LOWINFOOD

Multi-actor design of low-waste food value chains through the demonstration of innovative solutions to reduce food loss and waste

GA No. 101000439

D5.10 Report on the demonstration of the CozZo application

WP5 - Type of deliverable: Report - Dissemination level: Public - Due date: Dec 31, 2023

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LIST OF PARTNERS THAT HAVE CONTRIBUTED TO PRODUCE/REVISE THE DELIVERABLES

TAU, BOKU, HUA, COZ

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LOWINFOOD Consortium

N.	Full name of the organisation	Short name	Country
1	Università degli Studi della Tuscia	UNITUS	Italy
2	Alma Mater Studiorum Università di Bologna	UNIBO	Italy
3	Sveriges Lantbruksuniversitet	SLU	Sweden
4	FH Munster University of Applied Sciences	ISUN	Germany
5	The James Hutton Institute	JHI	United Kingdom
6	Universitaet Fuer Bodenkultur Wien	BOKU	Austria
7	Tampereen Korkeakoulusaatio SR	TAU	Finland
8	Charokopeio Panepistimio	HUA	Greece
9	Osterreichisches Okologieinstitut	AIE	Austria
10	Elhuyar Fundazioa	ELH	Spain
11	Matomatic AB	MATO	Sweden
12	Unverschwendet GmbH	UNV	Austria
13	Akademie Deutsches Baeckerhandwerknord GGmbH	ADB	Germany
14	Foresightee (terminated on 30/01/2023)	FOR	Belgium
15	Leroma GmbH	LER	Germany
16	Mitakus Analytics UG	MITA	Germany
17	Kitro SA	KITRO	Switzerland
18	Regione Emilia Romagna	RER	Italy
19	Pianeta Cospea srl	PICO	Italy
20	Cogzum Bulgaria OOD	COZ	Bulgaria
21	Uppsala Kommun	UPP	Sweden
22	Recuperiamo srl	REG	Italy
23	Antegon GmbH	FT	Germany
24	Confederazione Nazionale dell'Artigianato e della piccola e media impresa Associazione di Viterbo e Civitavecchia	CAN	Italy
25	Assemblee des Regions Europeennes Fruitieres Legumieres et Horticoles	ARE	France
26	L.V.L Anonymi Emporiki Toyristiki Kksenodoxeiaki Kataskevastiki Etaireia	BLU	Greece
27	Iridanos-Inabelos Anonymi Etaireiatouristikes Ksenodoxeiakes Kai Agrotikes Epixeiriseis	THA	Greece
28	Luonnonvarakeskus (started on 01/11/2023)	LUKE	Finland

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Summary

This deliverable (D5.10) is the tenth deliverable of WP5 in the LOWINFOOD project. The deliverable presents the results of task 5.5, where the objective has been to develop the CozZo application further through scientific research conducted on households in Austria, Finland and Greece. The CozZo application – currently available for iOS users only – is a holistic kitchen management application for households that helps to avoid spoilage of food, over-purchasing and over-cooking by optimising the purchase of food supplies and cooking planning. A total of 52 households in Austria, Finland and Greece used the application for a period of 3–6 weeks. This deliverable starts by introducing the CozZo application, followed by outlining the methodology used in the study. Then, the outcomes of the demonstration phase are presented, for example, the effects on food waste amounts as well as perceived strengths and challenges of using the app. Finally, the final chapters present learnings and recommendations for the future as well as conclusions drawn from the study.

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Introduction to the deliverable

LOWINFOOD is a project committed to co-design, together with actors of the food chain, low-waste value chains by supporting the demonstration of a portfolio of innovations in a set of value chains particularly concerned by food loss and waste (fruits & vegetables, bakery products and fish), as well as in at-home and out-of-home consumption. Each of these value chains corresponds to a single Work Package (WP) of the project.

The innovations are selected among promising solutions that have already been developed and tested by some partners of the consortium, with the aim to provide the necessary demonstration and upscale to allow market replication.

The LOWINFOOD consortium comprises 27 entities, located in 12 different countries, and ranging from universities and research institutes to start-ups, foundations, associations, and companies working in the food sector. During the 52 months of the project, the partners are committed to complete 30 tasks and to deliver 60 outputs (deliverables).

This deliverable (D5.10) is part of WP5, which is dedicated to reducing food waste within household and food service consumption settings. Specifically, D5.10 is connected to task 5.5 (T5.5) which aims to develop the CozZo application further through scientific research conducted on households. D5.10 presents the outcomes of the demonstration of the CozZo application in households in three countries (Austria, Finland, and Greece) in April 2022 – September 2023. As outlined in the methodology chapter of this deliverable, two approaches were used in the demonstration of the application – one developed for regular households, the other for student households. Depending on the approach, the participating households (52 in total) used the application either for at least three weeks or at least six weeks. The households' avoidable food waste was measured and sorted before and at the end of this demonstration period. D5.10 focuses on reporting the outcomes of the demonstration period (for example, effects of the demonstration on the amount food waste, use of the app, and perceived effectiveness and usefulness) as well as the strengths and challenges of using the app based on user experiences. Furthermore, based on the outcomes of the app demonstration in households, learnings and recommendations regarding this or similar mobile apps' development in the future will be discussed. The deliverable ends with conclusions drawn from the study.

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1. Introduction to the CozZo mobile application

According to food waste statistics, households are major contributors to food waste (UNEP Food waste index report, 2021). However, the problem is multifaceted, as wasting food is an outcome of several intersecting and interconnected everyday practices. These practices include planning for food purchases, shopping groceries, cooking and provisioning, storing food, as well as managing leftovers and surplus (Principato et al., 2021; Sirola et al., 2019; Stancu et al., 2016). For example, household members might not be aware of the items they currently have in their cupboards, fridge, and freezer, and as a result, end up over-buying items. Furthermore, planning of what to cook and when also has a role in food waste, as well as inefficient use of meal leftovers.

CozZo mobile application is a holistic kitchen management app for households that assist in avoiding spoiled food and making optimal grocery shopping and cooking planning. The app was created by Ivo Dimitrov, a software engineer, frustrated by the amount of food that got spoiled and wasted in his own household. CozZo's beta version was launched on the UK market in 2017. A study of UK residents published by the Institute of Grocery Distribution found that one in five would like to have food waste reduction technology for their homes (IGD, 2017).

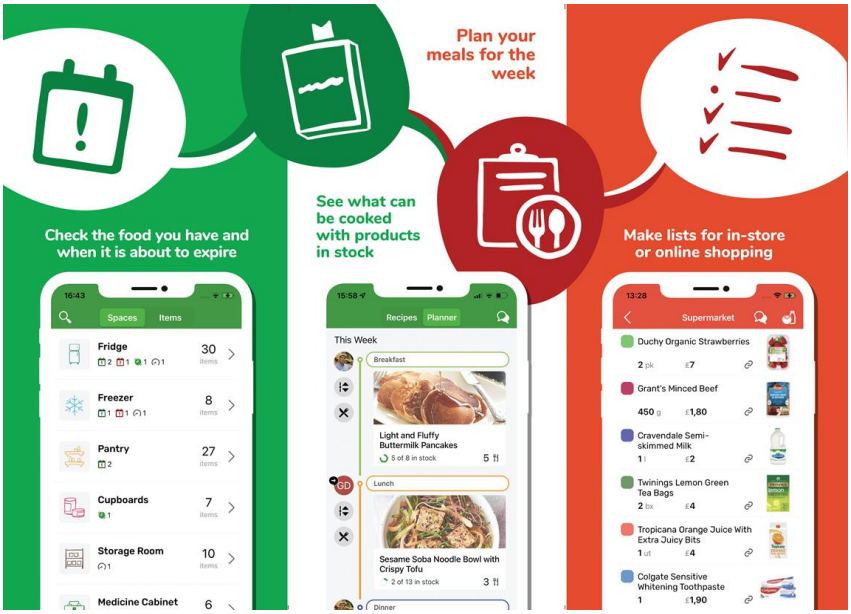

Figure 1 – Promotional material on the main features of CozZo

CozZo mobile application combines a digital shopping list with a proactive home catalogue (see Figure 1). It helps users to buy the needed products in the right quantity, to know what expires today or tomorrow and to see what their actual food waste level is. It enables shoppers to save time and money by planning their meals to avoid food from becoming spoiled and by being efficient in grocery shopping and inventory management. As part of deliverable D5.1 of LOWINFOOD project, a video has been produced that introduces CozZo mobile application (see https://lowinfood.eu/resources/videos/).

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To describe the main features of the CozZo app, the users should first assign their current food items into various 'Spaces' on the app (such as freezer, fridge, or pantry). When entering items into the app's inventory, the app automatically estimates an expiry date for the item, or the user can manually enter a specific date. Then, as these items are used or new items are bought into the household, the inventory should be updated on the app. As the items move closer to their expected expiry dates, the app sends the users reminders about soon-to-be expired items and suggests recipes that use these ingredients. Also, the users can search for recipes that suit their current inventory.

During the LOWINFOOD project, the app was demonstrated with users from Austria, Finland, and Greece. In Austria, the app was available before LOWINFOOD project, but in Finland and Greece, the app was introduced at the market during the project. During the demonstration, in Austria the app was fully available in German, whereas in Finland and Greece only the product catalogues were available in native language.

In order to develop the app further, the application has been improved in several ways. The following lists the features that have been added or modified in the CozZo application during the LOWINFOOD project.

Recipes

- Recipe finder: The users can search in half a million recipes, sourced from various cooking websites using keywords, time, cuisine, diet, and intolerances filters.
- Recipe scaling: The users can change the serving size of saved recipes to match their cooking plans. CozZo remembers your last setting for each recipe.
- Recipe matching: CozZo AI matches recipe ingredients instantly to products the user has in stock. Whatever language the imported recipe is in, CozZo can match it to the products in the user's inventories.
- Shop Recipe: Missing ingredients that are not already on a list can be selected and added quickly to a shopping list.

Weekly meal planner

- The users can plan breakfasts, lunches, or dinners for the week or for a particular day using recipes from their cookbooks or homemade ones.
- Leftovers Planning and Tracking: The users can add leftovers to their meal planners from dishes that are not eaten up. CozZo will add them automatically to their inventories and track freshness.

Smart multi-receipt reader

- CozZo receipt reader extracts accurately purchased items from up to 5 receipts at once in a matter of seconds. All household members can snap photos of the grocery receipts as they shop and CozZo will save them to all devices in their account.

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- CozZo automatically discards most non-product texts and replaces abbreviations to ensure the product names are easily readable and meaningful. Users can “blacklist” specific items to be automatically discarded henceforth.

My Kitchen dashboards

- ‘Cook Expiring Products’ meal ideas board identifies recipes from user’s collections that use products at the end of their shelf life.
- Recipe ideas board gives the first-time users an easy way to pick a recipe.
- Recently saved recipes board helps users to find the latest recipes.

Delivery & Online Shopping

- Online shopping assistant allows users to browse products in online stores directly from CozZo’s shopping lists. The user selects a retailer and CozZo runs an automated step-by-step search for items on their shopping list.
- The ‘Pending Delivery’ function allows the users to move their online purchases to ‘At Home’ without being expiry tracked or matched to recipes until the delivery date.
- ‘On Order’ Inventory displays items that are pending delivery and the retailer they have been purchased from.

Integrated Messaging

- Shopping list messaging allows users to coordinate shopping with preset messages and a dedicated chat room.
- Meal planner messaging allows families to discuss meal plans for the week.
- Active chats board show recent messages.

Localization

- Full localization in German language
- Translation of product catalogues to Finnish and Greek languages.

Other improvements

- Product price calculator allows the users to set a fair price for products bought regularly in their household. The price can be specified in weight/volume, product units or package size.
- Expanded view for lists and spaces shows product photos.
- Default shopping list
- Performance and stability

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2. Methodology

Overview of methodological approach

Demonstration of the CozZo application was conducted in three different countries (Austria, Finland, and Greece) by using two approaches – the household approach (see Figure 2) and the student approach (see Figure 3).

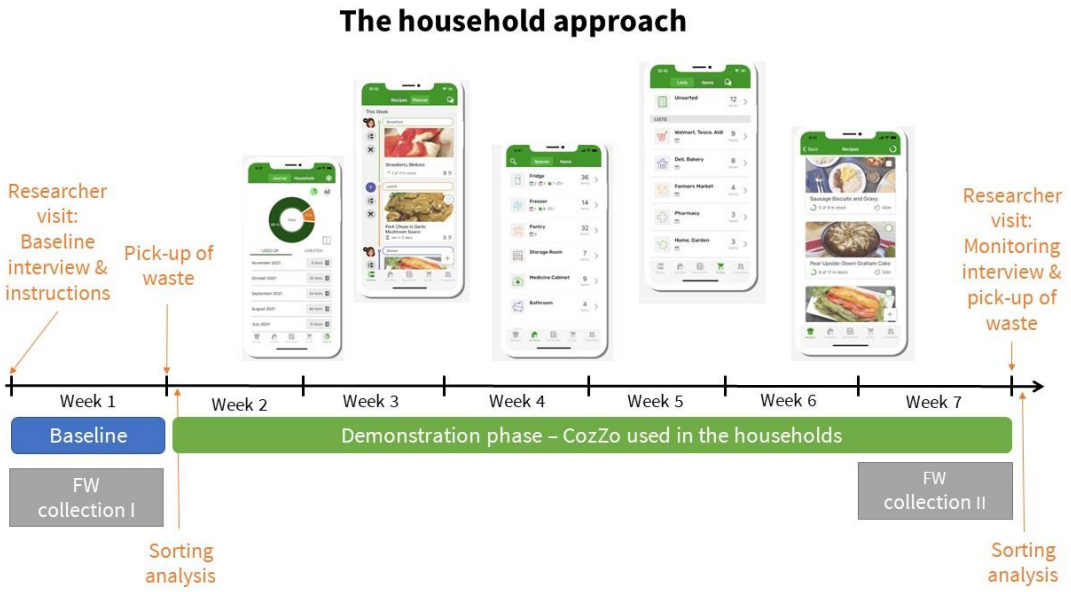

Figure 2 – The household approach in the CozZo demonstration

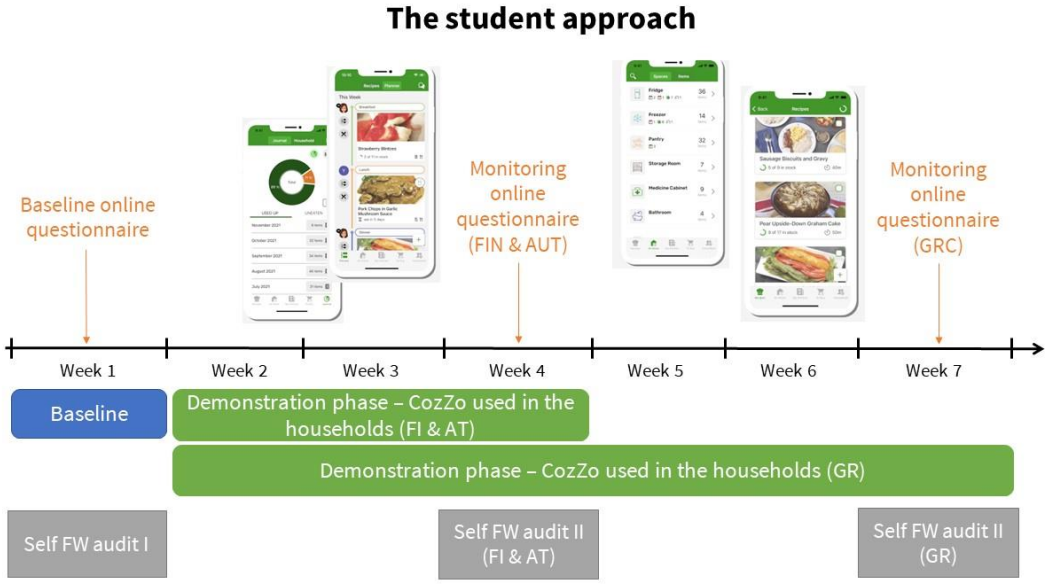

Figure 3 – The student approach in the CozZo demonstration

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Both approaches consisted of one week of baseline phase, when the food waste amounts were collected by the participants, followed by the demonstration phase, where the CozZo mobile application was used for at least three weeks (for student households in Austria and Finland) or six weeks (for all regular households in all countries and student households in Greece). The detailed description of the pre-demonstration (i.e., baseline) and the demonstration phase will be discussed in later sections.

