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Empowering People with Cognitive Disabilities to Live Independently By Supporting Their Self-Management of Food and Related Expenses

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EMPOWERING PEOPLE WITH COGNITIVE DISABILITIES TO LIVE

INDEPENDENTLY BY SUPPORTING THEIR SELF-MANAGEMENT OF FOOD

AND RELATED EXPENSES

by

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ABSTRACT

EMPOWERING PEOPLE WITH COGNITIVE DISABILITIES TO LIVE
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Apoorv Prasad

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People with ADHD (attention deficit hyperactivity disorder) often have difficulty in planning and organization that can impact their eating habits and lifestyle. We have created a novel mobile software application to support choosing meals and making healthy food purchases that meet dietary preferences within a specified budget. The core functions allow 1) Managing user profiles to support personalization 2) Obtaining recipe recommendations to fit profile, budget, and foods-on-hand 3) Planning food purchases, and 4) Reviewing foods-on-hand, budget and the nutritional balance of recent meals and food purchases.

The application supports self-introspection to help people with ADHD review their history of food purchases and consumption, using both scrollable inventories and visualizations of their aggregated behavior. These functions allow users to easily see how their choices distribute across different broad categories of food. This information provides a basis for them to make more informed decisions on their future purchases, while being mindful of the most and least frequently discarded foods. A user study was conducted to assess the usability of the app and to determine how different patterns of use correlate with food or shopping related behaviors that might impact the target population. 65% of the subjects found that providing the various types of data requested

seemed relevant and easy to do. On the other hand, 84% of the subjects feel that charts helped them to understand how well they were doing at keeping a budget, using foods, and not throwing away much.

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1 Introduction

1.1 Problem Statement & Rationale

There are over 16 million adults in the US who have an attention disorder. While there are plenty of resources telling them that they should be more organized, there are almost no software tools specifically designed to help them self-manage tasks they need to do to live independently, like plan, shop and cook meals on a budget. Most food consumption tracking apps in today's marketplaces (Apple's App Store or Google's Play Store) focus on helping users track calories, macronutrients, and calorie intake recommendations based on food allergies, BMI (Body Mass Index), target weight goal, etc. A few other food-based apps focus on providing recipe recommendations based on the user's diet and the ingredients on hand. And, some apps allow users to create a shopping list and track food on-hand. Though there are so many food-based tracking apps, little to no work has been done towards people with cognitive disabilities to empower them to live independent and healthy lives by supporting their efforts to manage their food and related expenses.

People with Attention Deficit Hyperactivity Disorder (ADHD) can find the tasks essential to independent living, such as money management, shopping, and preparing healthy meals to be challenging. It then becomes a risk for them to run out of food or money to purchase it before receiving additional income. They might also fail to buy the right balance of ingredients to create home-made meals; they might forget what foods they have on hand or need suggestions about using them effectively. Together, these risks can result in poor nutrition or missed meals, which can aggravate their disability. Those affected by these risks are sometimes aware of their limitations, but might be, reluctant to seek help or be averse to shopping in public, as fearing

criticism from others, a condition is known as "Rejection sensitive dysphoria" (RSD), is often a part of their disorder [7].

With ADHD, one finds it challenging to establish consistent eating habits because of impulsivity and inattention, leading to a lack of self-awareness and self-regulation. Questions, including "What can I eat today?" and "What food should I buy?" demand planning, preparing a schedule or investing time to shop, explore food groceries, as well as to make decisions of "What can be cooked today?". To make certain conclusions like that, it could be strenuous for ADHD cohorts. For example, they might fail to purchase a coherent balance of ingredients adequate for preparing meals. They might have difficulty forming an association with what ingredients or foods to utilize and consume before their expiration.

Furthermore, certain people with ADHD appear to have anxiety and depression [1], which may lead to meals being missed only to find themselves hungry and then overeating or binge eating as a repercussion. A person with ADHD is more prone to unplanned and spur-of-the-moment eating, possibly compromising physical condition over time [2]. Making more informed choices of what to eat and buy can help encourage more regular healthy eating and avoid food waste [2].

