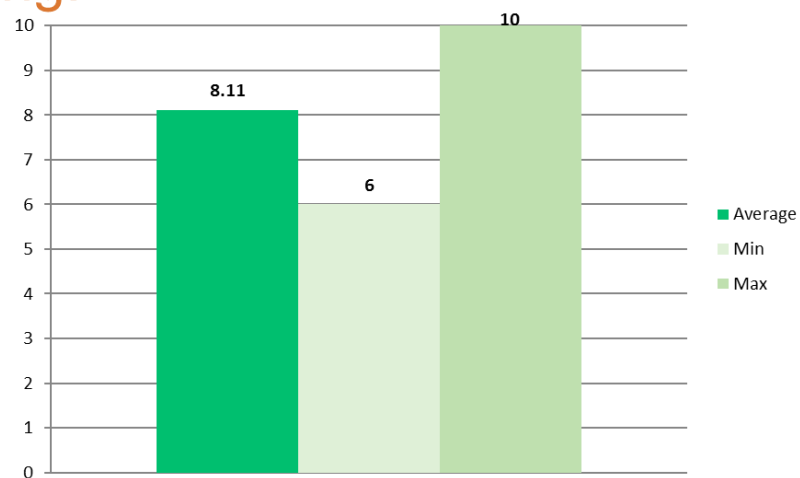
Q13. It is easy to use.

Average: **6.17**
Min: **2**
Max: **10**
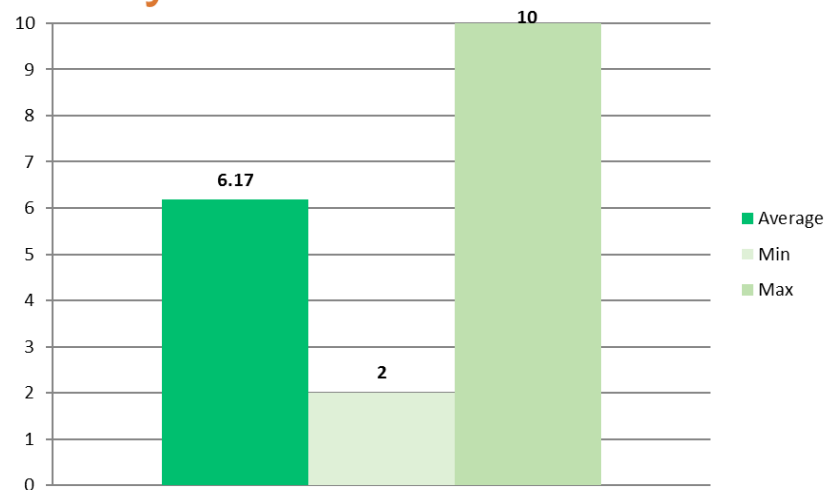
Q14. It requires the fewest steps possible to accomplish what I want to do with it.

Average: **6.05**
Min: **1**
Max: **10**

Q15. It is easy to find the information I need.

Legend: Average, Min, Max

Average: 5.47
Min: 1
Max: 10
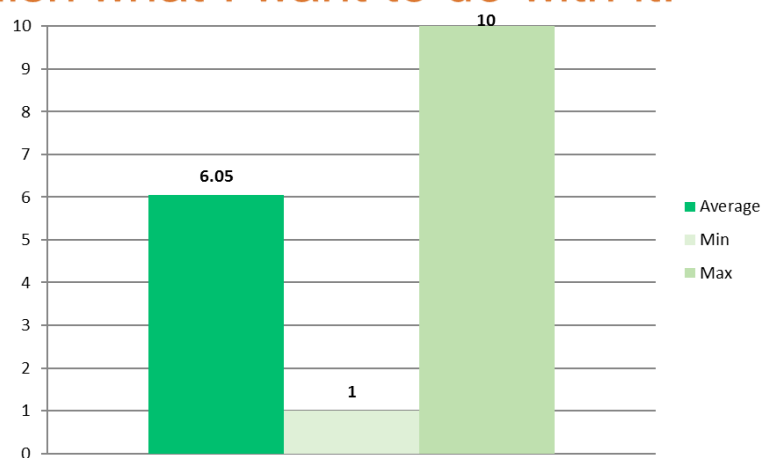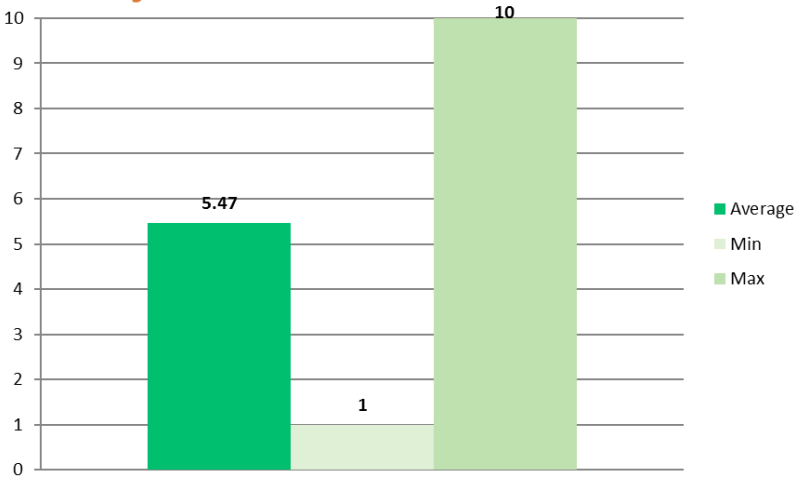
Q16. I can use it without written instructions.