Recruitment process of the users

During the demonstration period, the CozZo mobile application was available only for iOS devices, therefore the possession of an iOS device in the household was the primary criteria for participating in the study. In the beginning of 2022 when the recruitment of households started, the share of iOS users was about 40 percent in Austria, about 38 percent in Finland, and about 17 percent in Greece (Statcounter, 2023). Therefore, especially in Greece, the starting point for recruiting iOS users seemed challenging. Furthermore, in all countries, the recruitment started right after Covid-19 measures (e.g., lockdowns), which had an impact on the willingness of households to participate in a study where visits to households are necessary. In addition, for the demonstration to provide as accurate results as possible, it was considered necessary to delay the demonstration until households' living circumstances (including shopping and working schedules) had returned to closer to pre-Covid times. Due to these challenges in household recruitment, incentives for participating in the demonstration were used. Altogether, 52 households in Austria, Finland and Greece completed the demonstration.

The methods for recruiting the households for the demonstration of the CozZo application differed across the three countries. In Austria, the regular households were recruited utilising BOKU's website and social media accounts from ABF-BOKU and BOKU-University (also using paid social media commercials to reach more potential participants), distributing flyers to households by hand (500 pieces) and by mail (2,500 pieces), placing a paid advertisement in a regional newspaper, and, finally, utilising BOKU's existing contacts with households. The regular households were given an incentive worth 50 euros for participating in the study. 13 regular households completed the baseline phase, but 5 households dropped out during the demonstration phase (dropout rate: 38.5%). Thus, a total of 8 regular households completed the study in Austria. The student households in Austria were recruited from a lecture on a course called Human Ecology in BOKU. Participation in the demonstration phase was part of the term project and constituted a requirement for the passing of this class, valued at 3 ECTS. Baseline phase was completed by 21 students, but 10 students dropped out in the demonstration phase (dropout rate: 47.6%). Thus, a total of 11 students completed the study in Austria.

In Finland, regular households were recruited through purposive sampling utilising TAU's website, social media account of the research group, relevant local social media groups (e.g., neighbourhood Facebook groups and Facebook groups focusing on food waste reduction)

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as well as TAU researchers' existing contacts with households. The baseline phase was completed by 17 regular households, but 3 of them dropped out during the demonstration phase (dropout rate: 17.6%). Thus, 14 regular households completed the study in Finland. Households for the student approach in Finland were recruited through TAU's Intranet. The students in Finland were given an incentive of two movie ticket vouchers if they complete the study (value approx. 25 euros). 5 students completed the baseline phase, with one student dropping out in the demonstration phase (dropout rate: 20%). Thus, 4 students in total completed the study in Finland.

In Greece, the regular households were recruited through purposive sampling utilising HUA's contacts with households, the email list of the academic community, Facebook groups related to the four Departments of HUA, as well as Facebook groups focusing on the zero-food waste movement. In total 14 households volunteered to participate in the demonstration of the CozZo application, but 3 of these dropped out during or after the baseline phase (dropout rate: 21.4%). Thus, 11 regular households completed the study in Greece. To attract more participants, in June 2022, a participation call was issued to approximately 3,500 students at HUA, offering an economic incentive of 259 euros per participant from HUA's own funds. Surprisingly, only one participant responded to the call. Therefore, the call was cancelled. In the next semester, starting October 2022, the households for the student approach in Greece were recruited among students of two courses, "Environmental Management" and "Circular Economy", within the Department of Geography. An incentive was provided as follows: participation in the demonstration phase was voluntary and constituted an additional coursework for both courses. Completing this additional coursework provided the students with an extra 20% on the grade they achieved by the compulsory part of their coursework. To provide a fair grading system, the option for this additional coursework and its "bonus" contribution in their evaluation, was offered to all students and not only to iOs appliances owners, following the same approach as in Austria and Finland (see *Pre-demonstration phase*). Initially, 7 students started the baseline phase for the CozZo app, but 3 of them dropped out during or after it (dropout rate: 42.9%). Thus, a total of 4 students completed the study in Greece.

All participating households in all three countries received a free annual subscription of CozZo Household account (value approx. 23 euros). The Household account unlocked all features of the app, making full demonstration of the app possible.

Demographics of the users

The number of households in each approach of the final sample is outlined in Table 1, whereas the demographics of the final sample of households in all three countries are detailed in Table 2.

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Table 1 – The number of households in each approach and country

	Austria (n=19)	Finland (n=18)	Greece (n=15)	Total (n=52)
Household approach	8	14	11	33
Student approach	11	4	4	19

Table 2 – The demographics of the households

	Austria (n=19)	Finland (n=18)	Greece (n=15)	Total (n=52)
Household composition (% of households)				
single households	31.6	16.7	20.0	22.8
two-adult households (without children)	36.8	27.8	33.3	32.6
households with children	10.5	50.0	33.3	31.3
other	21.1	5.5	13.4	13.3
Household total net income (% of households)				
< 1.000 e/month	10.5	16.7	13.3	13.5
1.000 e – 1.999 e/month	36.8	5.6	13.3	18.6
2.000 e – 2.999 e/month	15.8	11.1	13.3	13.4
3.000 e – 3.999 e/month	0.0	11.1	13.3	8.1
4.000 e – 4.999 e/month	15.8	5.6	6.7	9.4
5.000 e – 5.999 e/month	0.0	11.1	20.0	10.4
6.000 e – 6.999 e/month	0.0	16.7	6.7	7.8
7.000 e – 7.999 e/month	5.3	11.1	0.0	5.5
Prefer not to say	15.8	11.1	13.3	13.4
Age (% of household managers)				
18–24 years	52.6	22.2	33.3	36.0
25–34 years	42.1	5.6	0.0	15.9
35–44 years	5.3	50.0	13.3	22.9
45–54 years	0.0	11.1	33.3	14.8
55–64 years	0.0	0.0	13.3	4.4
65–years or older	0.0	11.1	6.7	5.9

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	Austria (n=19)	Finland (n=18)	Greece (n=15)	Total (n=52)
Education (% of household managers)				
High school	57.9	0.0	6.7	21.5
Trade/technical/vocational training	0.0	5.6	13.3	6.3
Undergraduate degree (bachelors)	31.6	44.4	46.7	40.9
Postgraduate degree (master's or higher)	10.5	50.0	33.3	31.3

Pre-demonstration phase

For regular households (see Figure 2), in the pre-demonstration (i.e., the baseline) phase, the researchers first visited each household and conducted an interview with the household manager (see Appendix 1). By household manager we refer to the person who was in charge or partly in charge of food management as well as the CozZo demonstration in the household. In addition, a shortened questionnaire (see Appendix 2) was distributed to other household members over 16 years of age that participated in the demonstration (that would most likely also use the CozZo mobile application). The questionnaires were filled in either on paper or digitally via tablet computers or the participant's own mobile devices. Furthermore, the households were provided with bins where the avoidable food waste was to be collected as well as detailed instructions for how to collect the waste.

The households were instructed to separately collect all types of avoidable food waste, i.e., anything that would have been edible but was not consumed due to spoilage (e.g., inappropriate storage conditions, not consumed in time) or any other reason (e.g., personal preference, impulsive purchases). Parts of food that are removed during preparation of food for eating or for cooking (so called preparation waste), such as peels, bones, or eggshells, were asked not to be collected in the bin. Beverages, soups, or other liquid food were asked to be collected, but in a separate bin to facilitate separation and recognition of waste. For packaged products, participants were instructed to collect contents and packaging in order to facilitate handling and identification during a later waste sorting analysis. The households then collected their avoidable food waste for a period of 7 days. The CozZo application was not used in the households during this pre-demonstration phase.

After the baseline measurement week, the researchers collected the bins from the households (once per week in Austria and Finland, twice per week in Greece). As soon as possible after this, the researchers conducted a waste sorting analysis. In the analysis, the researchers sorted and weighed the waste for each household and took photos of the waste. An Excel sheet was jointly developed to help researchers with the sorting analysis. The sheet outlines the weighing and sorting procedure as well as directs how to sort the waste into categories. The sheet also provided a list of equipment needed for the researchers to

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conduct the sorting analysis (e.g., FFP2/3 masks, gloves, protective glasses, scale). The researchers entered the results of the analysis into the Excel sheet.

In the student approach (see Figure 3), the implementation of the pre-demonstration phase was somewhat different in each of the three countries. In Austria, first a cooperation was established with the lecturers of the course Human Ecology at BOKU university. For many years, this class has been featuring term projects where the students are required to participate in experiments focusing on ecological sustainability. Testing a mobile application to reduce food waste was the initial idea for the experiments in summer term 2022. An introductory presentation about the project was held during a regular lecture of the course. The students could choose between three groups: (1) testing the CozZo mobile application, (2) testing another similar mobile application that runs also on Android devices (the Nosh App was identified as suitable), and (3) making a photo documentation of their food wastage in the same period.[1] The third group acted as the comparison group. The students were responsible for food waste collection and audit in both measurement periods, for baseline and demonstration phase, giving feedback via an extensive online survey. During the initial presentation, students were given general information about the project, about the app in particular, and about the effort required to achieve a passing grade. Also, information and materials on how to perform the self-waste audits were provided.

In Finland, the students were recruited to a study to test a mobile application to reduce food waste. Those who volunteered to participate were given a choice to use either the CozZo app (iOS users) or Nosh App (Android users). Week-by-week instructions for participation, including instructions for the self-waste audit were given online in TAU's Moodle group that was created solely for the purpose of the study (restricted entry only to study participants). The links to the baseline online questionnaires were also provided in the group. The participants returned their self-waste audit Excel sheets as well as the photos taken of their audit through the Moodle platform.

In Greece, a strategy similar to the ones implemented in Austria and Finland was adopted. Specifically, participation in the CozZo app demonstration became an optional assignment within two courses: "Environmental Management" and "Circular Economy", offered by the Department of Geography at HUA. These courses typically involve term assignments and exams. An introductory presentation about the LOWINFOOD project was conducted during a regular lecture within these courses. During this presentation, students received comprehensive information about the project in general, with special focus on the CozZo app demonstration and the relevant assignment. Students were given the choice to test either the CozZo app (for iOS devices) or the Nosh app (for Android devices). In case they could not have access to either app, they could take photos of their waste instead. However, no student selected this option. In both cases, students were responsible for waste collection and sorting during both the baseline and demonstration phases, while providing feedback

[1] However, only the results of the CozZo demonstration are reported here.

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through surveys. Proper guidelines for food waste sorting were given to students prior to the baseline phase and during the whole demonstration phase, both in class and the courses' E-class.

In all three countries, the student households performed the food waste audit by themselves, i.e., weighing, sorting, and photographing their avoidable food waste every day for a period of 7 days. As with regular households, the students were directed to collect the waste they produced at their household, thus excluding the waste they might have produced when eating out. The students were given similar instructions for collecting avoidable waste as the regular households, i.e., to collect anything that would have been edible but was not consumed due to spoilage (e.g., inappropriate storage conditions, not consumed in time) or any other reason (e.g., personal preference, impulsive purchases). Parts of food that are removed during preparation of food for eating or for cooking (so called preparation waste), such as peels, bones, or eggshells, were asked not to be collected. The students then entered the results of their self-waste audit to an Excel sheet provided by the LOWINFOOD researchers.

For both regular and student households, the baseline waste collection period was scheduled and instructed so that public holidays (such as Easter time) were avoided. The timing of the pre-demonstration phase varied between the three countries (see Table 3). Due to the difficulties in recruiting enough households at the same time, the timing of the pre-demonstration differed in some countries. This was necessary in order not to delay the start of this phase for the households that had already agreed to participate in the demonstration.

Table 3 – Timing of the pre-demonstration phase

	Austria (month/year)	Finland (month/year)	Greece (month/year)
Pre-demonstration in regular households	05/22, 09–10/22, 03/23	03–05/22	05–06/22, 04–06/23
Pre-demonstration in student households	03–04/22	02–05/23	12/22–01/23

Demonstration phase

In the demonstration phase, all households were instructed to use the CozZo app as part of their daily household routines. All participants that would test the app were given access to the Household account of the app, unlocking all the features of the app. The households were not given any specific training or guidance on how to use the app and were not directed as to what features or functions they should use. Rather, the households could explore the app and use the functions that they were interested in or found useful. The households were given the opportunity to contact customer services of CozZo or the researchers in case they had any questions during the demonstration. In total, 12 households contacted either

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LOWINFOOD researchers or CozZo customer support about issues related to the use of the CozZo app.

For regular households (see Figure 2), the demonstration phase lasted for at least six weeks in all countries. Due to practical household-driven reasons, some households did not start to use the app immediately after the pre-demonstration phase and thus, for them, the time between pre-demonstration and demonstration phases was longer. During the final (usually the sixth) week of the demonstration phase, the households were instructed to follow the same food waste collection guidelines as in the pre-demonstration phase. Buckets for this phase were provided already during the earlier researcher visits or waste pick-ups in the pre-demonstration phase. The collection period for the waste was again 7 consecutive days. Like in the pre-demonstration phase, the waste bins were picked up by the researchers either once (in Austria and Finland) or twice per week (in Greece). The waste collection period was followed by a research team visit to the household (also including a pick-up of the waste bin). On this visit, a personal interview for the household manager (see Appendix 3) was conducted. Quantitative answers to the household manager interview were recorded via tablet computer, whereas qualitative statements were audio recorded and later transcribed. The other participants were given either paper questionnaires to fill in or a possibility (a link) to an online questionnaire (see Appendix 4). After collection of the waste bins, a similar sorting analysis was conducted by the researchers as in the pre-demonstration phase.