1.2 Research Objectives

Our research involves designing a software app specifically for people with ADHD related to managing the combination of tasks associated with eating and shopping for food. It will provide a straightforward user interface, with a layout that naturally reminds them of things they need to keep track of, without being intrusive. The transaction logs of the backend database could also be used to monitor for unsafe behaviors, such as skipping meals or binging on foods. The approach follows the principles of universal design – everyone should benefit, including those who have a

disorder. Specifically, the functionality supports food shopping, keeping track of foods on hand, searching for meal ideas that make the best use of food-on-hand, and reviewing the amount of money that has been spent on different types of food. The interface has been designed (and revised) to suggest the typical sequence of tasks: think about what foods you have, look for meal ideas, shop for things you need, record what you buy, eat and throw away. One can also review what has happened over the last week or month – how much money has been spent, how balanced one's diet has been over macronutrients, etc. Our goal is to see if this can help the target population make better use of their food budget, by examining whether it is possible to detect correlations between tasks involved with preparing to eat (searching for recipes or shopping) or task involved with self-monitoring, and reports related to using or disposing of food.

1.3 Research Approach

We created an initial version of the software, did a pilot test, made some revisions and then did a retest, along with a calculation of possible correlations between several behaviors that can be deduced from the usage logs. The first part of the study involved human subjects who live independently to see how they feel about using the app and what functions they will use and report as helpful. We examined what software features were being utilized by the user in making certain decisions such as buying meals, purchasing foods, recording usage, diet preferences, recipe search, visualization of data with charts in the interface, etc. We made some improvements to the user interface and did a second pilot study.

At the conclusion of both studies, we analyzed how food shopping frequency correlates with different food-related behaviors – using this measure as a proxy for (lack of) food planning, a

possible sign of ADHD and to make suggestions for future development. Based on the evidence already obtained we are developing a better recipe recommendation engine that will be a collaborative filtering-based recommendation algorithm for the recipe search module to help users find and explore various recipes based on other users that tend to have similar interests and behavior. This will allow it to address a variety of possible subgroups, including differences based on culture or income, without the user needing to explicitly add that information to their profile.

2 Background

2.1 ADHD & Eating behaviors

Fliers, Ellen A., et al. [4] conducted a study of 372 Dutch children of age between 5-17 years diagnosed with ADHD combined type. They found that for both boys and girls when they reach the age of 10, they have elevated risk of being overweight or obese.

Hershko, Shirley, et al. [5] investigated whether ADHD in students is correlated with overeating or making bad food choices. They found that for the 60 university undergraduate participants for their study age 20-30 years, the ADHD cohort had higher average BMI (24.02 vs 21.17, SD=3.02). However, both groups (i.e., ADHD students and non-ADHD students) consumed the same amount of servings, calories, and nutrients. They observed that ADHD students appeared to consume more unhealthy food and make more bad food choices rather than overeating.

Ptacek, Radek, et al.[2] took into account both quantitative and qualitative findings in their study, which included 100 boys with mixed type ADHD by DSM-IV criteria and 100 healthy male control subjects with an age range of 6 - 10. The quantitative analysis focused mainly on the number of meals per day in the ADHD versus the control group. The qualitative analysis considered the type of beverage consumption, fruit and vegetable intake, and the number of hours spent watching TV or computer in the ADHD and control group. They determined that 24% of ADHD children usually skip breakfast (vs. 9% in the control group), 45% miss dinner (vs. 0% in the control group), and 87% consume meals more than five times daily. From the qualitative point of view, 55% of ADHD children consumed a sweetened beverage, only 13% had fruit/vegetable intake within a week and spent more hours than the control group watching TV or computer.

Brunault, Paul, et al. [3] examined the extent of possibility for food addiction among obese patients diagnosed with adult ADHD. The participants' set was mainly adult obese patients with a BMI

greater than or equal to 35 kg/m2. For the first study phase, 125 patients were evaluated on the Yale Food Addiction Scale (YFAS) 2.0 and the Binge eating scale by completing self-administered questionnaires. In the final stage, for 105 patients, the psychiatric evaluations were done by using DIVA (Diagnostic Interview for ADHD in adults) 2.0. Around 9% of 77 patients without ADHD and 28.6% of 28 patients with ADHD were at higher risk for food addiction. Moreover, 6 out of 68 (8.8%) obese patients without childhood ADHD and 9 out of 37 (24.3%) obese patients with childhood ADHD were at higher risk for food addiction.