Legend: Average, Min, Max

Average: 6.41
Min: 1
Max: 10
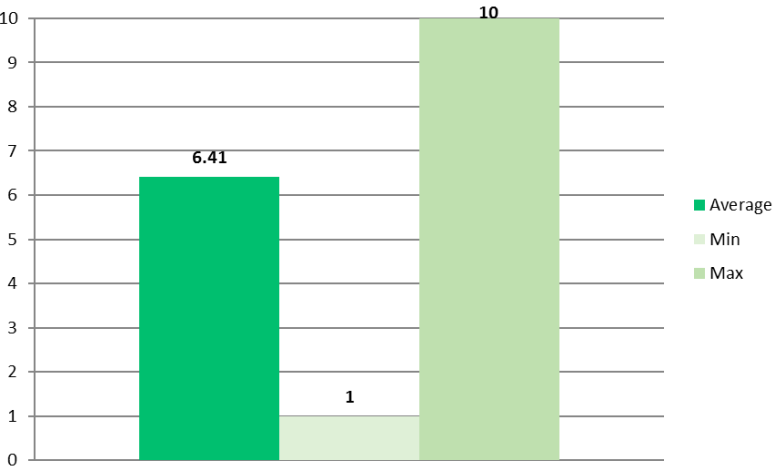
Q17. I don't notice any inconsistencies as I use it.
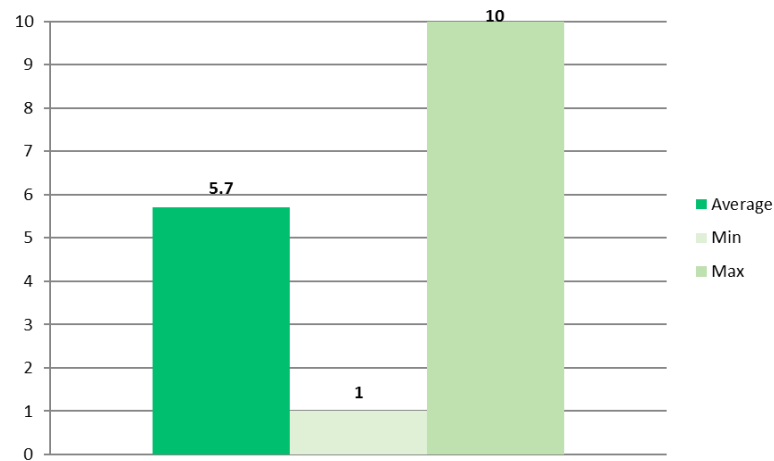
Q18. I can recover from mistakes quickly and easily.
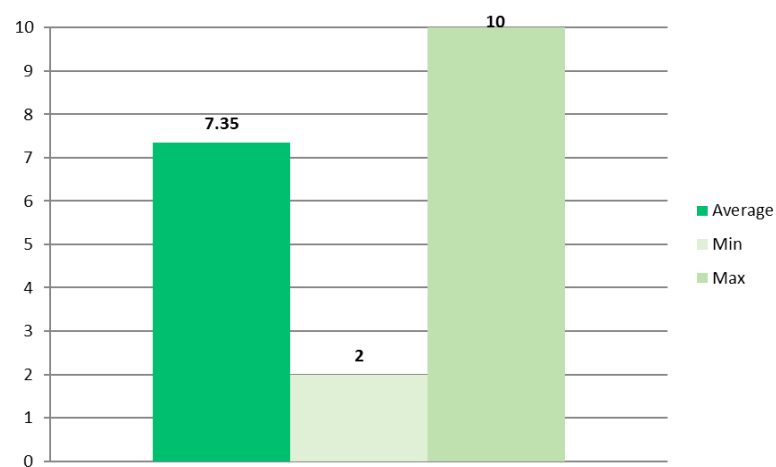
Q19. I can use it successfully every time.
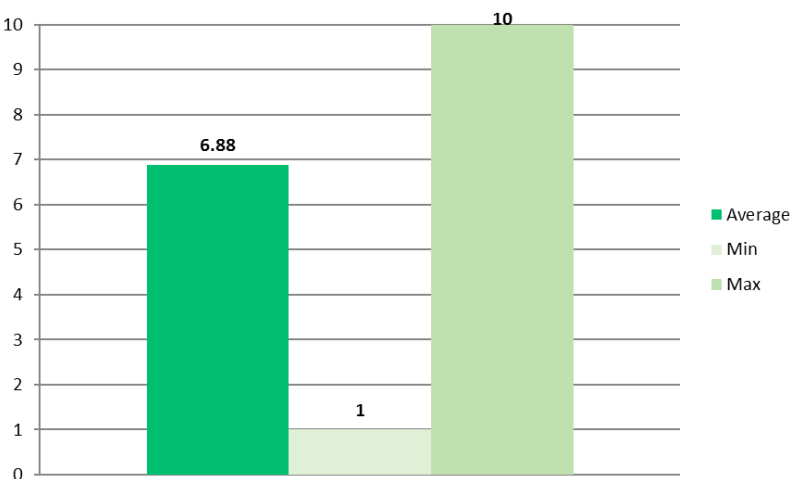
Q20. Overall, I am satisfied with how easy it is to use this system.
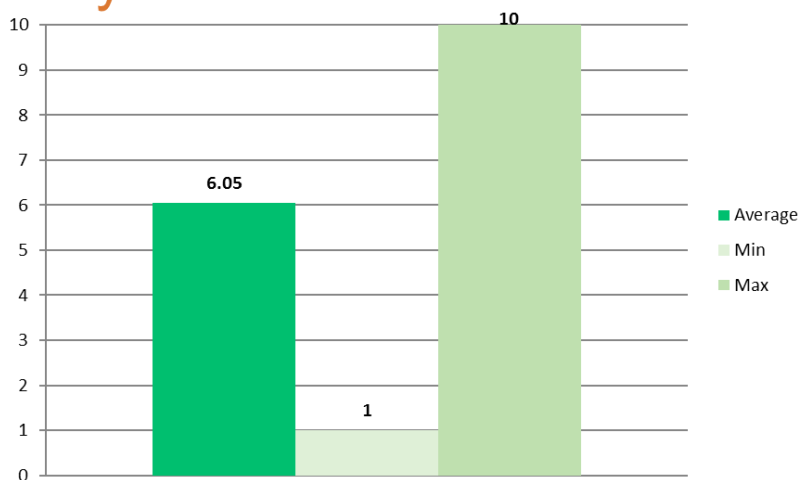
Q21. I learned to use it quickly.

Average
Min
Max

7.76
2
10
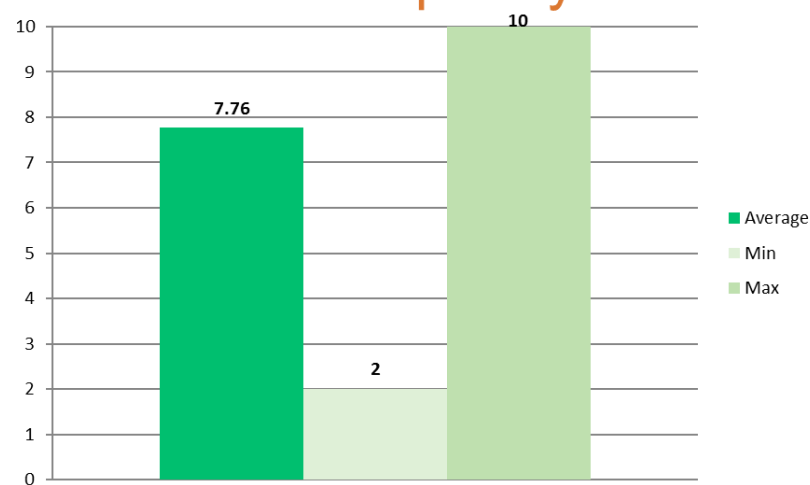
Q22. I easily remember how to use it.

Average
Min
Max

8.65
6
10
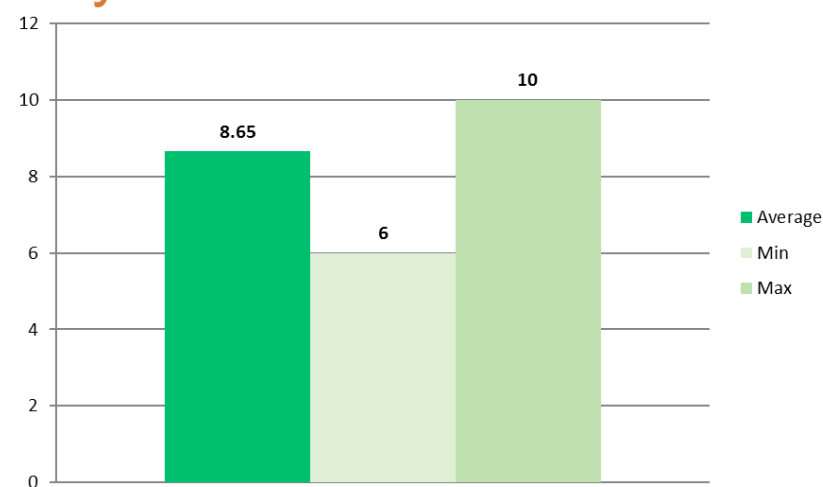
Q23. It is easy to learn to use it.
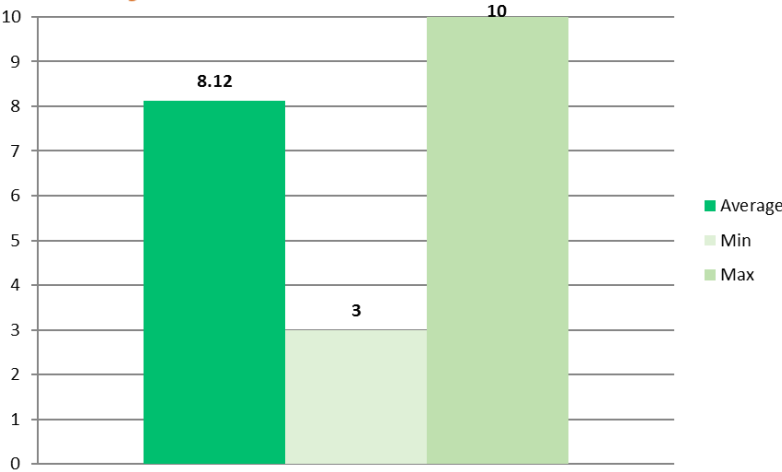
Q24. I can effectively complete my work using this system.
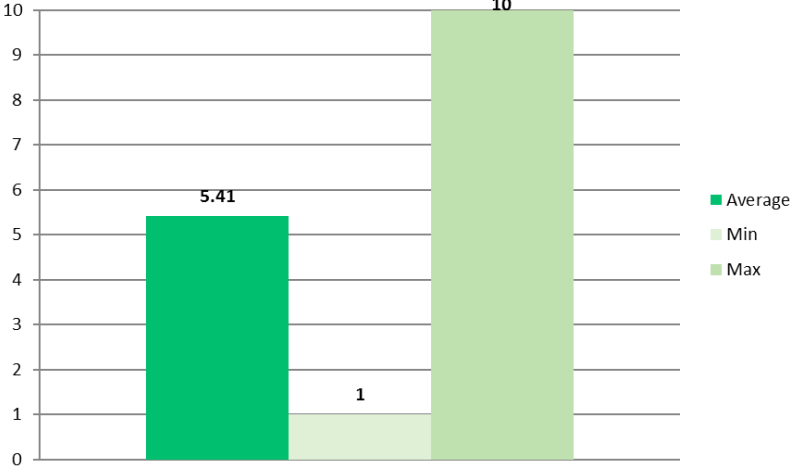
Q25. I can complete the tasks and scenarios.