In the student approach (see Figure 3), the implementation of the demonstration phase was somewhat different in each of the three countries. The demonstration period for students was at least 3 weeks in Austria and Finland and at least 6 weeks in Greece. Students in Finland and Austria were asked to take at least one screenshot of their CozZo application per week during the demonstration phase to prove that they have been using the app. In the final week of the demonstration period, participants in each country were asked to collect, sort, weigh and report their avoidable food waste for 7 consecutive days according to the same procedure they had followed during the baseline. The data of this self-waste audit was provided in the form of Excel sheets to the researchers. In Finland, students were also asked to take photos of their food waste. Those photos were also provided to the researchers. During this week, they were also instructed to fill in an online survey (see Appendix 3). In Finland, CozZo users additionally participated in an online group or personal interview (length approx. 30 minutes), where user experiences related to using the CozZo app were further elaborated. These interviews were recorded and transcribed. In Austria and Greece, only the online survey was used to receive feedback from participants.

For both regular and student households, the monitoring waste collection period was scheduled and instructed so that public holidays (such as Easter time) were avoided. The timing of the demonstration phase varied between the three countries (see Table 4).

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Table 4 – Timing of the demonstration phase

	Austria (month/year)	Finland (month/year)	Greece (month/year)
Demonstration in regular households	07/22, 11/22, 01–02/23, 09/23	05–06/22, 09–10/22	06–07/22, 05–07/23
Demonstration in student households	04–05/22	04–06/23	01–02/23

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3. Outcomes of the demonstration phase

In the following sections, the outcomes of the demonstration phase are presented. First, in order to evaluate how well the app was integrated into the daily lives of users during the demonstration period, the results on the frequency of app use are presented. After that, we will present the results based on the food waste audits, regarding the effects of the demonstration on the food waste amounts, followed by user perceived efficiency and usefulness. After this, the perceived strengths and challenges of using the app will be presented.

App use

In the monitoring questionnaires (see Appendices 3 and 4), all the users of the app[2] were requested to indicate how often did they use the CozZo application during the demonstration period. In the total sample, 40% of the users stated having used the app 'less than once a week', 31% stating '1–2 times a week', 22% stating 3–5 times a week', while only 2% stating 'once a day' and 4% stating 'several times a day'. Figure 4 outlines the distribution of the replies country-by-country.

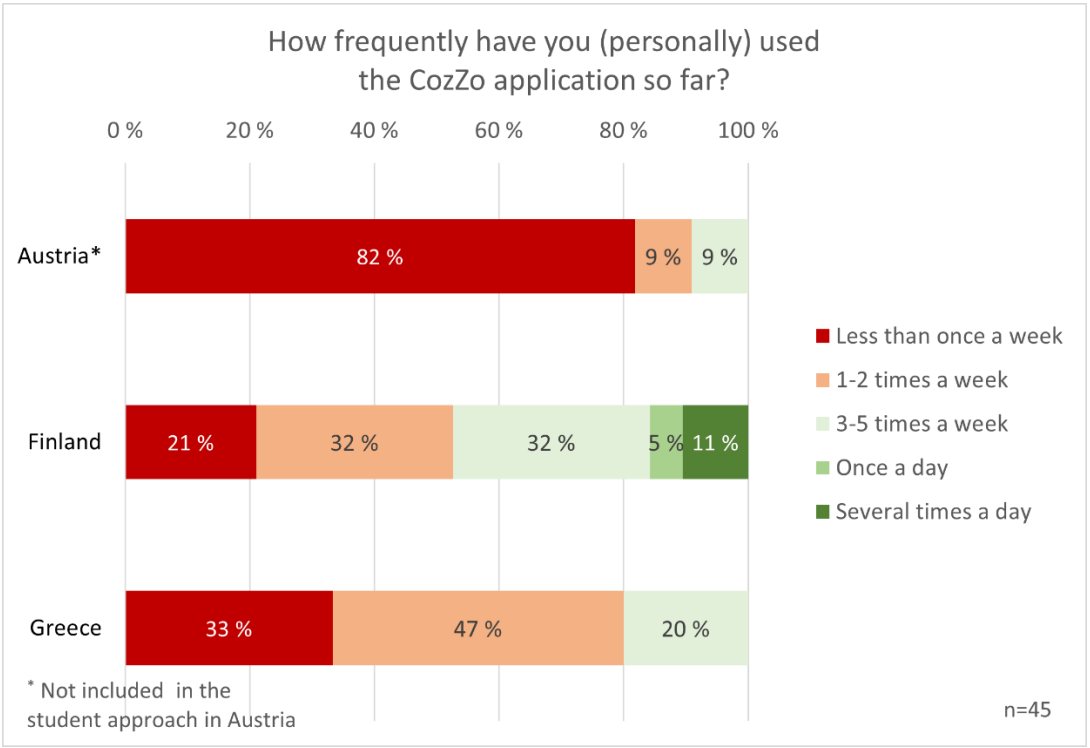

Figure 4 – Frequency of app use during the demonstration phase

[2] This question, however, was not included in the student approach in Austria. In addition to household manager responses (n=41), four responses were collected from other users.

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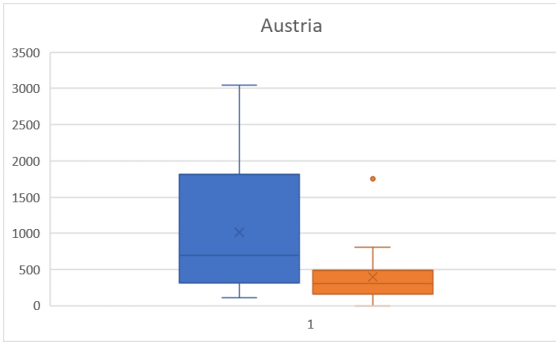
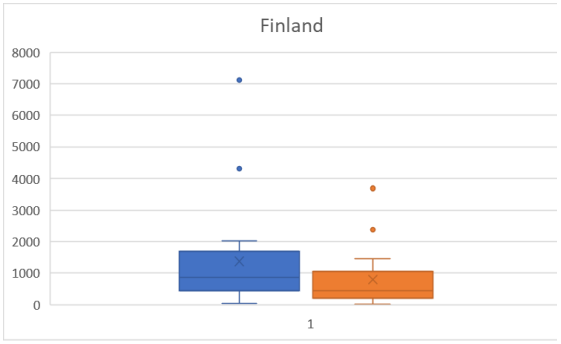
The users in Finland used the application most frequently, followed by Greek and Austrian users. Less than every fifth user (18%) in Austria had used the app at least once a week, and a majority (82%) used it less than once a week. In Finland, the distribution between the replies varied the most, and there were also some users (16%) who reported using the app at least once a day. In Greece, a majority (67%) had used the app at least once a week, while, similarly to Austria, none of them reported having used the app daily.

Effectiveness regarding amount of food waste

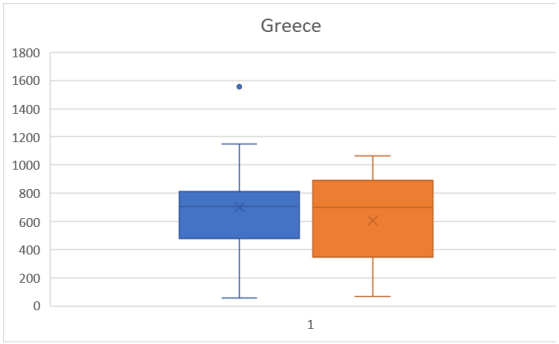
For the statistical analysis of the food waste quantities, a two-sample t-test with dependent samples (paired comparison test) was conducted with the data collected in the pre-demonstration and the demonstration phase (see Figure 5).



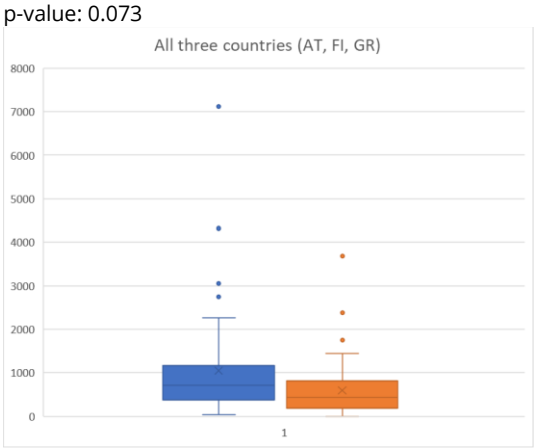
No. of observations: 19
Mean value: 1,015 g/HH (baseline), 398 g/HH (demonstration)
Reduction potential: 61%
p-value: 0.002



No. of observations: 18
Mean value: 1,374 g/HH (baseline), 794 g/HH (demonstration)
Reduction potential: 42%
p-value: 0.073



No. of observations: 15
Mean value: 702 g/HH (baseline), 605 g/HH (demonstration)
Reduction potential: 14%
p-value: 0.106



No. of observations: 52
Mean value: 1,049 g/HH (baseline), 594 g/HH (demonstration)
Reduction potential: 43%
p-value: 0.002

Figure 5 – Food waste quantities in g/HH for the pre-demonstration (blue) and the demonstration phase (orange) for each country and in total

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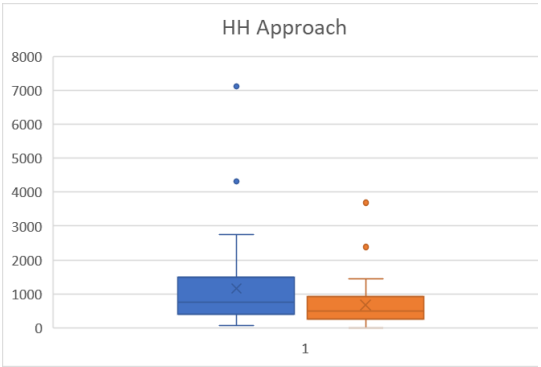
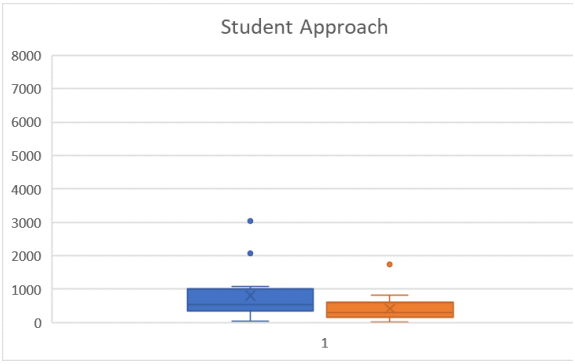
Figure 5 shows boxplot diagrams for each country (Austria, Finland, and Greece) and for all countries together. In all countries, a decrease of the food waste amounts in the demonstration phase compared to the pre-demonstration can be observed. The results of the t-test showed that the difference between pre-demonstration and demonstration was statistically significant across all participants. A reduction potential of 43% was achieved.

At country level, the difference is significant for Austria. In Finland, there are three households that have recorded a significant increase in waste volumes. On the other hand, the Finnish household that had the most food waste in the baseline was able to significantly reduce their waste volume in the monitoring. In Greece, significant increases and decreases almost balance each other out.

Additionally, it can be noticed that food waste levels in Greece are already in the baseline lower (702 g/HH) than in the other countries (1,015 g/HH in Austria and 1,374 g/HH in Finland). However, it must be noted that as the household composition of the sample was different in each country (see Table 2), comparisons between countries concerning the absolute amounts of food waste per household are not feasible. For example, half of the Finnish sample were households with children, whereas in Austria their share of the sample was significantly smaller (10.5%). Previous research has shown that households with children tend to waste more food than those without children (e.g., Parizeau et al., 2015; Porpino, 2016).



No. of observations: 36
Mean value: 1158 g/HH (baseline), 670 g/HH (demonstration)
Reduction potential: 42%
p-value: 0.014



No. of observations: 16
Mean value: 805 g/HH (baseline), 425 g/HH (demonstration)
Reduction potential: 47%
p-value: 0.007

Figure 6 – Food waste quantities in g/HH for the pre-demonstration (blue) and the demonstration phase (orange) for the household and student approach

Figure 6 shows the food waste quantities for each applied approach – the household (HH) approach and the student approach. It can be noticed that there was a significant difference between baseline and demonstration in both approaches. In the household approach, a reduction potential of 42% was achieved, and 47% in the student approach.

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A more detailed analysis of the food waste amounts will be conducted in the LOWINFOOD task 1.2 "Evaluation of the efficacy of innovations". Those results will be included in Deliverable 1.6 "FLW evaluation of innovations" which is due in Oct 2024.

Perceived effectiveness and usefulness of the application

The perceived effectiveness and usefulness of the application was examined through various questions in the monitoring phase. Firstly, we wanted to enquire how difficult or easy the users perceived the start of using the application. At the start the app directs users to make a check of their current food inventories as well as insert this information into the app. Furthermore, as the app has several features which the users encounter for the first time, we wanted to know how they experienced this. Figure 7 outlines the distribution of the replies from all users as well as the averages for each country and in total. The Greek users perceived the start of using the app to be the easiest (avg. 3.47). On the other hand, users from Finland perceived the start to be most difficult (avg. 2.47), followed by users from Austria (avg. 2.59).