Based on the studies for examining the correlation between ADHD and eating disorders[6], we found that patients with ADHD are more prone to eating disorders (Bulimia Nervosa, Binge eating disorder), which increases the individual's BMI (Body Mass Index), leading to being overweight or obese. These food disorders are known to increase the risk for many severe health problems such as heart disease, type 2 diabetes, high blood pressure, kidney disease, etc., impacting overall well-being with time. Thus, providing an acceptable means for ADHD to better self-regulate their eating behavior would be beneficial.

2.2 Preliminary Software Survey

To confirm the need for a software-based solution, we considered what relevant software might already be available. Since the goal is to improve links between meal planning and food consumption, our primary focus was on the meal and budget tracking apps rather than the apps that track calories and macro/micronutrients to achieve a weight goal. On 20th September 2020, we searched for "meal and budget tracking apps" and found very few apps in the marketplace. The apps that we found relevant to what we were looking for are shown in Table 2.1.

App Name	Total Reviews	Overall Rating
Out of Milk - Grocery Shopping List	234,326	4.5
Our Groceries Shopping List	47,138	4.6
Shopping List	25,802	4.7
That Shopping List	23,951	4.6
AnyList: Grocery Shopping List and Recipe Organizer	4,167	4.7

Table 2.1 Preliminary Survey of Software

While most of these apps have an average rating of at least 4.5, none of them would address helping people with cognitive disabilities (ADHD) make independent decisions on buying and eating food.

Out of Milk - Grocery Shopping List: It has a feature that makes transferring or copying pantry items between the shopping list and pantry list simple for users. Users can also share their to-do, pantry, and grocery lists by text or email. It is also possible to access these lists online through the web at http://www.outofmilk.com/.

Its Recipe Book module doesn't seem quite helpful if the user intends to search for recipes, however. It re-directs to the WebView of https://www.epicurious.com/, and after entering the search term for a food recipe, it returns search results of various kinds ranging from gallery to video to article, which are mostly sponsored ad contents. After the user saves a particular recipe in their Recipe Book, the list view of ingredients doesn't give any information about the quantity needed for each ingredient to cook food. If the user wants to view the recipe's instructions, he/she, after selecting the 'Go to recipe' option, will be re-directed to another browser-based app on their phone. Thus, the user will need to leave the app until the user again needs to open the app.

Our Groceries Shopping List: This app's primary feature is that it allows users to keep the grocery list of their families synchronized with recent updates and can be accessed either on the phone or the web browser. While adding the items to the shopping list, there is no way in which the user can specify the exact quantity unit required to purchase. Instead, the user has the option "Fewer" and "More" to decrement/increment in terms of number, but without quantity unit.

Users can add the recipe, but one cannot search recipes in the app. For a particular recipe, one can add the ingredients, but not with the actual quantity unit, just in terms of numbers. If the user doesn't upgrade the app by paying $4.99, then ads are displayed on various parts of the app, with no significant improvements such as specifying quantity units while creating a shopping list and adding ingredients to a recipe.

Shopping List: The app's interface is very minimalistic, and we found it to be of not much significance, rather a straightforward application. Users can create/manage different types of shopping lists and add/position items in a list. They can cross-off the items they bought, but the app doesn't record much information about the items such as quantity, price, purchased date, use-by/expiry date, etc. It also displays ads at the bottom of the screen, and one needs to make a purchase of around $1, to remove the ad display.

That Shopping List: This app appears to be a refined UI version of Shopping List with a color scheme for tagging different food categories. The functions are the same as Shopping List. The only exception is that one can add the amount of the item on their shopping list. It also displays ads at the bottom of the screen, and one needs to make a purchase of around $2.99, to remove the ad display.

AnyList: Grocery Shopping List and Recipe Organizer: We found the features offered by the app quite appealing such as recipe web import, meal planning calendar and adding recipe photos.

However, it gets cumbersome when the user wants to add a recipe through the app. The user will need to add the ingredients line by line, and while adding the quantity of an ingredient, the user must perform another screen navigation by tapping on the ingredient's name tab. Other than that, the user can't search for recipes in the app, and they will have to store the recipe manually in the app.

Also, a user will need to upgrade the app by paying $9.99 for 1 year, to enable support for adding prices to food/grocery items. Even purchasing the upgrade doesn't help users track use-by/expiry date, the storage location of food items, and recording their consumption with time.