Legend:
- Average
- Min
- Max

Average: 7.58
Min: 2
Max: 10
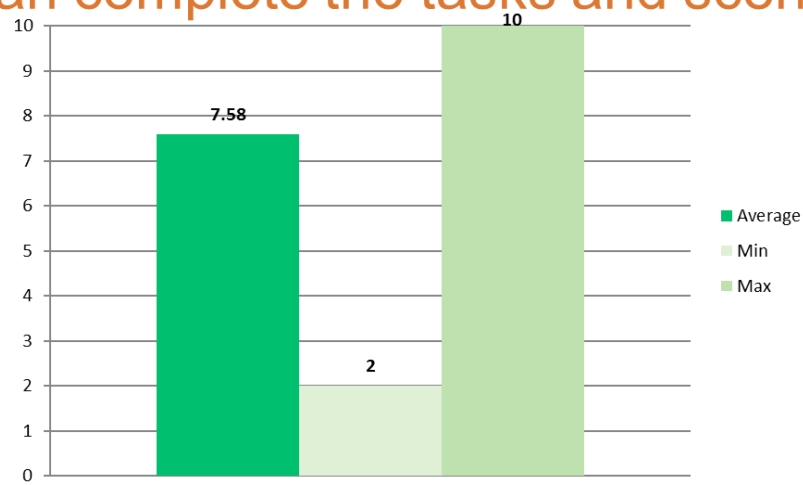
Q26. It is easy to navigate.

Legend:
- Average
- Min
- Max

Average: 6.53
Min: 1
Max: 10
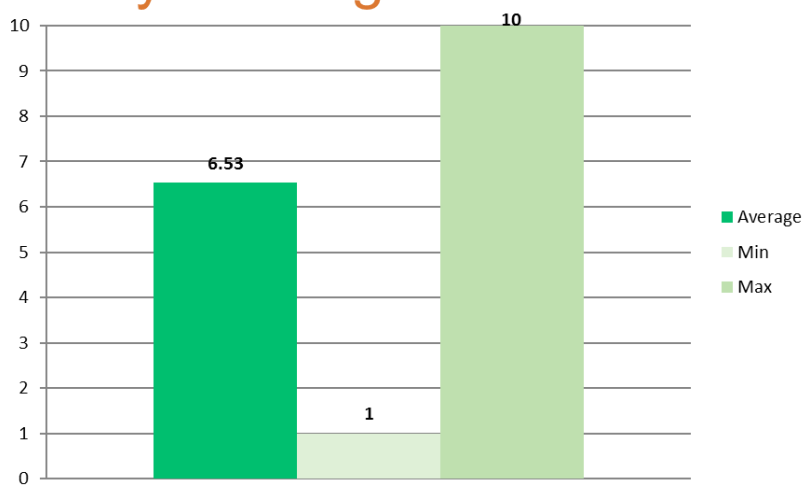
Q27. It has all the search tool types necessary.

Average: 5.59
Min: 1
Max: 10

Legend: Average, Min, Max
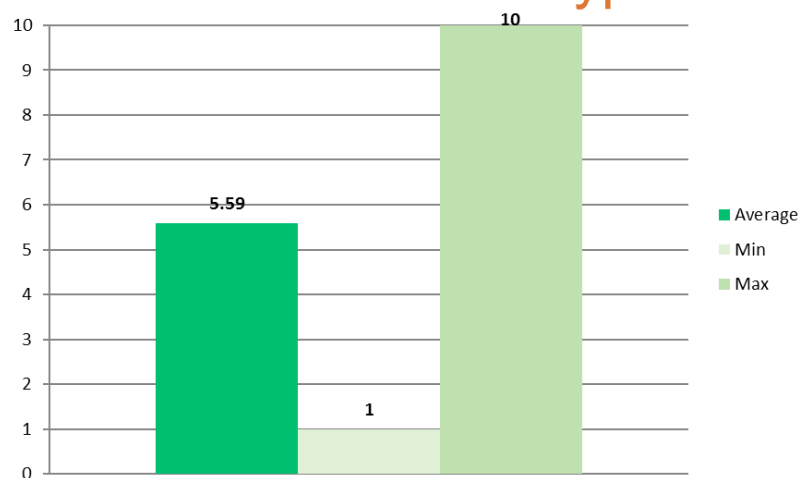
Q28. The information on Terms & Conditions and Privacy Policy is clear.

Average: 8.47
Min: 2
Max: 10

Legend: Average, Min, Max
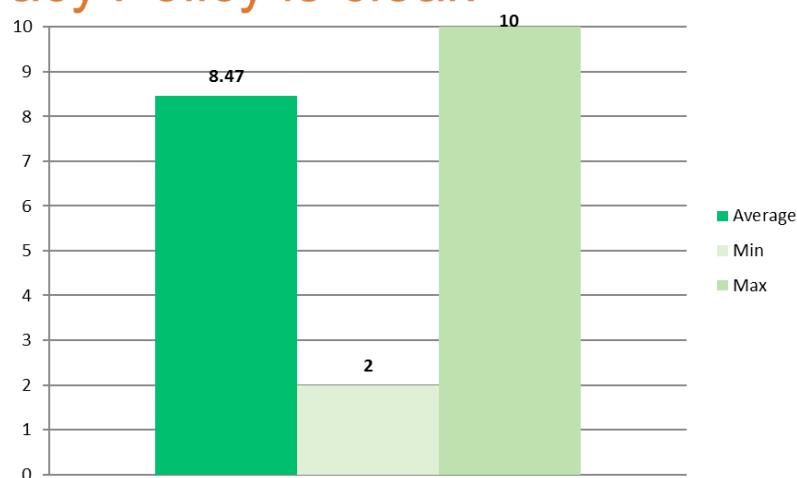
Q29. I can easily find the "Contact us" form.

Average: 9.29
Min: 6
Max: 10
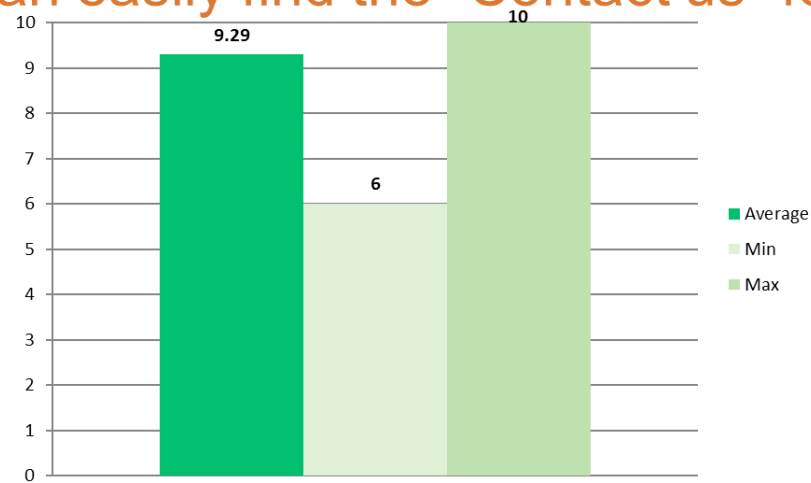
Q30. I can register easily.