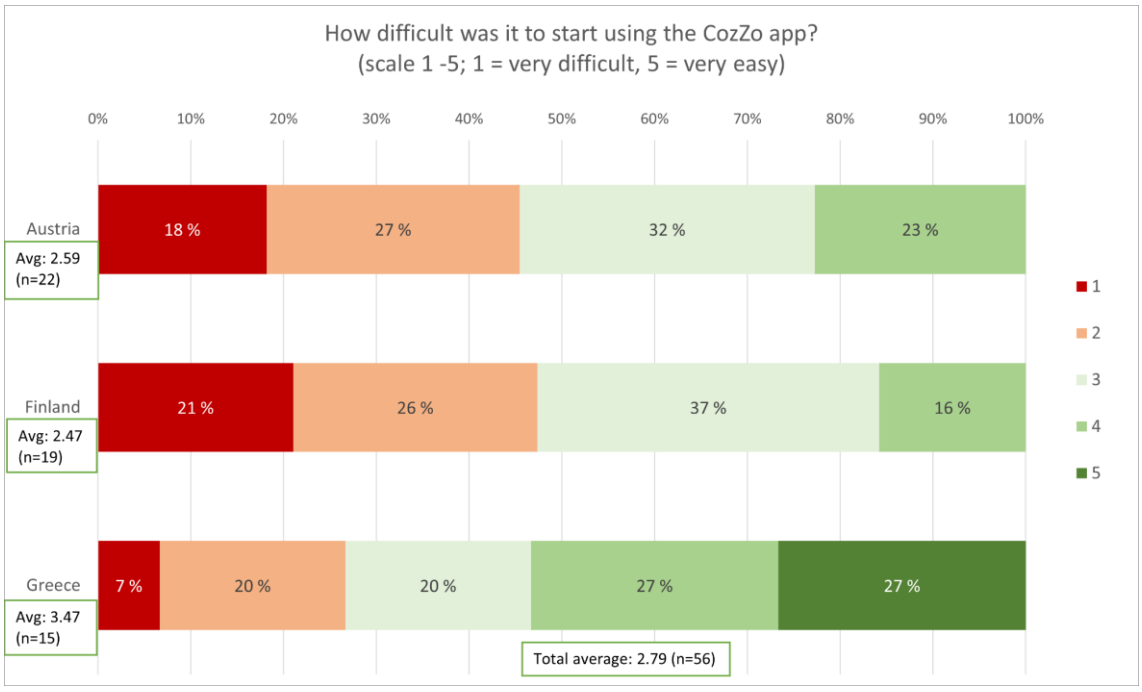

Figure 7 – Difficulty of start using the application

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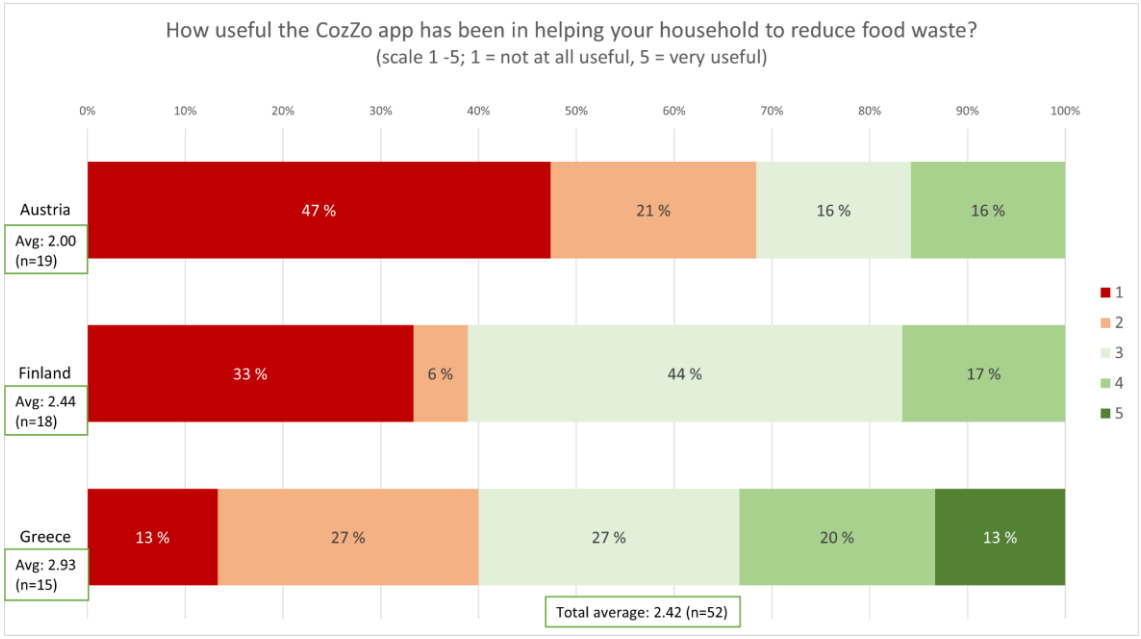

Figure 8 – Perceived usefulness of the app in helping to reduce food waste

Secondly, the household managers were requested to evaluate (on a scale 1–5), how useful the app has been in helping to reduce food waste in their household. As the results in Figure 8 indicate, the Greek household managers perceived the app the most useful (avg. 2.93), while the Austrian household managers scored usefulness the lowest (avg. 2.00), followed by the household managers from Finland (avg. 2.44).

To get a more detailed view of the usefulness of the main app features, the household managers were asked the same question (regarding usefulness in helping the household to reduce food waste) in relation to some of the main app features. Figure 9 outlines the results, showing the averages for each app feature and country, organised in a descending order according to the most useful app feature (avg. in total) among the respondents who reported using this feature in the app.

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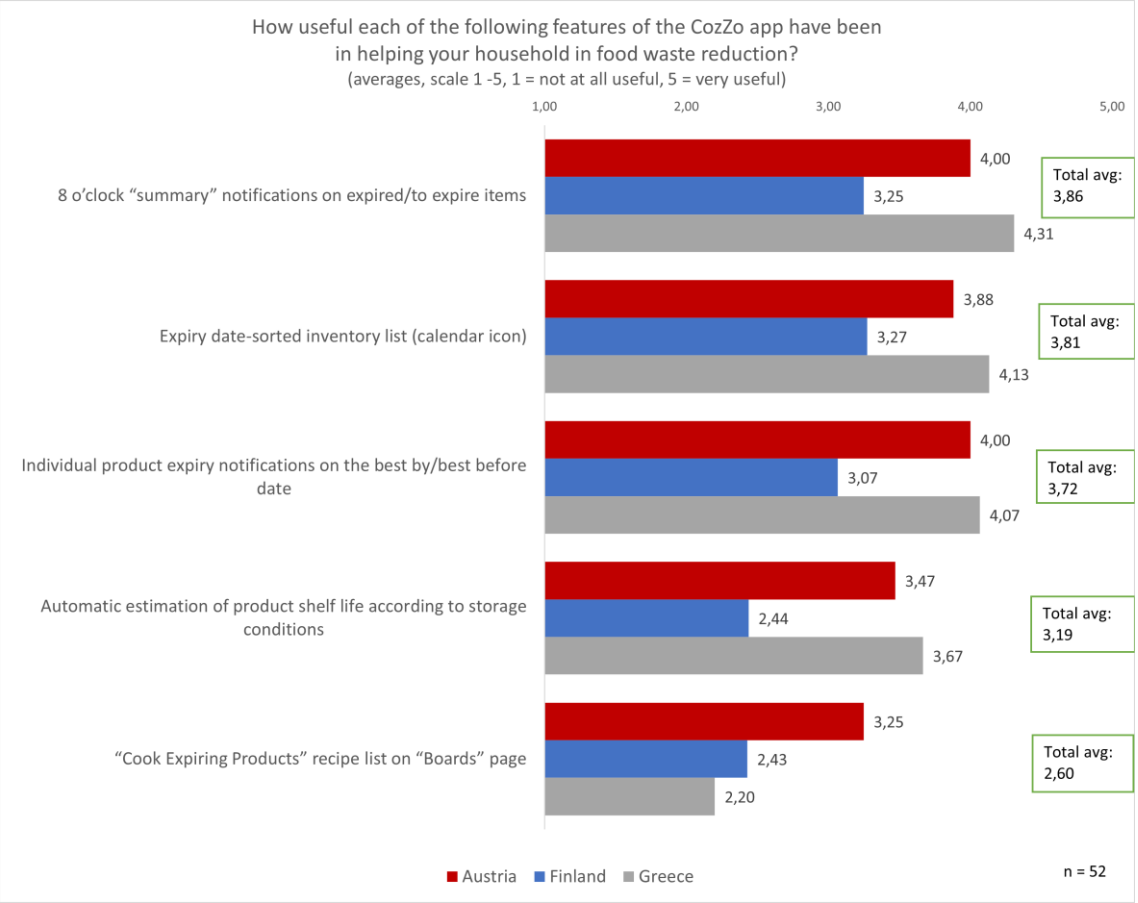

Figure 9 – Usefulness of the commonly used features to reduce food waste

Summary notifications sent to users about items about to expire (avg. 3.86), expiry-date sorted inventory list (avg. 3.81), and individual product expiry date notifications (avg. 3.72) were perceived to be the most useful features in helping to reduce food waste in the households. For all these three features, the Greek households scored the highest, with averages over 4.00. Also, the Austrian household managers rated these features highly (avg. 3.88–4.00). However, it must be noted that the households in Finland rated these three features significantly lower (avg. 3.07–3.25) than in Greece and Austria. The usefulness of the automatic estimation of product shelf life was, on the other hand, perceived to be significantly lower (avg. 3.19), while the suggested recipes based on about-to-expire products received the lowest score (avg. 2.60). The automatic estimation of shelf-life was valued the most useful by the Greek households (avg. 3.67), followed by the Austrians (avg. 3.47) and the Finnish (avg. 2.44). The usefulness of the recipe suggestion feature was valued the most by the Austrian households (avg. 3.25), while this feature scored especially low among the Greek household managers (avg. 2.20).

To the previous question regarding the usefulness of the features, the household managers also had the option to respond that they had not used the feature or were not familiar with it (see Figure 10). Overall, the least used or familiar feature seems to have been the recipes

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suggestion feature, as over half of all households had not either used or were not familiar with it. The most used or familiar feature, on the other hand, was the automatic estimation of product shelf life.

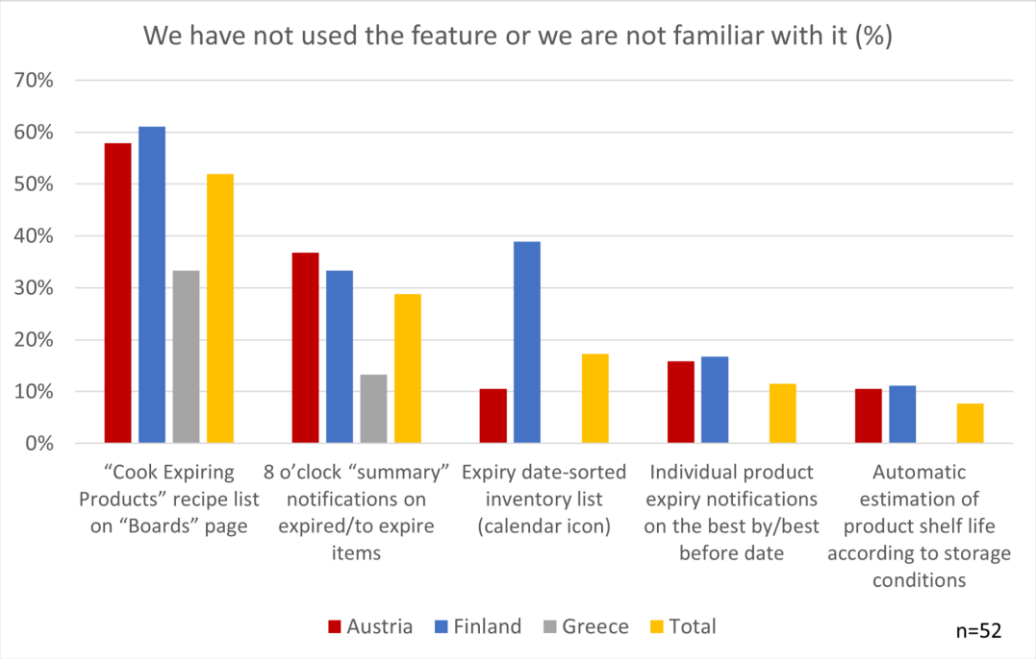

Figure 10 – Non-use or unfamiliarity with the app features

Thirdly, the household managers were asked to rate the usefulness of the app in relation to improving their household's purchasing habits. As with the previous questions, this was also evaluated on a 1–5 scale (see Figure 11).

Overall, the household managers rated the usefulness of the app in improving the household's purchasing habit higher (avg. 2.73) than its usefulness in helping to reduce food waste (avg. 2.42). Similar to the usefulness in food waste reduction, the Greek households valued the usefulness in improving purchasing habits the highest (avg. 3.13), but with quite a divided opinion, as almost a third of the households (27%) give the highest (5) as well as the lowest score (1). The Finnish (avg. 2.67) and the Austrian (avg. 2.47) households rated the usefulness of the app in improving their purchasing habits lower.

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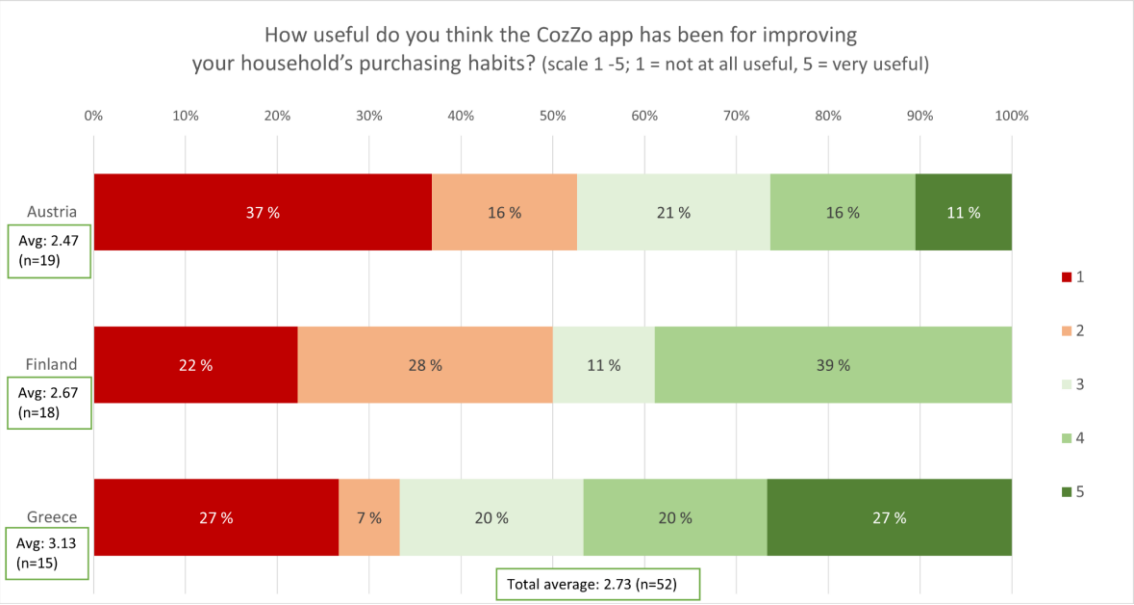

Figure 11 – Perceived usefulness of the app for improving purchasing habits

To evaluate the overall experience of using the app, all users were asked to rate how well the app had met their expectations as well as how likely they will recommend the app to their friends or relatives (both on a 1–10 scale). The averages to both questions are presented in Figure 12.