3 Track Your Food Prototype

3.1 Technology Stack & Overall Architecture

For the front-end, we have utilized the React Native framework. It is a JavaScript framework that supports the compilation of components for building user interfaces and then rendering them to native widgets for iOS and Android mobile platforms. To render iOS components, it invokes Objective-C APIs, and for Android components, it invokes Java APIs, which facilitates user experience as with native apps. React Native uses JSX - which connects markup and JavaScript code, which allows developers to add their rendering logic to the UI components with ease.

A React Native project comprises multiple UI components. It gets challenging to manage each application module's states and the flow of data across various components to child components. To overcome this complexity, we have used Redux (a third-party JavaScript library) [14], which helps manage the application state and has a central store updated via Action and Reducer. The central store is like a memory, but not the database, which stores the entire application state. The user interacts with the application, and whenever there is any modification of data, the dispatch (send data) happens through Action. The Reducer then receives the Action and derives the new state based on the old state, updating the central store.

There are two primary limitations of development with React Native, as follows

1. If there arises a need for intricate designs or sophisticated interactions for different mobile platforms, a developer might need to build it from scratch, which could be time-consuming.

2. Custom modules must be updated with the latest React Native version, to avoid the possibility of conflicts and runtime errors.

For the backend, we have utilized the Firebase server-side API to communicate with the Realtime Database (NoSQL), which has a fully managed backend. It has a set of protocols for communication between different parts of the application. An authenticated user can access the API using endpoints, typically URL patterns that one can use to specify what particular information or service (datastores) they want to access (GET), add some data (POST) or perform the update (PUT, PATCH), deletion (DELETE) that is supported by the API. The limitations of Firebase's Realtime database are as follows [13]:

1. It stores the data as one large JSON tree, making complex, hierarchical data more challenging to organize and scale.

2. It suffers significantly downgraded performance while making queries as the data set increases.

3. A developer can make a single query with either a filter or sort on a property, but not both, i.e., no chaining and combining with filter and sort.

3.2 Integrated Development Environment (IDE)

To manage the overall complexity of the application, we made use of WebStorm, which is a professional JavaScript IDE developed by JetBrains. It supports intelligent-code completion, on-the-fly error detection, and refactoring suggestions for the React Native framework [15]. It also has Version Control with Git integration, which is quite useful when dealing with source control conflicts. However, we found that the IDE is very resource-intensive (takes at least 550 MB of memory) and noticeably slow to startup.

3.3 Use Cases and Data Flow Diagrams

For each primary function, we developed a set of use cases that specify: the primary task (description) and the objective it addresses (triggers), the preconditions and postconditions, the basic, alternative and exceptional flows [8], comprising the steps the user will take to complete the task. There are four subgroups of use cases (3.4, 3.5, 3.6, 3.7) and each subgroup contains one to five cases, covering the basic tasks of creating a secure login and setting preferences, updating food inventories and shopping lists, recording foods as eaten or discarded and searching for recipes. The number of steps in each basic flow ranges from 3 to 18 steps. These use cases define the coverage of the app, guidance for white box testing, and an outline for the user-level documentation.

Along with the use-cases, we also defined Data Flow Diagrams (Figures 3.2 – 3.10) that helped us define interaction with the Firebase server-side API to communicate with the cloud database, which has a fully managed backend. The meaning of symbols used in the Data Flow Diagrams are defined in Figure 3.1. To provide recipe recommendations, we have made use of the Spoonacular Recipe API (External datastore) which contains information (ingredients required, step-by-step instructions) of more than 365,000 recipes. This API enables an application to refine the recipe search by taking into account a user's diet preferences such as vegan, vegetarian, pescatarian, gluten free, grain free, dairy free, high protein, low sodium and low carb.
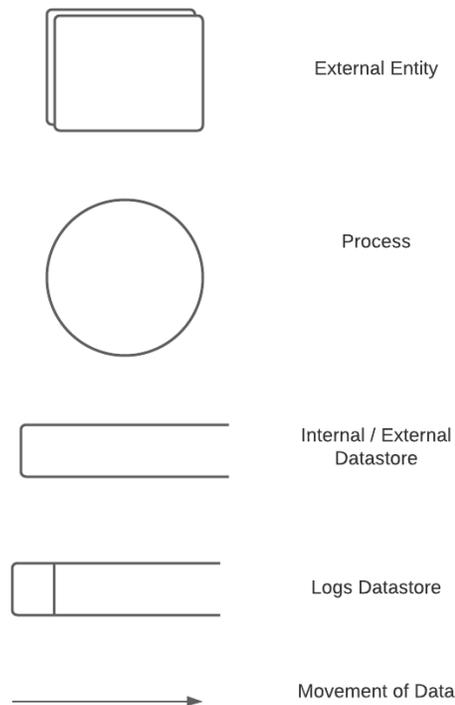
Figure 3.1 Symbols and their meanings for Data Flow Diagrams