Average: 9.06
Min: 1
Max: 10
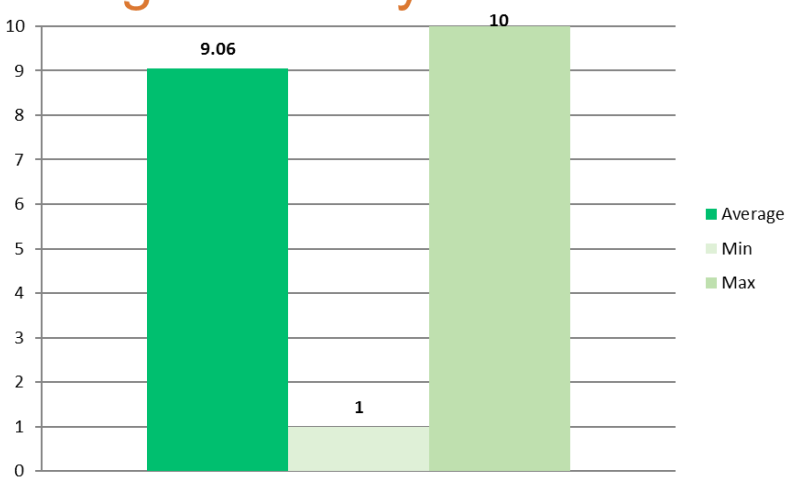
Q31. I can log in easily.
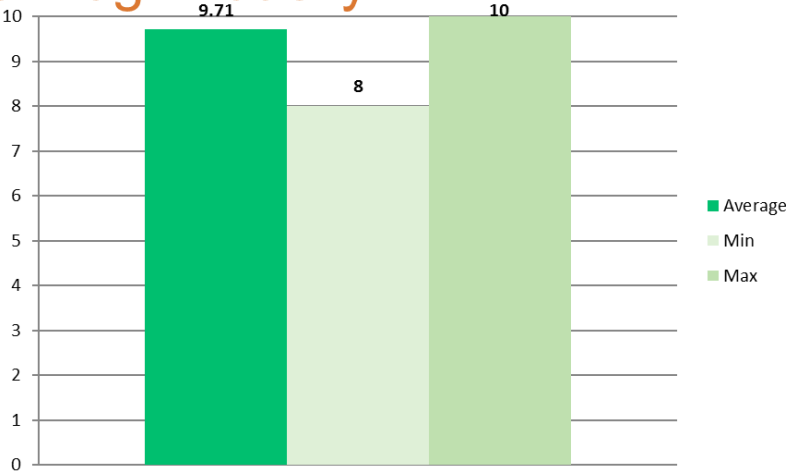
Q32. I like the aesthetics of the tool.
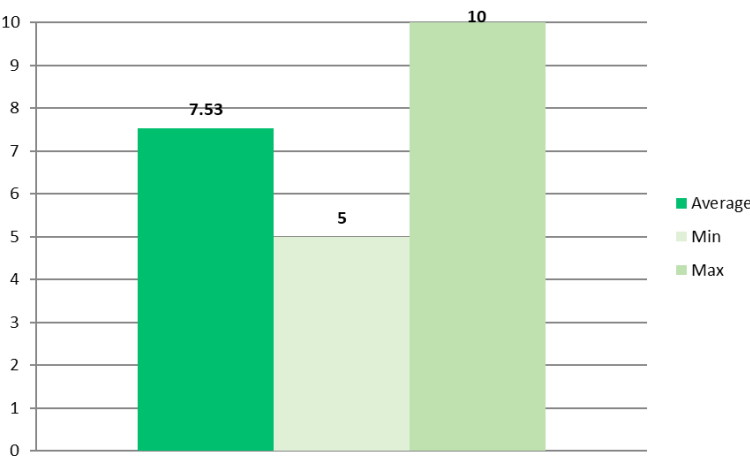
Q33. I like the design of the website.
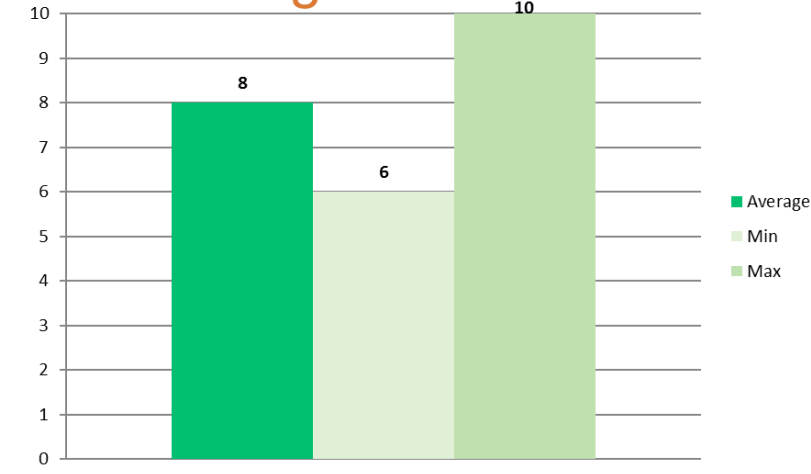
Q34. Overall, I am satisfied with it.
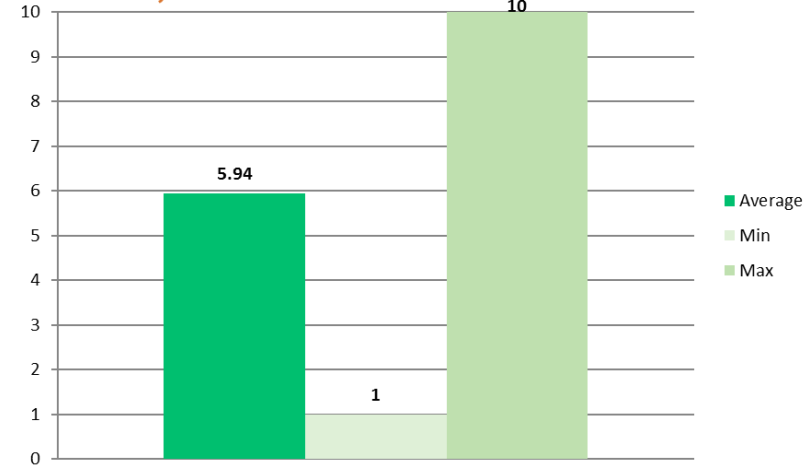
Q35. I would recommend it to a friend.
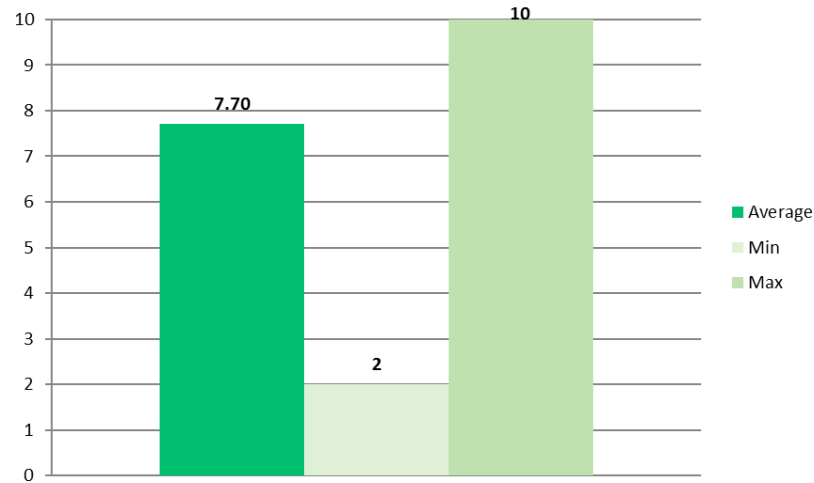
Q36. It is fun to use.