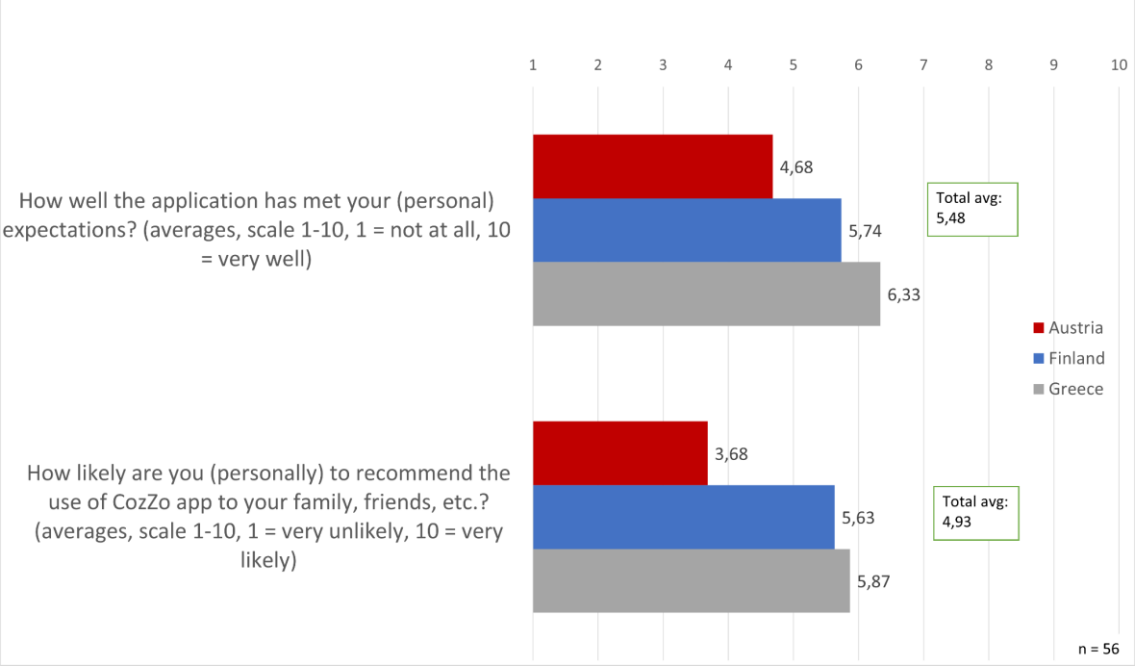

Figure 12 – Meeting expectations and likelihood of recommending the app

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The responses to these two questions show a similar trend as has been presented earlier with the questions related to perceived usefulness. The Greek users rated both questions the highest (avg. 6.33 and 5.87), followed by the Finnish users (avg. 5.74 and 5.63). The averages for Austria were significantly lower (avg. 4.68 and 3.68).

Finally, all users were requested to evaluate whether they will personally continue to use the application after the demonstration phase has ended.[3] The results are presented in Figure 13.

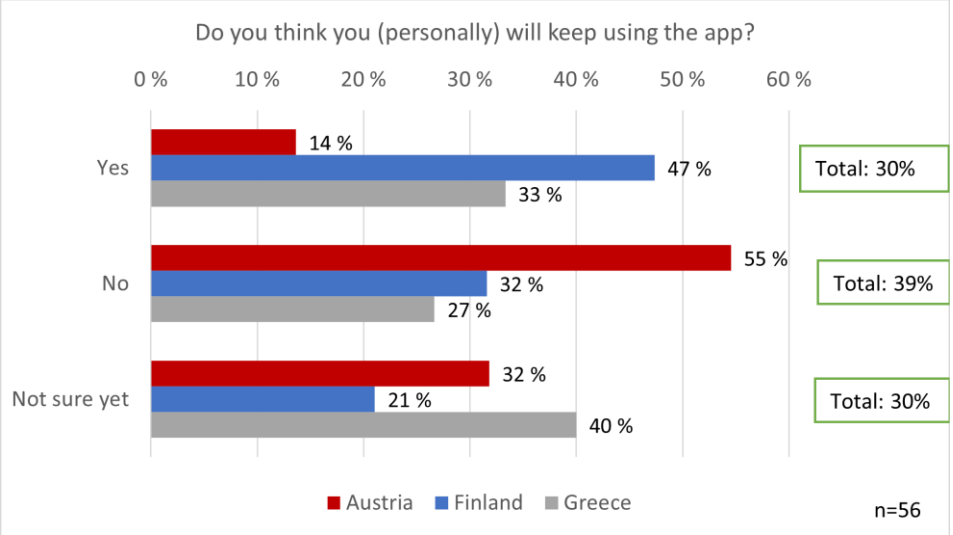

Figure 13 – Using the app after the demonstration period

Overall, about a third of the users (30%) reported they are willing to keep using the app, with the most positive responses from the Finnish users (47%). On the other hand, more than a third (39%) reported not willing to keep using the app, while another third (30%) were still unsure. The share of Austrian users willing to keep using the app was significantly lower (14%) than in the other countries, and over half of the Austrian users (55%) also reported that they will not be using the app in the future. In the 'not sure yet' category, the Greek users had the highest share of users (40%).

Perceived strengths of the app

The perceived strengths of using the app (based on the qualitative data, i.e., the interviews and open questions in the monitoring survey) were analysed based on the phases of food management at households that are related to both generation and prevention of food waste, i.e., planning purchases, shopping for groceries, storing food, cooking and consumption of food, and surplus and leftover use (e.g., Principato et al., 2021; Sirola et al.,

[3] As mentioned above, all the participating households were given free access to the household account of the app for a year.

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2019; Stancu et al., 2016). The identified strengths of the application – *increased overall awareness of food waste in the household, improved planning of purchases though shopping lists, improved awareness of items on stock at home, improved awareness of items about to expire,* and *innovative ways of using surplus and leftover foods* – are portrayed in Figure 14.

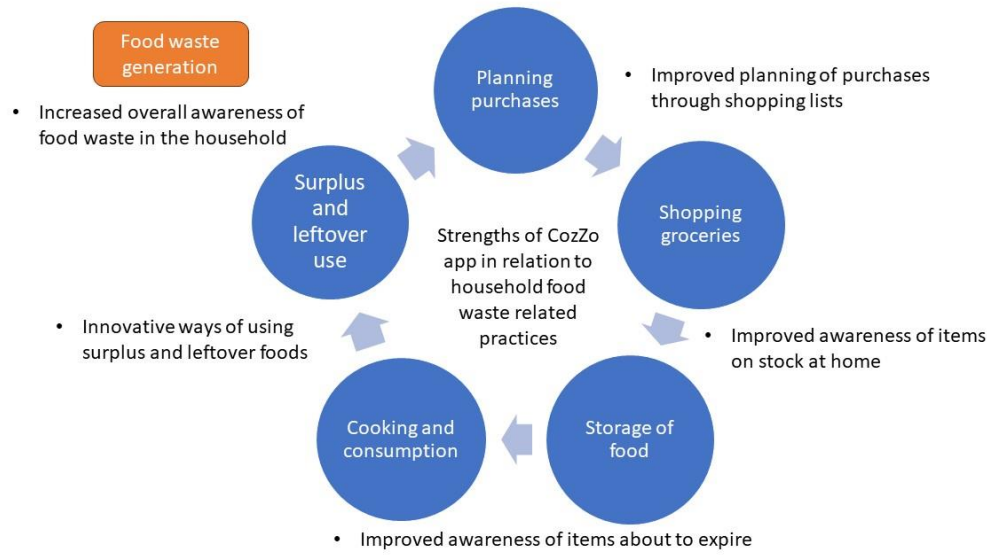

Figure 14 – Perceived strengths of the CozZo app

Increased overall awareness of food waste in the household

On a more general note, the app users perceived that their participation in the demonstration of the app improved their awareness of the issue of food waste, especially in their own household. The users perceived (also perhaps concretely when collecting the waste) that they have been able to avoid food waste, but also that they have changed their mindset as well as become motivated to act on the issue also through other means than by using the app only, such as through avoiding buying unnecessary items or searching for information on how to best store products. The following quotations highlight this:

> *By addressing food waste [as a topic], we definitely have avoided more food waste than usual. (AT)*

> *Using the app has brought to mind that we need to do more to reduce our amount of food waste. (AT)*

> *But it [the app] might have been useful so that I have started perhaps to focus even more carefully on food waste. I don't know whether that became concrete in the amount of food waste we produced, but on some level it provoked me to think about it and created an effort to do something about it. (FI)*

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All the time I was thinking about it [food waste] at some level, perhaps because of that I started to pay attention to for example, if I needed vegetables for some food, I would rather buy them with a more expensive per kilo price and buy only the amount that I need rather than buy the biggest bag [with the cheapest price]. (FI)

During the CozZo demonstration, I actively sought information on food waste prevention and generation. This experience shed light on the significant scope of the issue. Consequently, I've been committed to minimising my food waste ever since. One approach I've adopted is ensuring I purchase only the necessary quantity of food items required by my family, avoiding unnecessary excess. (GR)

I don't know whether this is directly related to the use of the app, but perhaps because of that, I have looked a little bit, searched [for information] elsewhere on how items, for example fruits preserve the best, which fruits should be stored apart and things like that. (FI)

Some of the respondents perceived that using the app made the effort of food waste reduction more concrete, illustrated in numbers and figures, thus increasing their motivation as well as competitive spirit. The following quotes from users from Finland illustrate this:

The biggest benefit for me was that I could see how much and from which sources my food waste comes, this helped me to make better consumption choices… I actually didn't produce that much food waste during the period, but having this feature [in the app], from where I can monitor, I need to pay attention to this… It has been really motivating. (FI)

Even though the app would not be the primary tool to reduce food waste […] it might be supporting it. It could work through some kind of competitiveness, that I want that number to go down, I want to use this [food item] so that the number goes down. And at the same time, it would support the food waste [reduction], like 'yes, I got something out of there'. (FI)

Improved planning of purchases

For some of the users, the app provided a new way to create shopping lists, even encouraging them to create more shopping lists than previously. The shopping list feature was perceived useful because the items on stock could be seen also in the app, and because the user interface of the list was more practical than their usual pen-and-paper list. Furthermore, as people usually carry mobile phones with them, they never forgot the list if they used the one in the app.

Thanks to the app, we shopped more consciously. (AT)

For me, the most useful feature has been the shopping list. I thought it was excellent. I don't usually use a shopping list, but with this app I did use and looked at what I have before going to the store. If I had the shopping list on paper, but not a pen [at the store], I wouldn't

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know which items I had already bought. But in the app, I could swipe the items away [from the list] as soon as I bought them, this was extremely convenient. (FI)

One of the good things standing out in the app was that when I have the physical shopping list [on paper], sometimes when shopping I might realise that I don't have it with me, not even a picture of it or anything. Now I have it always with me [in the app]. (FI)

In my opinion the app is particularly well-suited for newcomers to household management, such as students, young adults, and new couples, who are in the process of learning how to effectively handle their food supplies, including shopping, storage and meal preparation. (GR)

On the contrary, some of the users who were used to using either other digital shopping lists or paper lists admitted that changing to using the digital shopping list on this app was difficult due to their existing routines. For example, the user might have been accustomed to creating their shopping list based on the customer journey they take on their regular grocery store visit (i.e., the order in which they encounter the products), which was not possible when using the app's shopping list function. Some other digital shopping list apps provided by retailers, on the other hand, show the information where each item is located in the chosen store, which, again, creates additional value compared to the shopping list feature on CozZo.

Improved awareness of items on stock

The application provided a way for some of the users to check their inventories at home while away from home, such as when shopping for new items. This reduced buying any unnecessary or extra items that they already had on stock:

When I am at the store, I always check from there [the app], what I have put there [at the app]… I have even updated the amounts to the app, so that I could for example see that I have only this many tomatoes left. It has reduced buying unnecessary items, for example milk, 'oh I still have it, I don't need to buy it'. (FI)

For some, the use of the app highlighted the importance of checking their inventories as part of their shopping routines:

It [the app] streamlined inventory checks. Furthermore, after the monitoring phase, I've come to consider inventory checking as an integral part of my shopping routine. (GR)

Improved awareness of expiring items

Many of the users reported that the biggest strength of the app is related to the improved awareness of which items are about to expire. The app sends the users reminders of these items, and the items on stock also can be listed based on their expected expiry. This was deemed helpful especially in bigger households where fridges can be disorganised, at times quite fully stacked, and used by multiple family members.

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We no longer 'forgot' any food in the fridge, because the app reminded us of the expiring products. (AT)

I liked it the most that it [the app] reminds you what you have there. Hey, now this and that is about to expire. Sometimes some items are forgotten at the back of the fridge if it's really full. (FI)

The most significant feature of the app is its notification of expiring items. It truly assisted me in preserving and utilising some of the products I had in my fridge. (GR)

Furthermore, these notifications inspired the users to focus their attention to the about-to-expire items, for example to think of ways to use them. This also partly affected their shopping for new items and their urge to buy what they want, as the following quotations illustrate:

The feature of being notified when a product is about to expire has made me actively think of a way to use it. (AT)

If I were at a store, I could look [from the app] what I have in the fridge, what I should use and what I would need to buy to match them [in cooking]. (FI)

The most useful thing has been that it reminds me when things are about to expire there [in the fridge]. This then helps in planning… sometimes I feel like I would fancy this [food], even though I should really cook from something I already have in the fridge. Sometimes I just thought in the store that 'well, they will still manage there' [in the fridge]. But now when the app has the dates, while in the store I can check that 'okay, I must use that specific item from there'. (FI)

However, the proper functioning of the expiry reminders requires that the inventory on stock is kept up-to-date and that the expiry dates are valid in order to avoid unnecessary notifications. Both of these aspects created challenges during the app demonstration (discussed in the next sub-chapter), but their importance was acknowledged by users, as the following quotes indicate:

[The main strength of the app is] perhaps the notifications. As soon as you have entered them [the items you have], you could see in an organised way which items are about to expire. (FI)

The option to manually adjust the expiration date of the food items is valuable. It ensures that you will use each product on time. (GR)

Innovative ways to use surplus food and leftovers

The recipe suggestions provided by the application were deemed useful by some of the users for avoiding food waste. The recipes finder suggests recipes that match the items that the

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user has on their inventory. The recipes encouraged the users to utilise the about-to-expire items and to innovate new uses to use ingredients:

> *As a student setting up a household for the first time, I found the recipe creation in the app to be very useful. It enabled me to utilise ingredients that otherwise would have been wasted. (GR)*

> *This feature in the recipe database that, after adjusting the setting which cuisine from which country, which special diet and all… this encouraged innovating new ways to use some specific ingredient. (FI)*

Even though some of the users did not see the recipes suggestions from the app as relevant for them, they perceived that the recipe finder encouraged them to either innovate other uses for the about-to-expire items or to search for recipes elsewhere for that particular ingredient.

> *But this feature [recipe finder] made me focus more on… I also started to think to myself that 'hey, if I have these, what could I make out of them and where could I use them'. And specifically from the point of view of generating as little food waste as possible. (FI)*

> *As it notified me of expiring items many days in advance, anyhow I had the time to look for recipes [elsewhere] and think of how I could use them. (FI)*

Perceived challenges of using the app

The qualitative data from the users was analysed also to examine the perceived challenges and barriers to using the application in their daily lives. The perceived challenges – discussed below – are related to the work required from users of the app, the estimation of product expiry, some usability issues, and as a result, the perceived added value of the app.