3.4 Use Cases for accessing and providing foods-on-hand information to the application

Unique Identifier	3.4.1
Title	Signup to the Track Your Food application.
Description	Creation of account for the first time or new user.
Actor	New User
Preconditions	The new user has installed the application on the phone.
Post conditions	The new user will be able to login with their credentials after successful creation of the account.
Triggers	A need to use the Track Your Food application.
Basic Flow	1. Installs the app. 2. Launches the app from the phone. 3. Move into email id designated area. 4. Enter email id. 5. Move into password designated area. 6. Enter password. 7. Activate the email id/password validation.
Alternative Flow	Alternate to step 7.

	7. Account created after successful validation.
Exception Flow	Added after step 7
	8. User not able to create the account since email id is not matching the general format.
	9. Repeat steps 3 to 7.
	10. User not able to create the account since email id is already registered in the application's database.
	11. Repeat steps 3 to 7.
	12. User not able to create the account since password doesn't match the expected length of characters and format.
	13. Repeat steps 3 to 7.
	14. User not able to create the account since email id and/or password fail the validation.
	15. Repeat steps 3 to 7.

Table 3.1 Signup to the Track Your Food application.

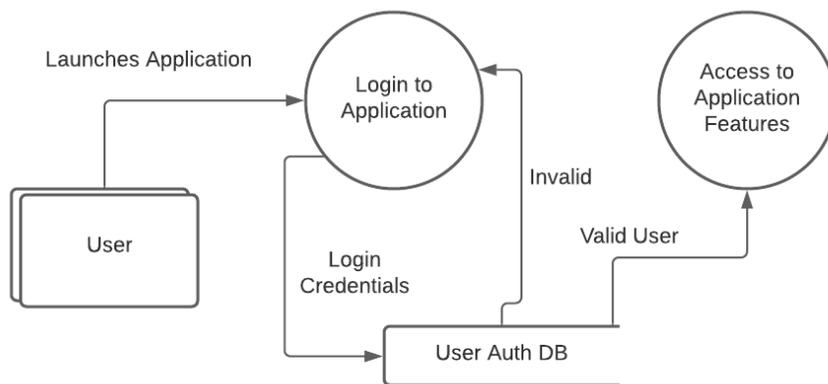|	
Unique Identifier	3.4.2
Title	Login to the Track Your Food application.
Description	Gain user access into the Track Your Food application.
Actor	Track Your Food users
Preconditions	Actor has been enrolled in the Track Your Food application.
Post conditions	The actor gains access to the Track Your Food application.
Triggers	A need to use the Track Your Food application.
Basic Flow	1. Launches the app from the phone.
	2. Move into email id designated area.
	3. Enter email id.
	4. Move into password designated area.
	5. Enter password.
	6. Activate the email id/password validation.
Alternative Flow	Alternate to step 6.
	6. Granted access after successful validation.
Exception Flow	Added after step 6
	7. User access is denied since email id and/or password do not match what is in the application's database.
	8. Repeat steps 2 to 6.

Table 3.2 Login to the Track Your Food application.

Figure 3.2 Data Flow Diagram of login to the application

Unique Identifier	3.4.3
Title	Creation of dynamic user profile by including diet preferences.
Description	The enrolled user can set up the diet preferences (if any) to the Track Your Food application.
Actor	Track Your Food users
Preconditions	The actor has signed in with an active session into the Track Your Food application.
Post conditions	The actor has specified one or more than one dietary preferences, which allows the application to understand the actor's needs and make relevant recommendations when searching for recipes.
Triggers	A need to create a profile for actors and getting recommendations for recipe ideas based on diet preferences.
Basic Flow	1. Navigates to the Profile module of the application. 2. Toggles (either yes or no) across the set of diet preferences in the designated area. 3. An actor profile with information about diet preferences is created.