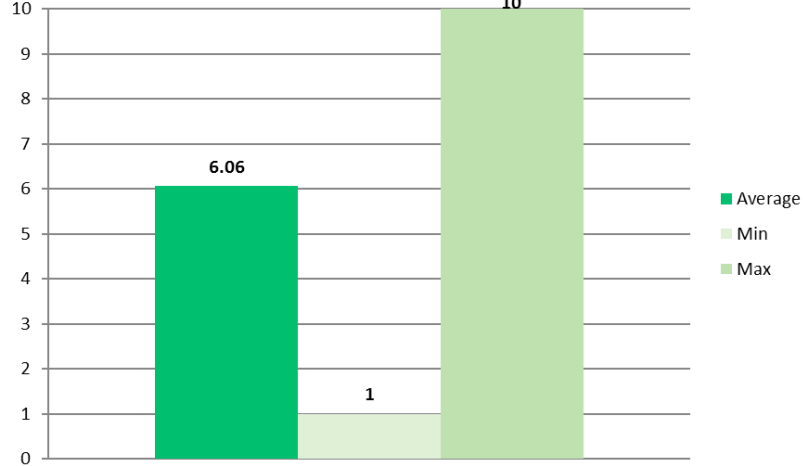
Q37. I will use this tool in the future.
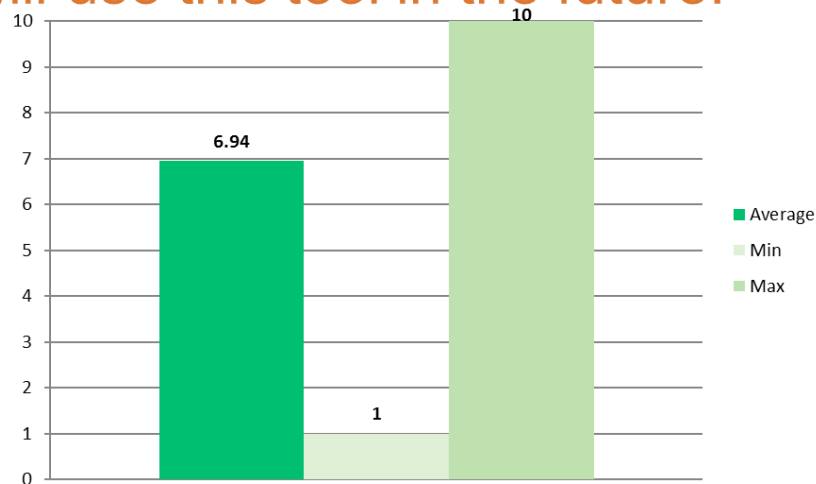
Q38. I enjoyed using it.
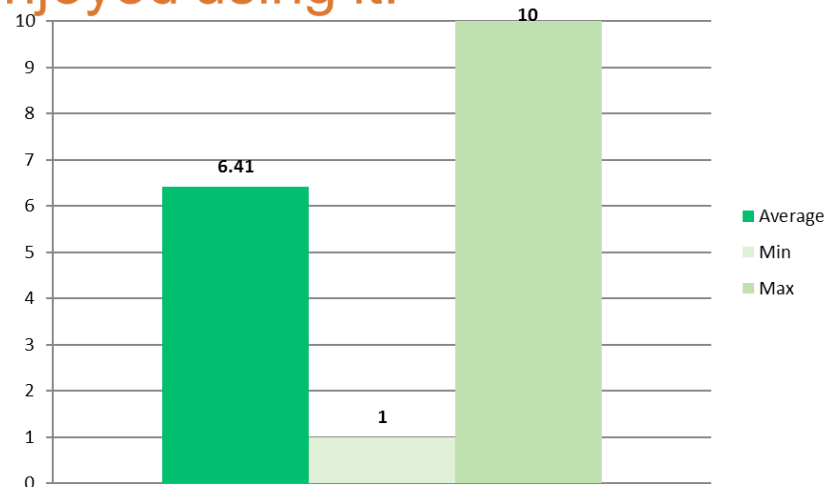
Q39. This system has all the functions and capabilities I expect it to have.
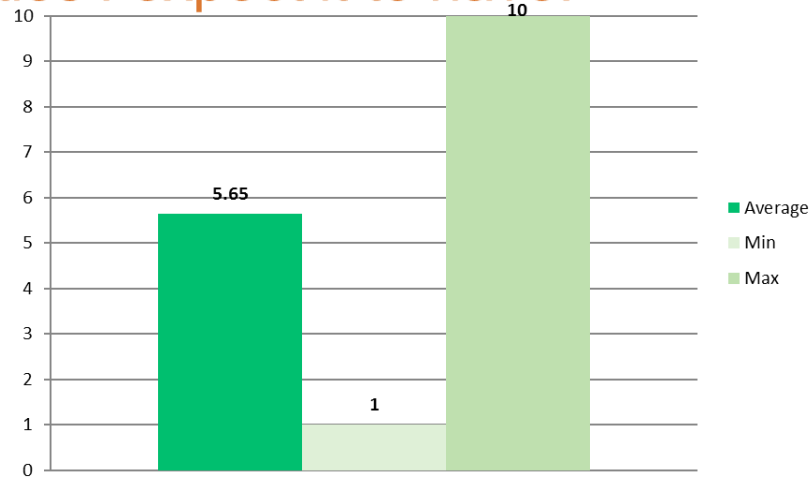
Q40. I was able to complete Scenario 1.
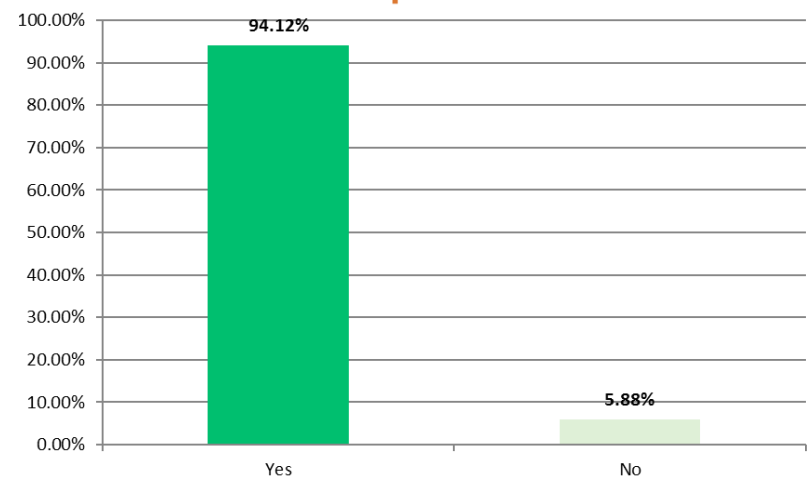
Q41. I was able to complete Scenario 2.
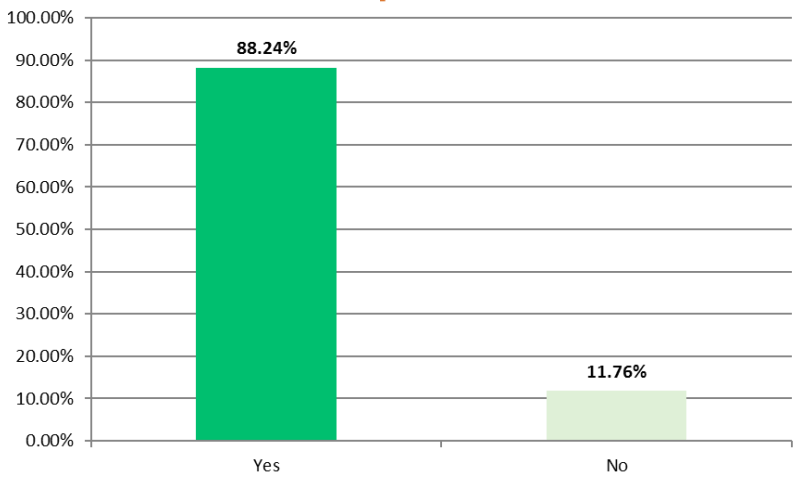
Q42. I was able to complete Scenario 3.