Effort needed from users

Most of the users in the study felt that the app required a lot of effort from the user in order to fully benefit from its features. Keeping the inventory up to date, i.e., adding food items as they are purchased and removing them as soon as they are used, is necessary for the main features of the app to work properly. For example, the expiry notifications and recipe suggestions rely on the inventory being up to date. At the start of using the app, the user should go through all their food inventory, i.e., their pantry/cupboards, fridge, and freezer, and enter the information from each item into the app. Some of the users did not end up doing this at all, but ended up using the app in another way, for example by entering only the fresh food items they bought during the demonstration period or by not using this feature at all and using the app only for example for planning of purchases. The following quotes illustrate this:

> *Way too time-consuming to integrate it into everyday life. (AT)*

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Due to time management, we were not able to use all functions of the app. (AT)

I can imagine that the basic idea of the app is useful, but you put a lot of time and effort into the app if you really want to use it. (AT)

I have so much food in my pantry, that it felt really burdensome to start going through all the cupboards and all and input them in the app. Actually, I didn't end up doing that, but I developed another way to use the app. (FI)

In the end, we used the app very little simply because we felt that it required too much effort. In order for it to function well, we would have to keep it updated for real, regarding both the incoming and outgoing food. It is, in my opinion, simply too burdensome that you have to constantly fiddle those things into the system. (FI)

As it [keeping the stock up to date] requires, after all, a lot of engagement and effort, it's always off, it never shows it correctly. It is a nice idea, but without that, it never works. (FI)

Most of the users understood that it would be essential to add items to the app as soon as they enter the household kitchen. However, entering them into the app was perceived to require a lot of effort. The app provides users the possibility to enter products manually, but also through barcode scanning as well as through scanning of paper receipts. The challenge, however, was, that the app did not always recognize the barcodes and/or paper receipts correctly.

The primary concern is that if you don't add products to the inventory right after entering the kitchen, it's quite easy to lose track. (GR)

Uploading data for each one of the food supplies can be quite time-consuming and may discourage working family members. (GR)

That barcode scanner, it was really useful, but it recognized only about half of the products, so I then had to enter them manually, which made it really laborious. (FI)

Uploading the necessary information takes up quite a bit of time. While scanning the barcode of the food items is a helpful feature, there's room for improvement in this aspect. (GR)

On the other hand, in the few households where multiple users had downloaded the app, it was perceived as useful that all the users could add the items to the app. This was perceived to ease the effort needed for keeping the inventory up to date.

Then I also downloaded the app for my partner, so that we both could add [items]. It was really convenient, if either one went shopping, that we could simultaneously add them there, I didn't have to do it only by myself, then it wasn't such a big burden. (FI)

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Keeping the inventory in the app up to date required that the users would also need to remove the items as soon as they were used. This also felt like extra effort, it was perceived difficult to estimate the partial amounts (e.g., the amount of milk used from a one-litre container, or the amount of oatmeal used from a one-kilogram-package), and sometimes deleting items was also forgotten. Furthermore, in larger households, it was deemed challenging to keep the inventory up to date as there were other family members who used items from the inventory, but did not register their use in the app or were not users of the app. Consequently, many of the users felt that it was much easier just to look in the fridge rather than from the app what they have on stock.

> *It's way more effort than just looking in the fridge. (AT)*

> *Only yesterday I realised that I should probably remove these from here [from the app] as well, that I have these things here that I have used a long time ago. (FI)*

> *Especially with snacks, if some other family member had eaten something, I might not have noticed that. And at that point when I did notice it, I didn't go to the app to remove it from there. The usefulness of the recipes database was reduced by the fact that it [the list of items on stock] wasn't always accurate, you couldn't trust that it was up to date. (FI)*

> *It can be time-consuming to discover and use certain features, such as how to 'save' the remaining quantity of a product, like when you've used half a package of flour. (GR)*

Estimation of product shelf life

Another essential requirement for the application to work properly in the reduction of food waste is that the expiry dates of the products on stock are valid, i.e., reflect the actual edibility/inedibility of the product. The application has a feature that automatically suggests a proper shelf life for a product. However, some of the users perceived these automatic suggestions not to be correct. For example, some of the suggested shelf lives for products in the freezer were deemed to be too short, likewise for some dry goods in the pantry (e.g., flour).

> *In my opinion, it [the estimated shelf life] doesn't always tell how long the product actually lasts… When I looked at the 'guesses' in the app [for the shelf life of products], in many cases I disagreed with them a bit. (FI)*

The consequences of these are twofold. Firstly, if the automatic expiry dates are not valid, they create expiry notifications that are deemed as unnecessary by the users. And if there are too many of these, the value of the notifications diminishes, as the valid notifications might not become noticed, or the users end up turning them off.

> *I quickly felt annoyed by the numerous notifications through the app and tended to ignore them. (AT)*

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What makes it tricky is that some of them [the expiry reminders] are wrong, then there are quite many of them. The right ones are then covered up in the flow of reminders. (FI)

Secondly, if a user thinks that the automatic shelf-life estimation is not valid, they will need to manually enter the expiry date of the product to the app. Entering these exact dates was perceived as laborious, as the user would need to manually choose the date (day, month) from a scrollable menu rather than from a calendar. Also, it was suggested that the most convenient option would be if the app could read the exact expiry date directly, for example through the barcode scanning function.

Milk has the [expiry] date on the package, and I could also accept the default option [suggested by the app], but they didn't necessarily match. […] Then the date had to be searched so that you scroll numbers and month. If it were like a calendar view, then I could press it only once. Now I had to spin it like a lucky wheel, whether it would stop at the correct spot. (FI)

The app would be even more valuable if it could automatically determine the precise expiration date for products. Currently, the user has to input the date manually, which can be time-consuming and requires effort. However, what's the point of an app if it consumes that much time? (GR)

Usability issues

The app users also encountered some usability challenges. The users mentioned a sense of discouragement as they felt that the app could not be apprehended intuitively and that the interface of the app was not in line with commonly known iOS practices. This mainly refers to input gestures (e.g., unfamiliar swiping commands) to control functions, to challenges with the design of the user interface, as well as to the navigational structure (e.g., accessibility of menus).

The application is not intuitive. You have to think carefully about where the single functions could be hidden. When to swipe to the left, when to the right? When down? The operation is not really self-explanatory. (AT)

I think you have to be a bit tech-savvy to find your way around the app. The app is not very intuitive, it requires a lot of fiddling - little things, here a setting, there a setting. (AT)

[We] had to find out that swiping to the left or to the right has a different function each time, sometimes even duplicate functions. (AT)

Could it be that you just tap once? In the app, you first had to pull and then [swipe] to either direction… And then the finger must slide on the screen all the way to the right selection, otherwise it doesn't work. In many cases I couldn't choose because the screen 'ended', I couldn't get where I wanted. (FI)

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In general, many users perceived the app to include too many features. This made starting the use of the app difficult, as it was difficult to understand how the app worked. Furthermore, as previously discussed, some users admitted they had used only some of the features during the demonstration.

> *The app is not intuitive enough to make sense of so many functions. (AT)*

> *I would say that there is a certain overload of functions, which is a bit difficult at the beginning. (AT)*

> *It had a lot of everything, and for sure, I didn't use all the features. I didn't even research all the features. It seemed really interesting, but then at that stage, when at the beginning I had put a lot of time and effort to that, then [later] I didn't have any energy to see [all the features]. (FI)*

> *We didn't utilise the feature for creating a shopping list. Instead, we found it more convenient to use the 'spaces' option for checking out food supplies. (GR*)

Finally, in Finland and in Greece, some users experienced a language barrier for using the app. In these countries, the app menus are in English, while most of the food items are in native language, i.e., in Finnish or in Greek[4].

> *Perhaps it was the language after all. Even though I speak and understand English, somehow it felt that it [English language] was the biggest reason. If it were in Finnish, perhaps then the situation would have been different, so that I would have been better engaged, then would have been more eager to learn the app more. (FI)*

> *While many food items are translated into Greek, the identification and translation of the local products can be improved. Additionally, the features, notifications, and the newsletter being in English may not be user-friendly. (GR)*

Added value of using the app

In general, and based partly on the challenges discussed above, some of the users perceived that using the app would not create any major added value to their current household food management practices. This was especially apparent with those households who already were aware of the problem of food waste, and/or felt quite proficient in their current food management practices, such as planning for meals, checking inventory, or avoiding food waste.

> *I think I already have a pretty good knowledge of food waste, I didn't really learn anything new through the app. (AT)*

[4] In Austria, the app is fully available in German.

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I feel that we are quite well organised in filling and emptying our fridge, we rarely encounter any real surprises like 'oh, I have this here'. (FI)

I acknowledge that I was quite good at these things already before, so I felt this [using the app] more like an extra inconvenience. (FI)

I typically purchase the same food items, and as a result, I have some favourite recipes for using them. There's no need to experiment with new recipes. I don't think I need an app for that. (GR)

No, the app did not lead to a change in my household's purchasing habits. I have had the habit of regularly checking our food inventory and making a shopping list for many years. (GR)

Some smaller, single households on the other hand, felt that the amount of food that they manage in their household is so small, and that they create so little waste anyway that the app does not create that much value in their current life situation.

I didn't really get that much out of it that I would continue using it. But I did see a lot of potential, if it develops and becomes easier [to use], and especially if I had a bigger family with more food waste, then it certainly would be more useful. But for someone like me, living alone and buying only the items I need, I produce very little food waste in the first place, and that's why I didn't get that much added benefit from it. (FI)

Furthermore, some users were reluctant towards increasing the use of technology in their lives. They perceived that using an app like this would create even more reliance on technology, phones, and apps, and that especially the kitchen in the household was a space that technology was not welcomed into.

I try to resist having a mobile phone in my hand all the time. Then on top of that, there are now things I should do in my kitchen [with the app using a mobile phone]. I don't want to expose myself to being reliant on any extra apps. (FI)

The value of using the app was perceived as a balance between the effort required to use the app and the benefits received from using it. Some users admitted that perhaps the demonstration period was too short for them to properly change their practices and to integrate the app into their lives. On the other hand, some users felt that they needed a change in order to reduce their food waste, but the app was not the answer to their current needs.

So that you get the benefit from this, it always requires effort. And for it to integrate into daily life, it doesn't always happen that quickly. (FI)

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I felt that the problem is somewhere in our daily practices, and it can't be solved by entering the items we have [on stock] to an app. I felt that the change must happen in my head. […] The app just didn't match our needs. (FI)

The app made me reflect on our consumption habits, but I don't believe it was a game changer. (GR)

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4. Learnings and recommendations for future applications

The outcomes of the demonstration of the CozZo application in Austria, Finland and Greece suggest that mobile applications like CozZo may have a potential in reducing the amount of food waste at the household level. However, when evaluating the effects on the food waste amounts, it should be noted that for all households, in addition to using the CozZo app, participation in the project required other activities related to food waste, such as collecting their household's avoidable waste and answering surveys related to the issue. As a result, it can be also assumed that the participating households were more aware of the issue of food waste than the general population.

The question remains what the exclusive effect of using the app is on the levels of household food waste, especially as the findings on the app use indicate that most users ended up using the app only about once or twice a week or less. Especially the qualitative data indicates that the largest impact of the app may be that the users put more attention on their daily food waste management practices. These practices are then related to their food waste reduction. Overall, the results of the demonstration are a combined effect of all the activities related to the participation in the research project.

When comparing the countries, the potential for reduction of food waste was the highest in Austria, followed by Finland and Greece. However, when comparing the app users' perceptions and experiences of the app across the three countries, the findings were quite the contrary. The Greek users rated the app the most favourable overall, for example in relation to how easy they perceived the start of using the app, how useful the app was perceived to be, how well the app met their expectations and how probably they will recommend the app to others. The Greek users, however, had the largest proportion of users that were unsure whether to continue using the app. The Austrian users, on the other hand, perceived the general usefulness of the app the lowest, both regarding reduction of food waste and improving the household's shopping habits. The Austrian households also scored the lowest score on meeting expectations and probability of recommending to others. They also were the least willing to continue using the app. The results from Finland lay somewhere in the middle of these – the start was perceived to be the most difficult among the Finnish users, whereas for the perceived usefulness, the Finnish scores settled between the Greek and Austrian. However, the sample from Finland had the highest share of users willing to continue using the app.

Despite the differences in the methodology for the household and student approach, both approaches resulted in significant results regarding the effectiveness to reduce food waste. In the student approach, the participants completed the waste audit by themselves, which could explain – despite a shorter demonstration period in Austria and Finland – a bit higher reduction potential (47%) compared to the household approach (42%). In the self-waste audit, the participants could see the amounts and types of waste they produced daily, which could have increased their awareness for the issue a bit more than in the approach where

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the waste weighing and sorting was conducted by researchers. On the other hand, as reporting the results requires more effort, the self-waste audit might encourage underreporting of their food waste.

Suggestions for future app development

The user experiences indicate several take-aways for the development of applications like CozZo. Firstly, perceived difficulties encountered at the start of using the app can discourage the regular use of the app, engagement with the app, and, as a result, full adoption of the app into daily household routines. This can be even more challenging for those users who are not interested food waste reduction (as much as the users joining the demonstration most likely were). The users from Finland and Austria perceived the start of using the app as more difficult than users from Greece. This implies that usability of an app like this should be made as intuitive as possible, with easy-to-use tutorials available in the users' native language. Many of the users also perceived the app to have too many features, which complicated comprehending the app in the first place. The solutions to this could be that the number of features should be streamlined, or the users have the possibility to customise the app to include only some of the features. Furthermore, some users from Finland and Greece reported a language barrier, as the main menus of the app were available only in English, along with some of the content (such as suggested recipes). This indicates the importance of content availability in native language of the user. For the Austrian users, the name of the application 'CozZo' had aroused some negative connotations at the start, as a phonetically similar word in German (the verb 'kotzen' and the related noun 'die Kotze') refers to vomiting. At the start, some users also reported being overwhelmed by the tasks of starting the use of the app, experiencing a lack of time and effort that creating a perfect inventory at the start of using the app would have required. As a result, many of the users did not end up using all the features provided by the app, and or used the app less frequently than its full adoption would require.

Secondly, as discussed earlier, using a mobile application like CozZo for household food management requires a lot of effort and time from the users. For an application like this to work as intended, the inventory listed in the app should be kept up to date by the users, and usually, that would mean updating the incoming and outgoing items and amounts daily. This should be made as easy as possible and with an added value to existing household practices, such as looking into the fridge. Technologies that have been developed for the easy entering of items (scanning of receipts and barcodes) might not have worked perfectly in this app during the demonstration, but they and other related future technologies offer a promising way to ease off the load from the users. Another feature from the avoidance of food waste point-of-view is to accurately estimate the time when an item on stock becomes inedible. The automatic estimation of product expiry was deemed (especially by the Greek and Austrian users) a somewhat useful feature, but the qualitative data revealed that some users did not agree with the suggested expiry dates and/or wanted to enter the date manually. The findings show that manual entering of dates was considered an extra inconvenience and

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thus should be made as easy as possible. Perhaps in the future, with the adoption of two-dimensional (2D) barcodes, the expiry date can be entered to the app by scanning the barcode on the item. Whatever the technology used, the expiry date does not always forecast the exact day when the item turns inedible. Therefore, the final evaluation of (in)edibility of food items relies currently on the consumer and their senses. Despite this, as the findings show, one of the strongest features in an app like CozZo is that it directs the users' attention to items that most probably are about to expire next. With notifications coming a few days before the estimated expiry, the users have time to think about where to utilise these items. And for that purpose, the recipe finder can give further inspiration.