Q43. I was able to complete Scenario 4.

Bar chart with values: Yes 94.12%, No 5.88%.

Y-axis: 0.00% to 100.00% in 10.00% increments.

Q44. I was able to complete Scenario 5.

Bar chart with values: Yes 82.35%, No 17.65%.

Y-axis: 0.00% to 100.00% in 10.00% increments.
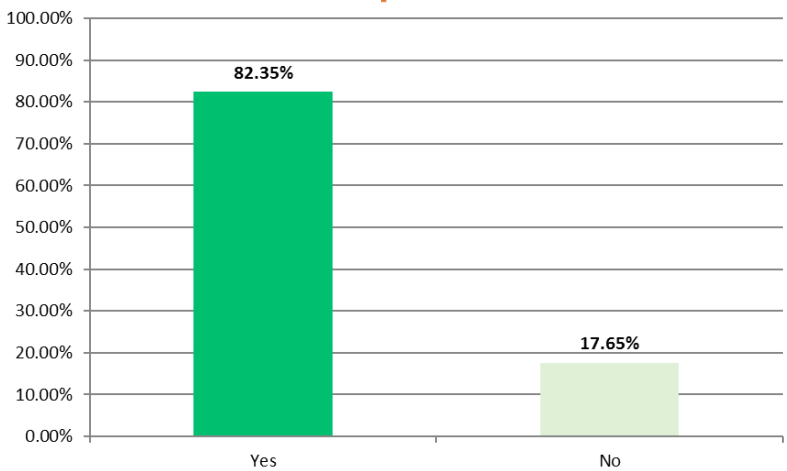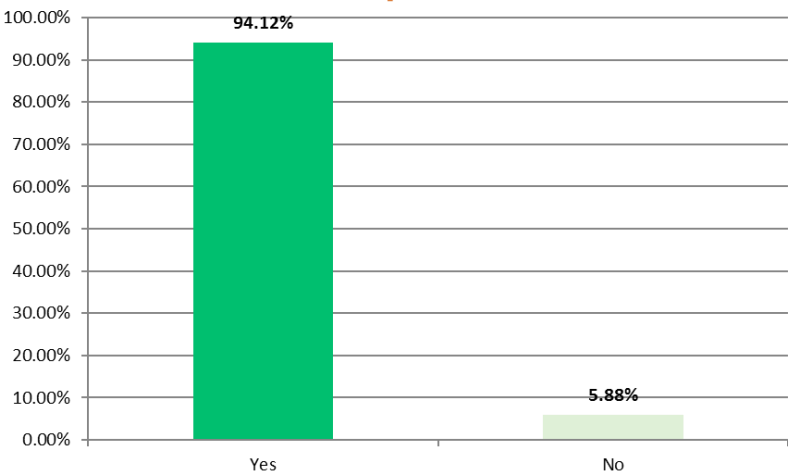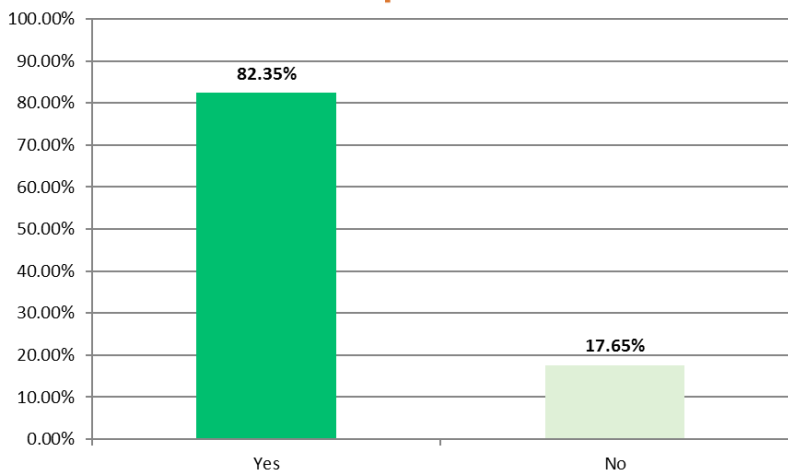
Q45. I was able to complete Scenario 6.
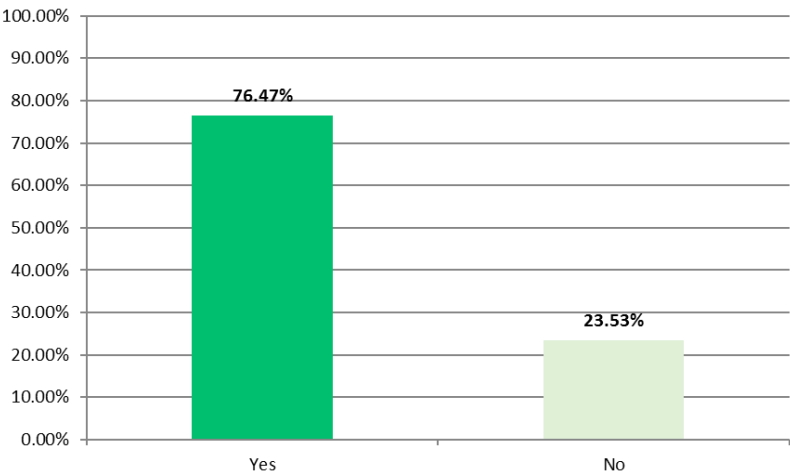
Q46. I was able to complete Scenario 7.
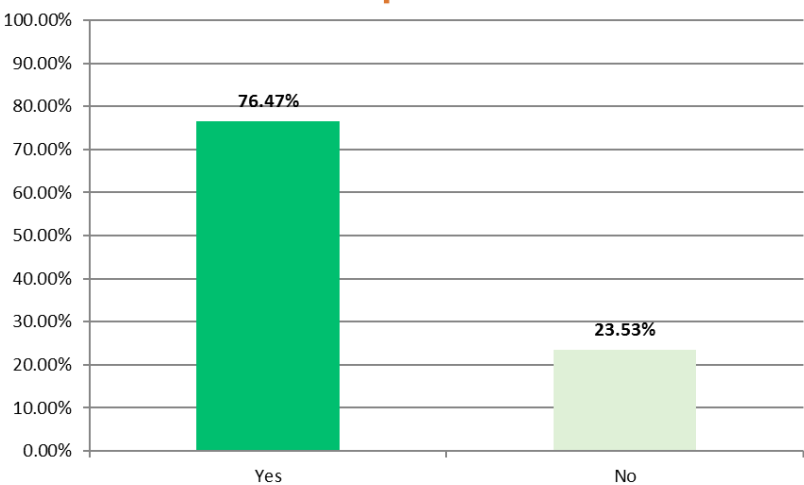
Q47. I was able to complete Scenario 8.

70.59%

29.41%

Yes

No
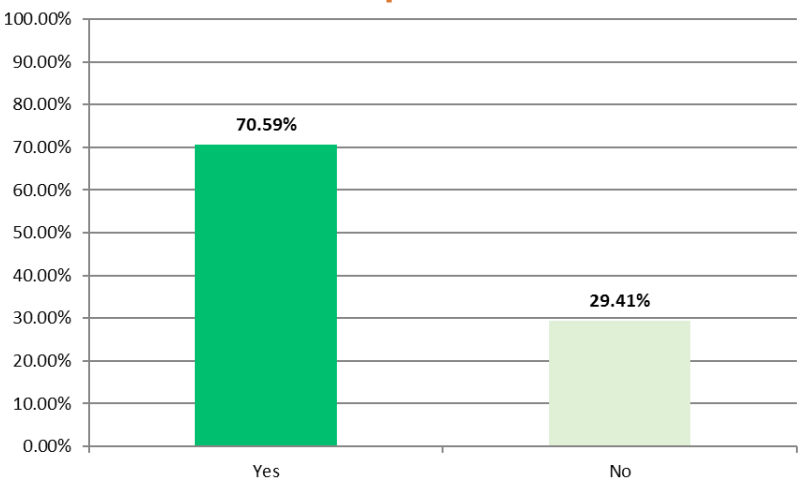
Q48. I was able to complete Scenario 9.

82.35%

17.65%

Yes

No
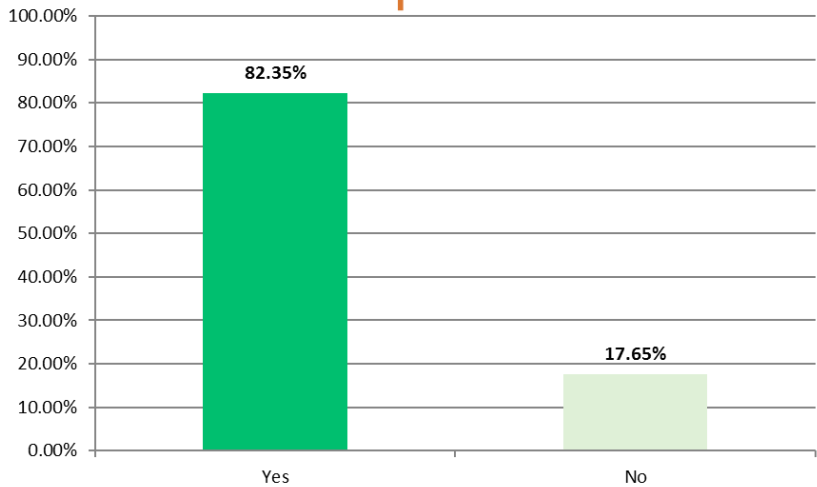
Q49. Did any errors occur while performing the task from Scenario 1?

	Yes	No
	0.00%	100.00%
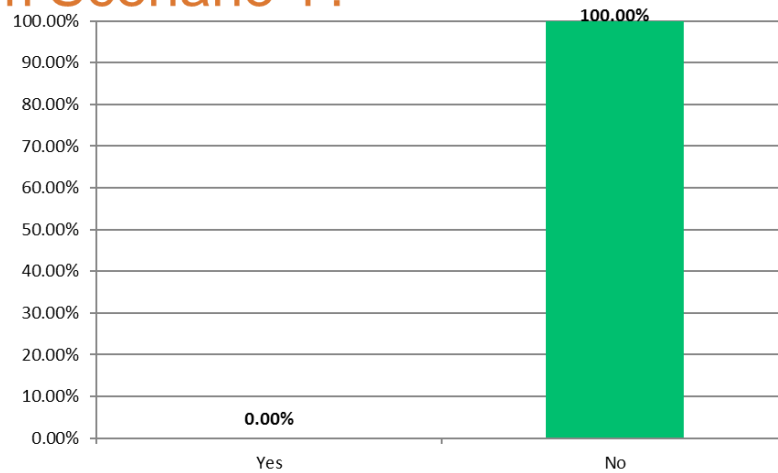
Q50. Did any errors occur while performing the task from Scenario 2?

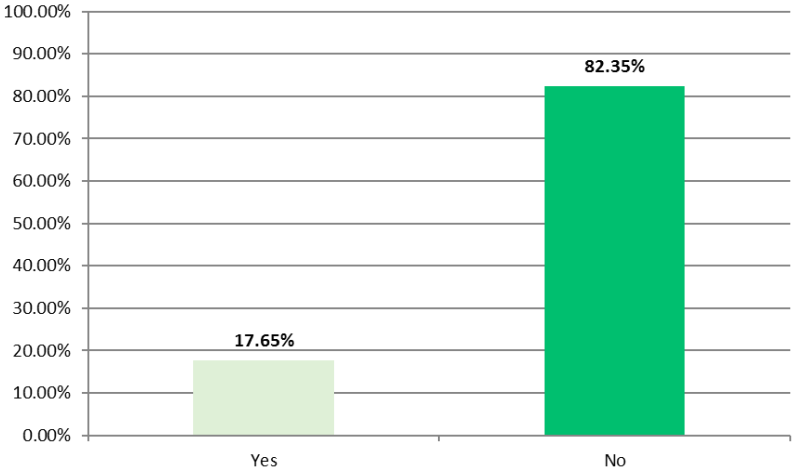|	Yes	No
	5.88%	94.12%
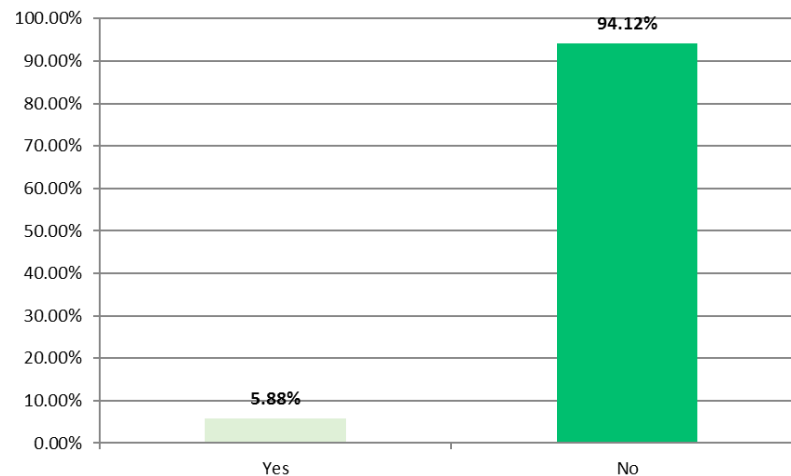
Q51. Did any errors occur while performing the task from Scenario 3?
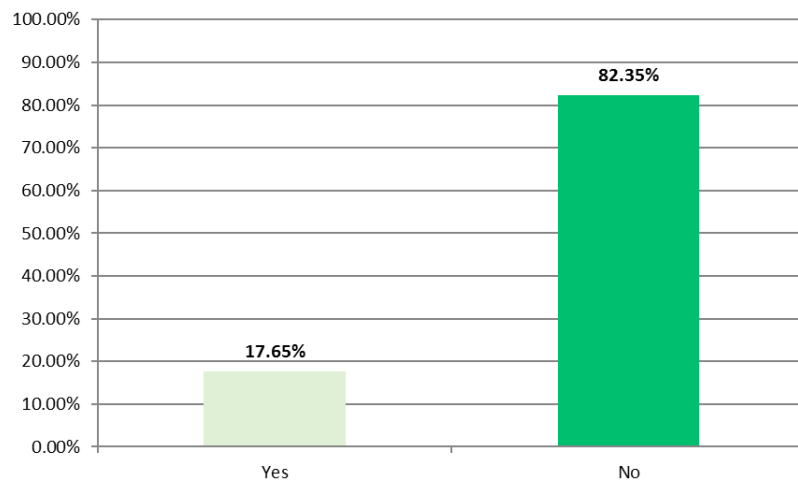
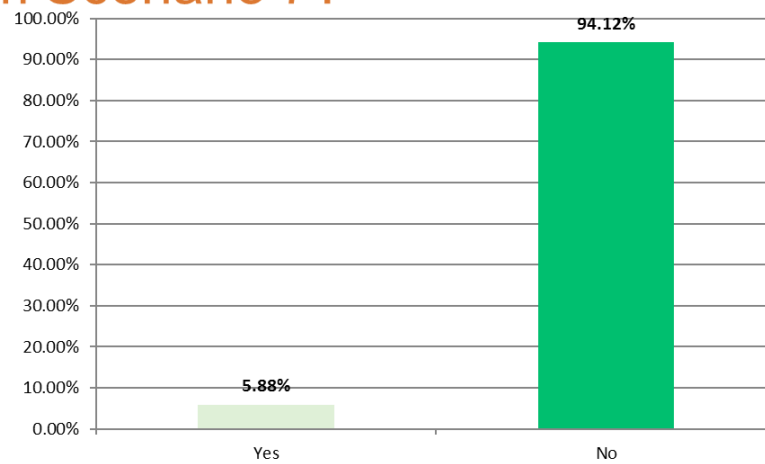## Q52. Did any errors occur while performing the task from Scenario 4?
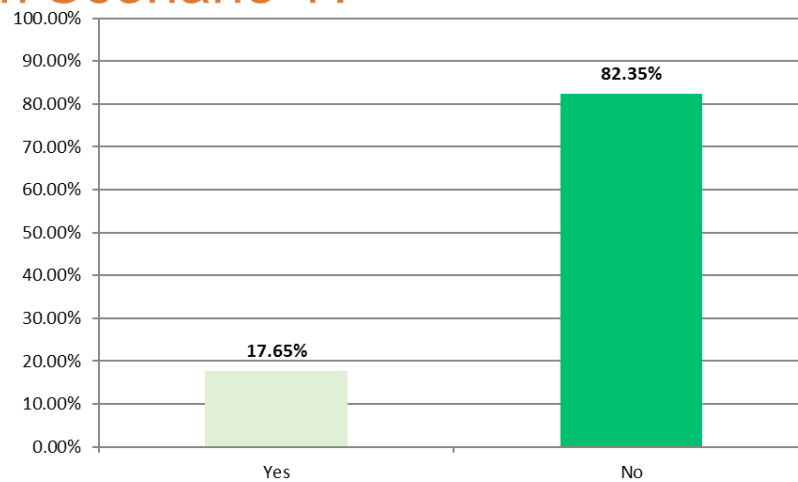
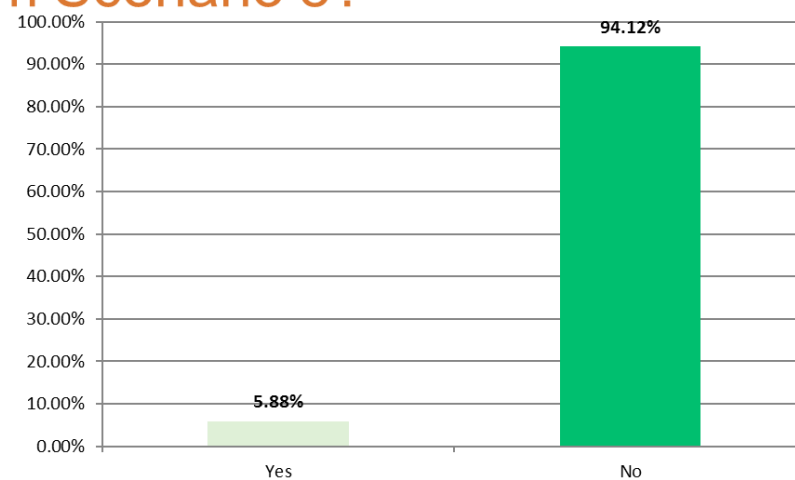## Q53. Did any errors occur while performing the task from Scenario 5?

Yes: 5.88%
No: 94.12%
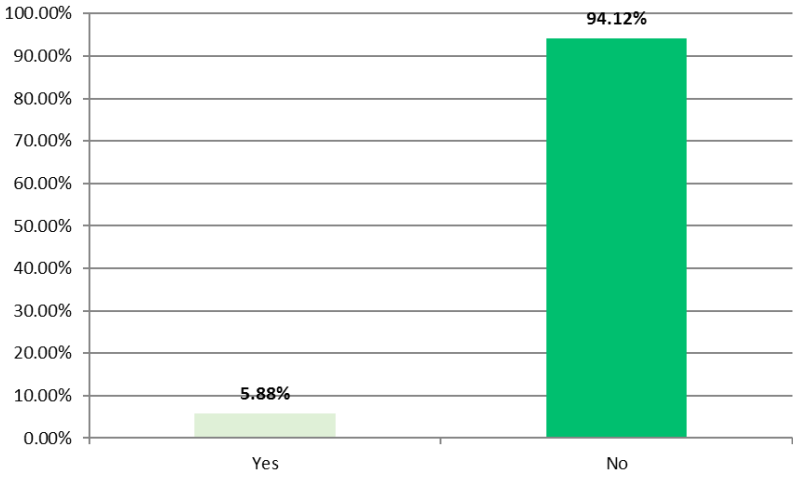
Q54. Did any errors occur while performing the task from Scenario 6?