Thirdly, the experiences gained from the demonstration of CozZo app implies that in the context of food waste reduction at households, adopting new practices related to household food management can be challenging. The households not only needed to learn to use a new type of mobile app, developed in an area of the home that the users might not have been used to using technology before (i.e., in food management). Inclusion of technology to this area created resistance in some users. The users also needed to start incorporating the app into their existing practices (e.g., start listing items on the app instead of looking in the fridge or to start creating shopping lists in the app rather than on paper). This learning of new (or adjusting old) practices might take more time than the demonstration period allowed. To further complicate things, some household managers were confident that their current food management skills were good enough, they simply did not see how an app like CozZo would help them, especially if multiple members of the household use the inventory, but not all have the possibility to use the app. On the other hand, those users who have recently started their own household (e.g., students), might be more willing to learn new house management skills, with a possibility to also integrate apps such as CozZo to these new practices.

To summarise the previous, the following lists the most relevant points for developing the CozZo and other similar applications:

- *Cross-platform availability:* For apps that offer collaborative aspects (e.g., shared household inventory, shared shopping lists), cross-platform availability (both iOS and Android) should be provided. Homogeneity of mobile devices across household members cannot be assumed, given the current market situation. This might be particularly relevant for apps whose intended strength is the facilitation of shared household inventories.
- *Less is more:* Focus on core features and extend only thoroughly tested functionalities. Usability may be the most important aspect: use simple user interface layout; use familiar, operating system-specific control gestures and coherent navigational structure and placement of interactive elements. Users might not encounter the advantages of an app if they are not engaged from the start.

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- *More assistance within the app:* Provide guidance on how to use the app for different food waste prevention scenarios. Provide a comprehensive tour (e.g., present different use scenarios) at the beginning and an easily accessible help items across all sections of the app.
- *Less user effort:* Automatization provides a large future potential for an increased user engagement through less user effort needed. Repeated manual, time-consuming tasks are currently discouraging users (e.g., the manual management of groceries and inventory stocks).
- *Cultural aspects:* Pay attention to cultural aspects of food and cooking. For example, if recipes are provided, they should cover multiple food cultures and encourage the possibility of adding own recipes and/or easily importing recipes to the app.

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5. Conclusion

Digital technologies, such as mobile applications, have potential to reduce food waste but their influence is not yet well known. Many applications currently in the market focus on redistribution of surplus food, such as restaurant meals. In LOWINFOOD T5.5, we have investigated the potential of an application that is targeted to reduce food waste in the household context, CozZo. We examined the potential of this application to reduce food waste both qualitatively and quantitatively. A total of 52 households in Austria, Finland and Greece completed the study where they used the CozZo application for at least three or six weeks. The households' avoidable food waste amounts were measured before and during the demonstration phase. In addition, the household managers were interviewed about their experiences.

Based on the findings reported in this deliverable, mobile applications such as CozZo may have potential to reduce food waste in households, especially when combined with a food waste collection or audit. This was manifested in the quantitative evidence, suggesting a 43% reduction potential. Qualitative findings, however, seem to somewhat contradict this finding, suggesting that the reduction potential might be due to increase in general awareness towards food waste and changes in food management practices, rather than the app use alone. This questions the role of technological innovations as sole solutions to the reduction of food waste at households. Furthermore, the reduction potential cannot be generalized as the sample of households was not representative of the population in the studied countries, did not include quotas for various user profiles, and did not take into account external factors related to food waste quantification (such as day-to-day variations in household food waste generation during the relatively short 7-day period). Also, the study did not include control groups, and thus it was not possible to segregate the effects of using the app from other activities. Overall, the study, however, has provided valuable information on how to improve the app and bring it closer to its users – therefore, increasing its technology readiness level.

The qualitative evidence provided an in-depth understanding of how this innovation may reduce food waste and what are its strengths and challenges from users' perspective. Using this type of an application or even familiarising oneself with it seems to increase the general awareness of food waste and the multiple areas in food management to which it relates (e.g., planning of purchases, inventory management, storing and cooking). However, adopting the application as part of everyday practices can be a challenge, especially when users have already established their own ways of food (and waste) management. In such a case, the technological innovation may even hinder or disrupt users' food waste management. Furthermore, as the demonstration period was relatively short in this study, some changes might be observable only later.

Based on user insights, this deliverable presented several paths for future application development. The study reported here highlights the value of engaging users early on in app

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development processes to ensure that the functionalities of the technological solution fit with users' everyday practices. It is also foreseen that when and if new technologies such as IoT or packaging technology will remove most of the user effort currently needed, the potential of these kinds of apps to reduce household food waste will be further increased.

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Appendices

Appendix 1. Baseline questionnaire for managers

Q1. Household code

Q2. What is your responsibility in the food management of your household?

- I am the only person in charge of food management in my household
- I am one of the main people involved in food management in my household
- I use or help with the food management without a decision-making role
- I am distantly/ indirectly involved in the use or support of the food management
- Other (please specify)

Q3. What is your age?

- 16-17
- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65 or more

Q4. What is your gender?

- Female
- Male
- Other (please state in your own words)
- Prefer not to say

Q5. What is your current level of education?

- No qualifications after compulsory education/school
- High school or equivalent qualification
- Trade/technical/vocational training
- University or college undergraduate degree
- Post graduate education (masters or PhD degree)

Q6. Which of the following describes your current work life situation the best?

- Employed full-time (including self-employed)
- Employed part-time (including self-employed)
- Unemployed or laid off
- Student
- Stay-at-home parent
- On long-term sick leave
- Retired

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Other: please specify_____

Q7. Household composition:

One adult
One adult + one child
One adult + two children
One adult + three or more children
Two adults without children
Two adults + one child
Two adults + two children
Two adults + three or more children
Three or more adults without children
Three or more adults + one child
Three or more adults + two children
Three or more adults + three or more children

Optional: Please specify gender and age of other household members:
_____

Q8. Total household income (net income per month in total):

Less than 1.000 €
1.000 €–1.999 €
2.000 €–2.999 €
3.000 €–3.999 €
4.000 €–4.999 €
5.000 €–5.999 €
6.000 €–6.999 €
7.000 €–7.999 €
8.000 €–8.999 €
9.000 € or more
I prefer not to say

Q9. Please estimate how often do you waste food in the following food groups in your household?

Frequency (for each food group):

6–7 times per week
3–5 times per week
1–2 times per week
2–3 times per month
about once per month
less often
never

Food groups:

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fruits and berries
vegetables, legumes and fresh herbs
potatoes and potato products
pasta, rice and corn products
meat
fish
eggs
dairy products
bread and rolls
sweet and savoury bakery products
home-made meals
fresh convenience meals (including take-away meals)
processed vegetable and fruit products
spices
Other, please specify: _____

Q10. Estimate which three food groups constitute the highest amount of waste in your household? [Interviewer will show the list of food groups to the interviewee]

fruits and berries
vegetables, legumes and fresh herbs
potatoes and potato products
pasta, rice and corn products
meat
fish
eggs
dairy products
bread and rolls
sweet and savoury bakery products
home-made meals
fresh convenience meals (including take-away meals)
processed vegetable and fruit products
spices
Other, please specify: _____

Q11. Which options do you use for your food waste disposal? [Choose all that apply.]

Redistributing to other people (e.g., family, friends, neighbours)
Feeding to pets (or wild animals)
Home-composting
Municipal solid waste collection system ('residual waste bin')
Separate waste collection system ('organic waste bin')
Other: please specify

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Q12. Have some of your household members (i.e., at least one member) engaged in the following activities during the past two weeks? [Choose all that apply.]

Purchased grocery products near their expiry date (e.g., products discounted for their expired/soon-expiring date labels)
Purchased excess food from restaurants, cafes or other catering companies (e.g., through "food rescue" mobile applications)
Went dumpster diving (e.g., picked up products from grocery store recycling areas)
Picked up excess food from other people (e.g., family members, friends)

Q13. Estimate (in euros), how much money does your household spend on food weekly (for a regular week, not including e.g., holidays or parties). Please make the estimation by calculating from your shopping receipts or debit/credit card statements. This amount excludes occasions of eating out or ordering take-away by household members.

_____

Q14. Estimate (in euros), how much money does your household spend on food monthly for eating out or for ordering take-away meals?

_____

Q15. Please indicate how much you agree or disagree with the following statements (1- strongly disagree, 5- strongly agree)

[If you are a survey respondent who is a full-time student, please consider your school as your workplace. If you are a survey respondent temporarily out of work now, please consider your previous workplace.]

Everyday huge quantities of food are wasted in the world.
Wasting food at home is inevitable.
It is impossible to avoid food waste at the workplace.
The problem of food waste worries me a lot.
Wasting food is irresponsible.
When I waste food, I feel guilty.
Wasting food does not go against my principles.
Everybody has a responsibility to reduce food waste.
I do not care if I waste food.
I am committed to reducing food waste in my household.
I am committed to reducing food waste in my workplace.
The daily amount of food waste is a serious problem for the planet.
Food waste is a major economic issue.
Wasting food is wasting other resources such as water and energy.
Many people in our society do not care about their food waste.
My household supports my efforts to reduce food waste at home.
My colleagues support my efforts to reduce food waste at work.

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I feel social/peer pressure to avoid wasting food.
I regularly throw away food that I could have consumed due to food spoiling
I seldom throw away food that could have been eaten because I have bought too much.
I regularly throw away food that could have been eaten because I have prepared too much food.
I know what to do to reduce food waste at home.
I know what to do to reduce food waste when I eat out.
I know what to do to reduce my food waste when eating at a restaurant.
I know what to do to reduce food waste at work.
I have the ability to recycle my unavoidable food waste such as the inedible peels, pits and stones of fruits and vegetables, bones in meat and fish etc.
I have control over the amount of food waste produced in my workplace.
I have control over the amount of food waste produced in my household.
Reducing food waste in my household is a hassle.
Reducing my food waste requires a lot of time.
To reduce the food waste in my household I need to buy new equipment/new technology.
The local council provides satisfactory resources for recycling food waste.
My workplace provides satisfactory resources for recycling food waste.

Q16. In your household, how often does food end up wasted due to the following reasons? (Scale 1-5: 1=never due to this, 5=very often due to this)

The date in the date label has passed.
The packaging size of the food I bought does not meet my needs and food is left over.
The food has spoilt (e.g., rotten or become mouldy) before I manage to use them.
I have prepared too much food for one meal.
I am not sure whether I can still eat the food and I throw it away just to be safe.
I don't want to eat the same kind of food for several days at a time.
I/we didn't like the taste of the food.
Children leave food uneaten.
I buy ingredients for a recipe and part of them are left unused.
I buy food that I later do not fancy eating.
I/we have bought too much food.

Q17. How often do your household members go grocery shopping in brick-and-mortar stores?

several times a day
6–7 times per week
3–5 times per week
1–2 times per week
2–3 times per month
once per month or less
never

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Q18. Which mean(s) of transport do your household members primarily use for their grocery shopping trips? [Can choose max. 2 options]

car
bike
bus
train
scooter
by foot
other, please specify_____

Q19. How often do your household members buy groceries online?

several times a day
6–7 times per week
3–5 times per week
1–2 times per week
2–3 times per month
once per month or less
never

Q20. Number of meals per day, and weekly number of take-away meals, eating out-of-home and home-made/home-prepared meals for the household members.

Household member (list all, both adults and children)	Number of meals (excluding snacks) this person has *in an average day*	Number of times this person eats *take-away meals* (excluding snacks) at home *in an average week*	Number of times this person eats meals (excluding snacks) *out-of-home* (e.g., at a school or workplace canteen, restaurant etc.) *in an average week*	Number of *home-made or home-prepared meals* (excluding snacks) this person eats at home *in an average week*
Family member 1				
Family member 2				
Family member 3				
Family member 4				

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Family member 5				
Family member 6				
etc.				

Q21a. Are there any members in the household that follow a vegan or vegetarian (incl. lacto-, ovo-, pesco-vegetarian) diet?

Yes

No

Q21b. If Yes: How many members in your household are vegan? [insert the number]

Q21c. If Yes: How many members in your household are vegetarian? [insert the number]

Q22. Are you satisfied with this survey?

Not at all satisfied

Somewhat dissatisfied

Neither satisfied nor dissatisfied

Somewhat satisfied

Very satisfied

Q23. If you have any additional comments, please write them:_____

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Appendix 2. Baseline questionnaire for participants

For all other people who will be using the app (besides the one user who has already filled the manager survey), and only for those over 16 years of age.

Q1. Household code _____ [to be inserted by the researchers]

Q2. What is your responsibility in the food management of your household?

- I am the only person in charge of food management in my household
- I am one of the main people involved in food management in my household
- I use or help with the food management without a decision-making role
- I am distantly/ indirectly involved in the use or support of the food management
- Other (please specify)

Q3. What is your age?

- 16-17
- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65 or more

Q4. What is your gender?

- Female
- Male
- Other (please state in your own words)_____
- Prefer not to say

Q5. What is your current level of education?

- No qualifications after compulsory education/school
- High school or equivalent qualification
- Trade/technical/vocational training
- University or college undergraduate degree
- Post graduate education (masters or PhD degree)

Q6. Which of the following describes your current work life situation the best?

- Employed full-time (including self-employed)
- Employed part-time (including self-employed)
- Unemployed or laid off
- Student
- Stay-at-home parent
- On long-term sick leave

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Retired
Other: please specify_____

Q7. Please indicate how much you agree or disagree with the following statements:
(1- strongly disagree, 5- strongly agree)

[If you are a survey respondent who is a full-time student, please consider your school as your workplace. If you are a survey respondent temporarily out of work now, please consider your previous workplace.]

Everyday huge quantities of food are wasted in the world.
Wasting food at home is inevitable.
It is impossible to avoid food waste at the workplace.
The problem of food waste worries me a lot.
Wasting food is irresponsible.
When I waste food, I feel guilty.
Wasting food does not go against my principles.
Everybody has a responsibility to reduce food waste.
I do not care if I waste food.
I am committed to reducing food waste in my household.
I am committed to reducing food waste in my workplace.
The daily amount of food waste is a serious problem for the planet.
Food waste is a major economic issue.
Wasting food is wasting other resources such as water and energy.
Many people in our society do not care about their food waste.
My household supports my efforts to reduce food waste at home.
My colleagues support my efforts to reduce food waste at work.
I feel social/peer pressure to avoid wasting food.
I regularly throw away food that I could have consumed due to food spoiling
I seldom throw away food that could have been eaten because I have bought too much.
I regularly throw away food that could have been eaten because I have prepared too much food.
I know what to do to reduce food waste at home.
I know what to do to reduce food waste when I eat out.
I know what to do to reduce my food waste when eating at a restaurant.
I know what to do to reduce food waste at work.
I have the ability to recycle my unavoidable food waste such as the inedible peels, pits and stones of fruits and vegetables, bones in meat and fish etc.
I have control over the amount of food waste produced in my workplace.
I have control over the amount of food waste produced in my household.
Reducing food waste in my household is a hassle.
Reducing my food waste requires a lot of time.
To reduce the food waste in my household I need to buy new equipment/new technology.