Yes: 17.65%
No: 82.35%

Q55. Did any errors occur while performing the task from Scenario 7?

Yes: 5.88%
No: 94.12%

Q56. Did any errors occur while performing the task from Scenario 8?


Yes: 5.88%
No: 94.12%

Q57. Did any errors occur while performing the task from Scenario 9?
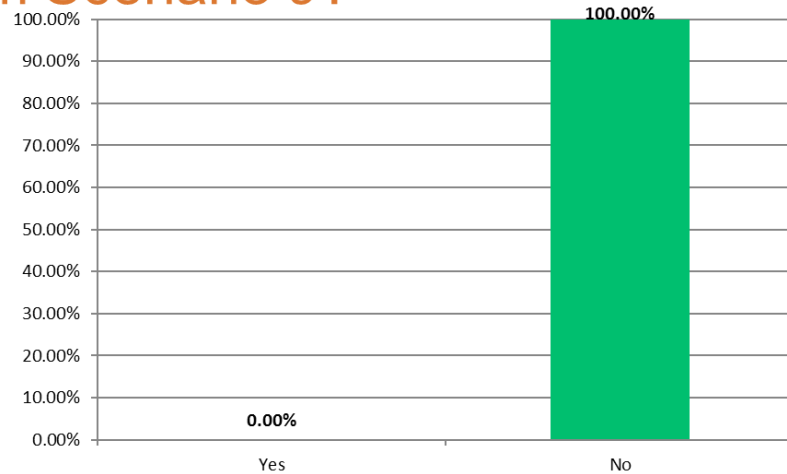
Q58. Do you have any suggestions or comments regarding the errors encountered?

- Problem with the drop down - an open search and repeat use of the same category would be nice.
- Improve the mobile version, as it was difficult to navigate and find the terms on the lists (android).
- Add a search function.
- Don't log me out after I update element on my profile.
- When you enter "Edit Data" it should not log you out if you haven't altered anything. It's inconvenient when you have to log in again immediately after logging in once.
- Organise products to more general groups in search (for example in dairy group, I would expect to find milk, yogurt, cheese, butter).

Q59. Which export option would you prefer?
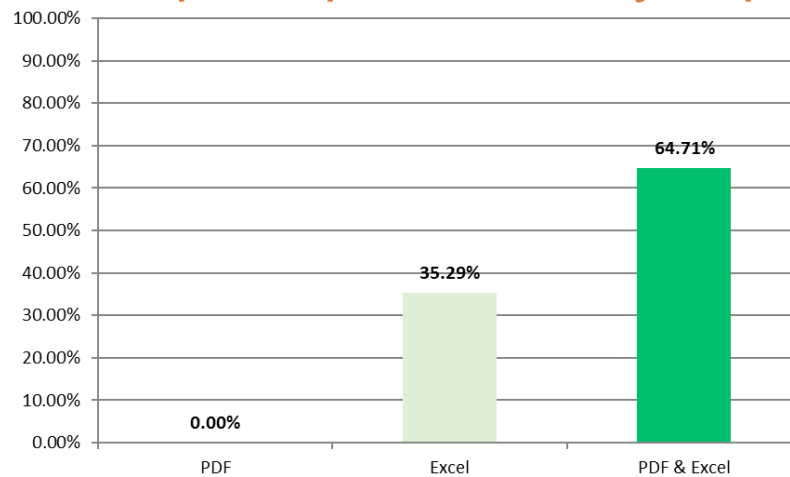
Q60. Do you have any suggestions or comments on how to improve the tool?

- There was ambiguity in several instances. This can be eliminated by having a search field to complement the drop down menu. The drop down menu contains too many items and this is the result of human-created ambiguity, better leave the user the opportunity to disambiguate by adding a search field (text box).
- Add a link to the REFRESH website to find out more about the project.
- When I registered, it took me to an "inactive" token page, even though I had not entered a token.
- Not clear after how much inactivity you are logged out.
- The black text boxes are basic and ugly.
- On the privacy policy page, there are hyperlinks to the mail to but it is not clear whether it will take you there by clicking these.
- Add an obvious home button.
- Why is there an about page link in the top right and bottom left?

- There needs to be a search/go/click button rather than clicking the text in the search bar. The type function in the search bar is ineffective.
- Sorting of products consistently (either by product or process or product group, but not mixed).
- Waste streams are coded inconsistently: some include the source of data, some list the waste product first and then the food, others have food first then the waste making it impossible to search. When clicking on a component group, it filters the table but it is not click it will do this or why.
- Hard to compare the values when all the units are different. Sometimes the components are repeated but with different values, e.g. in scenario 7. When the waste stream has a long name, like the sugar cane leaves (higher...), it makes the search bar too long too which distorts the orientation of the page.
- The waste streams should be listed alphabetically.

- Report should be a proper button rather than just hyperlinked text as it is too discreet.
- Why is the information in the report presented in a different way to the table on the previous page? Why is the report having a weird discreet section in the top left which uses terminology not explained elsewhere, e.g. why are distillers grains a waste stream and the maize a description?
- In cases were for the same food multiple reference sources are provided, giving different amounts of components (for example Ca in orange peel), it would be nice to have some more details on type of food (e.g. origin, etc.) so we can understand were are the differences come from.
- Not obvious there is a second page of information as the button is too small and discreet, could be improved by showing a button of "showing X entries".
- Search bars keep moving and so does the report button.

- The typeface of the excel files are not so clear (e.g. inorganics or proximates).
- The list of waste streams is not always easily understandable. For instance in the case of "Citrus" there are too many options (e.g. citrus peel, pulp) and it is not clear how to differentiate between lemon and orange (peel, pulp etc etc).
- Search function: google-like and tree-based.
- Change abbreviations into full names.
- One standard per component.
- Under "select waste streams" you have sometimes twice or more the same option. What's the difference? - When you hide some information, it still appears in your report.

- It took me a bit of time to work out how to search for specific items. Intuitively, when completing scenario 5 I started looking for orange peel rather than citrus. It might be helpful to add some basic instructions to help users get started. The orange/citrus peel might be a good example showing how some food waste may not be located in the category they initially expect it to be.
- Include a reversed search option: search for a bioactive/mineral/nutrient and provide the list of food waste containing it.
- Difficulties understanding some terms and if they are synonyms (e.g. pomace, bagasse etc.), would it be possible to streamline the terms used? Or offer a glossary?

- Add link to activation page in email with code.
- Standardise units of measure where possible so comparisons can be made.
- Expand compound names as well as chemical symbols.
- Tooltip to learn more about what a datapoint means (eg. pig nitrogen digestibility).
- Add a loading bar on interface when processing.
- Some recommendation on what to do with the waste components would make it more practical, not just the nutrients in it.
- Concentrations should be expressed in standard units where possible, this was a confusing aspect when trying to compare levels of components in a food.
- Ranges should be expressed in one row, rather than having two rows for one component, which I found confusing as it was not expressly stated that it was a range and not two separate values.
- Report should be exportable as a PDF or Excel, or both.

- Food descriptions need to be vastly improved- it was the only thing that would really put me off using this tool. When trying to locate types of wine in the wine section, or types of orange peel, you are met with a multitude of vague leading words that doesn't accurately describe the food type (e.g. Citrus peel being used to describe orange, lemon, lime peel.) A better method would be to lead with the most detailed description, and follow it with the food group (e.g. Mandarin peel, dried > Mandarin peel > Citrus peel). Overall, this tool is quite intriguing and bar the issue with food descriptions, it is very easy to use.
- I think you could add a search engine to add key words. I think the list of food/waste streams is not always very intuitive, which add time for looking and trying.
- I would prefer general groups of products like in food databases.

- Put a home button in the first page when one is navigating to the about, contact, etc.
- Provide more options for area of interest, or make it a text box.
- For organisation type, and organisation name, a text box should be added, as some users are from organisations that are not on the list.
- Do not add items that have no data (users wont feel bad if they aren't aware of the inexistent).