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The local council provides satisfactory resources for recycling food waste.
My workplace provides satisfactory resources for recycling food waste.

Q8. Are you satisfied with this survey?

- Not at all satisfied
- Somewhat dissatisfied
- Neither satisfied nor dissatisfied
- Somewhat satisfied
- Very satisfied

Q9. If you have any additional comments, please write them:_____

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Appendix 3. Monitoring questionnaire for managers

It is important that the same person who has filled in the baseline manager questionnaire fills out this manager questionnaire as well (all other CozZo users above the age of 16 will fill out the participant questionnaire). If the person (manager) has changed, please collect their background information (at least age & gender).

Q1. Household code

Q2. What is your current responsibility in the food management of your household?

I am the only person in charge of food management in my household
I am one of the main people involved in food management in my household
I use or help with the food management without a decision-making role
I am distantly/indirectly involved in the use or support of the food management
Other (please specify)

Q3a. Has any of the background information (gender, level of education, work life situation, household composition, household income, vegetarians/vegans in household) changed since filling in the previous questionnaire? (Yes/No)

Q3b. If Yes → How? _____

Q4. Have some of your household members (i.e., at least one member) engaged in the following activities during the past two weeks? [Choose all that apply.]

Purchased grocery products near their expiry date (e.g., products discounted for their expired/soon-expiring date labels)
Purchased excess food from restaurants, cafes or other catering companies (e.g., through "food rescue" mobile applications)
Went dumpster diving (e.g., picked up products from grocery store recycling areas)
Picked up excess food from other people (e.g., family members, friends)

[RECORDING STARTS]

Q5. How frequently have you (personally) used the CozZo application so far?

several times a day
once a day
3-5 times a week
1-2 times a week
less than once a week

Q6. Please evaluate how many minutes a day (on average) you (personally) have dedicated to the use of the CozZo app? _____ minutes per day

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Q7a. How difficult was it to start using the CozZo app on a scale from 1 to 5?
(1=Very difficult, 5 = Very easy)
Q7b. Please describe your experiences of the app at the start. If you had any difficulties, please describe what kind of difficulties did you encounter?

Q8. How many shopping lists have your household members created on the app so far?

Q9. How many recipes have your household members created on the app so far?

Q10a. Have you built any wish lists by bookmarking items from ecommerce sites? (Yes/No)
Q10b. If Yes → Please explain about your experiences.

Q11a. Please evaluate how useful the CozZo app has been in helping your household to reduce food waste. (Likert scale 1–5: 1= not at all useful, 5=very useful)
Q11b. Please describe this in more detail:
- How has it helped your household in reducing food waste?
- How has it not helped?

Q12a. Please evaluate how useful each of the following features of the CozZo app have been in helping your household in food waste reduction. (1=not at all useful; 5=very useful; 6 = we have not used this feature, or we are not familiar with this feature)

8 o'clock "summary" notifications on expired/to expire items
Individual product expiry notifications on the best by/best before date
Expiry date-sorted inventory list (calendar icon)
Automatic estimation of product shelf life according to storage conditions (subzero, cold, normal)
"Cook Expiring Products" recipe list on "Boards" page

Q12b. Are there any other features that you have experienced as helpful in food waste reduction? If so, please describe.

Q13a. How useful do you think the CozZo app has been for improving your household's purchasing habits (e.g., planning, checking inventory etc.)? (Likert scale 1–5: 1=not at all useful, 5=very useful)
Q13b. Please describe this in more detail.
- How the purchasing habits have improved?
- Which features of the app have helped in this?
- How have they not improved?
- Which features of the app have not helped in this?

Q14a. Do you think your household's purchasing habits have changed in some other way not related to the use of CozZo since you started using the CozZo app? (Yes/No)

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Q14b. Please describe how they have changed.

Q15a. Have your household members purchased any food storage tools and equipment as a result of using the CozZo app (e.g., food containers, freezer or fridge)? (Yes/No)

Q15b. If Yes → Please describe in more detail.

Q16a. Since you started using the CozZo app, has your household's members' time spent in grocery shopping:

1=diminished
2=slightly diminished
3=stayed the same
4=slightly increased
5=increased

Q16b. Please describe in more detail.

Q17. Estimate (in euros), how much money does your household spend on food weekly (for a regular week, not including e.g., holidays or parties). Please make the estimation by calculating from your shopping receipts or debit/credit card statements. This amount excludes occasions of eating out or ordering take-away by household members.

_____ euros per week

Q18. Estimate (in euros), how much money does your household spend on food monthly for eating out or for ordering take-away meals?

_____ euros per month

Q19a. Do you think your household has saved money due to your use of the CozZo app? (Likert scale 1 = not at all, 5 = very much)

Q19b. Please describe in more detail.

Q20. During your usage of the CozZo app, please evaluate how often in your household food ended up wasted due to the following reasons.
(Scale 1-5: 1=never due to this, 5=very often due to this)

The date in the date label has passed.
The packaging size of the food I bought does not meet my needs and food is left over.
The food has spoilt (e.g., rotten or become mouldy) before I manage to use them.
I have prepared too much food for one meal.
I am not sure whether I can still eat the food and I throw it away just to be safe.
I don't want to eat the same kind of food for several days at a time.
I/we didn't like the taste of the food.

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Children leave food uneaten.
I buy ingredients for a recipe and part of them are left unused.
I buy food that I later do not fancy eating.
I/we have bought or ordered too much food.

Q21a. In the previous phase questionnaire, we asked you about the number of meals eaten per day, the weekly number of take-away meals as well as the number of the home-made/home-prepared meals for each member of the household during an average week. [Now the researcher goes through their previous answer to the question.] Have any of these numbers changed since then? (Yes/No)

Q21b. If Yes → Please fill in the number of meals in the following table for each household member.

Household member (list all, both adults and children)	Number of meals (excluding snacks) this person has *in an average day*	Number of times this person eats *take-away meals* (excluding snacks) at home *in an average week*	Number of times this person eats meals (excluding snacks) *out-of-home* (e.g., at a school or workplace canteen, restaurant etc.) *in an average week*	Number of *home-made or home-prepared meals* (excluding snacks) this person eats at home *in an average week*
Family member 1				
Family member 2				
Family member 3				
Family member 4				
Family member 5				
Family member 6				
etc.				

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Q21c. If yes: please explain the reasons for these changes (e.g. change in circumstances, such as school holidays)?

Q22a. Please evaluate how much the following skills you have (personally) improved thanks to the use of the CozZo app on a scale from 1 to 5.
(Likert scale 1–5: 1=no improvement at all, 5= improved a lot)

Technological skills, such as the use of mobile apps
Better understanding of food management at home (e.g., planning, buying, cooking, storing)

Q22b. Please describe in more detail:
- How has it improved your skills?
- Which features of the app have helped you in this?
- (If not What has prevented you from learning these skills?)

Q23a. Do you think you (personally) will keep using the app? (Yes/No/Not sure yet)
Q23b. What do you consider as the main strengths of this application?
Q23c. What do you consider to be the major weaknesses of this application?
Q23d. What features or capabilities you would like to be added to CozZo app?

Q24. How well the application has met your (personal) expectations (on a scale from 1 to 10)? (1 = not at all, 10 = very well)

Q25. How likely are you (personally) to recommend the use of CozZo app to your family, friends, etc. on a scale from 1 to 10? (1 = very unlikely, 10 = very likely)

Q26. How many people in your household have downloaded CozZo app on their devices?

Q27a. Are any of the above persons under the age of 16? (Yes/No)
Q27b. If Yes → Please indicate for each of them their
- age
- gender (female, male, other, no prefer not to say)
- role in food management: mostly in charge of food purchases (yes/no), mostly in charge of cooking (yes/no), participates in food purchasing (yes/no), participates in cooking (yes/no)
- how many minutes a day (on average) each of them have dedicated to the use of the CozZo app?

Q28a. Have you or any other in your household contacted either LOWINFOOD researchers or CozZo customer support about issues related to the use of CozZo app? (Yes/No)

Q28b. If Yes → How many times? _____

Q28c. If Yes → Regarding what types of issues?

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[RECORDING ENDS]

Q29. Please indicate how much you agree or disagree with the following statements (1- strongly disagree, 5- strongly agree)

[If you are a full-time student, please consider your school as your workplace. If you are a survey respondent temporarily out of work now, please consider your previous workplace.]

Everyday huge quantities of food are wasted in the world.
Wasting food at home is inevitable.
It is impossible to avoid food waste at the workplace.
The problem of food waste worries me a lot.
Wasting food is irresponsible.
When I waste food, I feel guilty.
Wasting food does not go against my principles.
Everybody has a responsibility to reduce food waste.
I do not care if I waste food.
I am committed to reducing food waste in my household.
I am committed to reducing food waste in my workplace.
The daily amount of food waste is a serious problem for the planet.
Food waste is a major economic issue.
Wasting food is wasting other resources such as water and energy.
Many people in our society do not care about their food waste.
My household supports my efforts to reduce food waste at home.
My colleagues support my efforts to reduce food waste at work.
I feel social/peer pressure to avoid wasting food.
I regularly throw away food that I could have consumed due to food spoiling
I seldom throw away food that could have been eaten because I have bought too much.
I regularly throw away food that could have been eaten because I have prepared too much food.
I know what to do to reduce food waste at home.
I know what to do to reduce food waste when I eat out.
I know what to do to reduce my food waste when eating at a restaurant.
I know what to do to reduce food waste at work.
I have the ability to recycle my unavoidable food waste such as the inedible peels, pits and stones of fruits and vegetables, bones in meat and fish etc.
I have control over the amount of food waste produced in my workplace.
I have control over the amount of food waste produced in my household.
Reducing food waste in my household is a hassle.
Reducing my food waste requires a lot of time.
To reduce the food waste in my household I need to buy new equipment/new technology.
The local council provides satisfactory resources for recycling food waste.

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My workplace provides satisfactory resources for recycling food waste.

Q30. How satisfied are you with this survey?

- Not at all satisfied
- Somewhat dissatisfied
- Neither satisfied nor dissatisfied
- Somewhat satisfied
- Very satisfied

Q31. If you have any additional comments, please write them:_____

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Appendix 4. Monitoring questionnaire for participants

For all other people who have been using the app and/or who have filled in the baseline survey also (besides the one user who has already filled the manager survey), only for those over 16 years of age.

Q1. Household code _____ [to be inserted by the researchers]

Q2. What is your responsibility in the food management of your household?

- I am the only person in charge of food management in my household
- I am one of the main people involved in food management in my household
- I use or help with the food management without a decision-making role
- I am distantly/ indirectly involved in the use or support of the food management
- Other (please specify)

Q3. What is your age?

- 16-17
- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65 or more

Q4. What is your gender?

- Female
- Male
- Other (please state in your own words)_____
- Prefer not to say

Q5. What is your current level of education?

- No qualifications after compulsory education/school
- High school or equivalent qualification
- Trade/technical/vocational training
- University or college undergraduate degree
- Post graduate education (masters or PhD degree)

Q6. Which of the following describes your current work life situation the best?

- Employed full-time (including self-employed)
- Employed part-time (including self-employed)
- Unemployed or laid off
- Student
- Stay-at-home parent

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On long-term sick leave
Retired
Other: please specify_____

Q7. How frequently have you (personally) used the CozZo application so far?
several times a day
once a day
3-5 times a week
1-2 times a week
less than once a week

Q8. Please evaluate, how many minutes a day (on average) you have dedicated to the use of the CozZo app. _____ minutes

Q9. How difficult was it to start using the CozZo app on a scale from 1 to 5?
(1=Very difficult, 5 = Very easy)

Q10. Please evaluate how much the following skills you have (personally, as an individual) improved thanks to the use of the CozZo app on a scale from 1 to 5.
(Likert scale 1–5: 1=no improvement at all, 5= improved a lot)
Technological skills, such as the use of mobile apps
Better understanding of food management at home (e.g., planning, buying, cooking, storing)

Q11. Do you think you (personally) will keep using the app? (Yes/No/Not sure yet)

Q12. How well the application has met your expectations (on a scale from 1 to 10)? (1 = Not at all, 10 = Very well)

Q13. How likely are you to recommend the use of CozZo app to your family, friends, etc. on a scale from 1 to 10? (1 = Very unlikely, 10 = Very likely)

Q14. Please indicate how much you agree or disagree with the following statements:
(1- strongly disagree, 5- strongly agree)

[If you are a survey respondent who is a full-time student, please consider your school as your workplace. If you are a survey respondent temporarily out of work now, please consider your previous workplace.]

Everyday huge quantities of food are wasted in the world.
Wasting food at home is inevitable.
It is impossible to avoid food waste at the workplace.
The problem of food waste worries me a lot.

LOWINFOOD has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000439.

Wasting food is irresponsible.
When I waste food, I feel guilty.
Wasting food does not go against my principles.
Everybody has a responsibility to reduce food waste.
I do not care if I waste food.
I am committed to reducing food waste in my household.
I am committed to reducing food waste in my workplace.
The daily amount of food waste is a serious problem for the planet.
Food waste is a major economic issue.
Wasting food is wasting other resources such as water and energy.
Many people in our society do not care about their food waste.
My household supports my efforts to reduce food waste at home.
My colleagues support my efforts to reduce food waste at work.
I feel social/peer pressure to avoid wasting food.
I regularly throw away food that I could have consumed due to food spoiling
I seldom throw away food that could have been eaten because I have bought too much.
I regularly throw away food that could have been eaten because I have prepared too much food.
I know what to do to reduce food waste at home.
I know what to do to reduce food waste when I eat out.
I know what to do to reduce my food waste when eating at a restaurant.
I know what to do to reduce food waste at work.
I have the ability to recycle my unavoidable food waste such as the inedible peels, pits and stones of fruits and vegetables, bones in meat and fish etc.
I have control over the amount of food waste produced in my workplace.
I have control over the amount of food waste produced in my household.
Reducing food waste in my household is a hassle.
Reducing my food waste requires a lot of time.
To reduce the food waste in my household I need to buy new equipment/new technology.
The local council provides satisfactory resources for recycling food waste.
My workplace provides satisfactory resources for recycling food waste.

Q15. How satisfied are you with this survey?

Not at all satisfied
Somewhat dissatisfied
Neither satisfied nor dissatisfied
Somewhat satisfied
Very satisfied

Q16. If you have any additional comments, please write them:_____

LOWINFOOD has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000439.