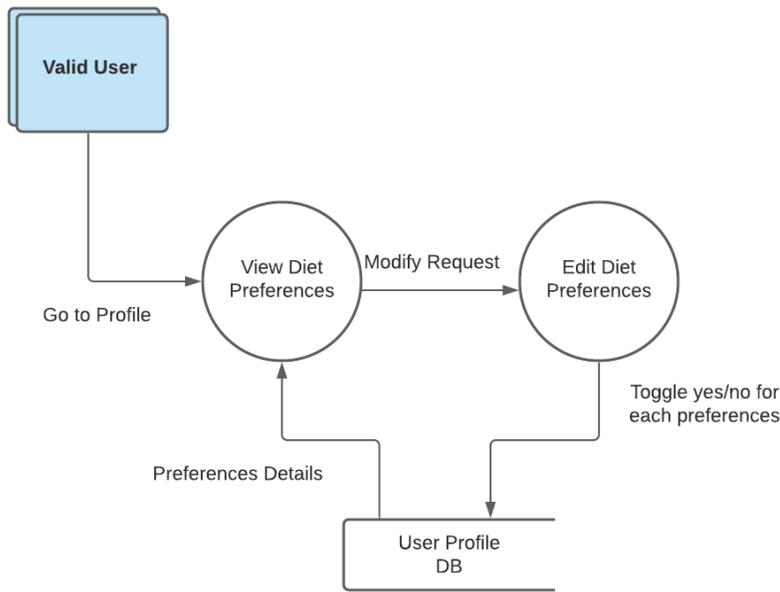Table 3.3 Creation of dynamic user profile by including diet preferences.

Figure 3.3 Data Flow Diagram of adding or modifying diet preferences

Unique Identifier	3.4.4
Title	Ability to add grocery items to the inventory.
Description	The enrolled user can add current grocery items and categorize them based on ingredients, produce, meats, and others (i.e., bakery, milk, eggs, etc.) to the Track Your Food application.
Actor	Track Your Food users
Preconditions	The actor has signed in with an active session into the Track Your Food application.
Post conditions	The actor has specified one or more than one grocery items along with price, quantity, and use-by date, allowing the actor to decide what to shop or cook and help the application make relevant recommendations when searching for recipes.
Triggers	A need to add grocery items into the application from time to time to effectively track quantity and use-by date whenever required and get recommendations for recipe ideas based on foods-on-hand.
Basic Flow	1. Navigates to the Inventory module of the application. 2. Selects the Grocery submodule for recording or tracking grocery items. 3. Selects the + (Add) button from the designated area to add a grocery item. 4. Move into store name designated area.

	5. Enter store name. 6. Move into item name designated area. 7. Enter item name. 8. Move into item category designated area. 9. Choose one of the categories from the dropdown list. 10. Move into item quantity designated area. 11. Enter item quantity. 12. Move into item storage location designated area. 13. Choose one of the storage locations from the dropdown list. 14. Move into item price designated area. 15. Enter item price. 16. Move into item use-by date designated area. 17. Select item use-by date from the date picker. 18. Activate the grocery item validation.
Alternative Flow	Alternate to step 16. 16. Grocery item saved to the user's inventory after successful validation.
Exception Flow	Added after step 16. 19. Item cannot be saved to the user's inventory since the store name is not entered or not meeting the characters' minimum length. 20. Repeat steps 3 to 16. 21. Item cannot be saved to the user's inventory since the item name is not entered or not meeting the characters' minimum length. 22. Repeat steps 3 to 16. 23. Item cannot be saved to the user's inventory since the item category is not selected. 24. Repeat steps 3 to 16. 25. Item cannot be saved to the user's inventory since the item quantity is not entered or not meeting the minimum quantity. 26. Repeat steps 3 to 16. 27. Item cannot be saved to the user's inventory since the item storage location is not selected. 28. Repeat steps 3 to 16. 29. Item cannot be saved to the user's inventory since the item price is not entered or not meeting the minimum price. 30. Repeat steps 3 to 16.

	31. Item cannot be saved to the user's inventory since the use-by date is not selected or made invalid date selection.
	32. Repeat steps 3 to 16.
	33. Item cannot be saved to the user's inventory due to failure in more than one different combinations of validation.
	34. Repeat steps 3 to 16.

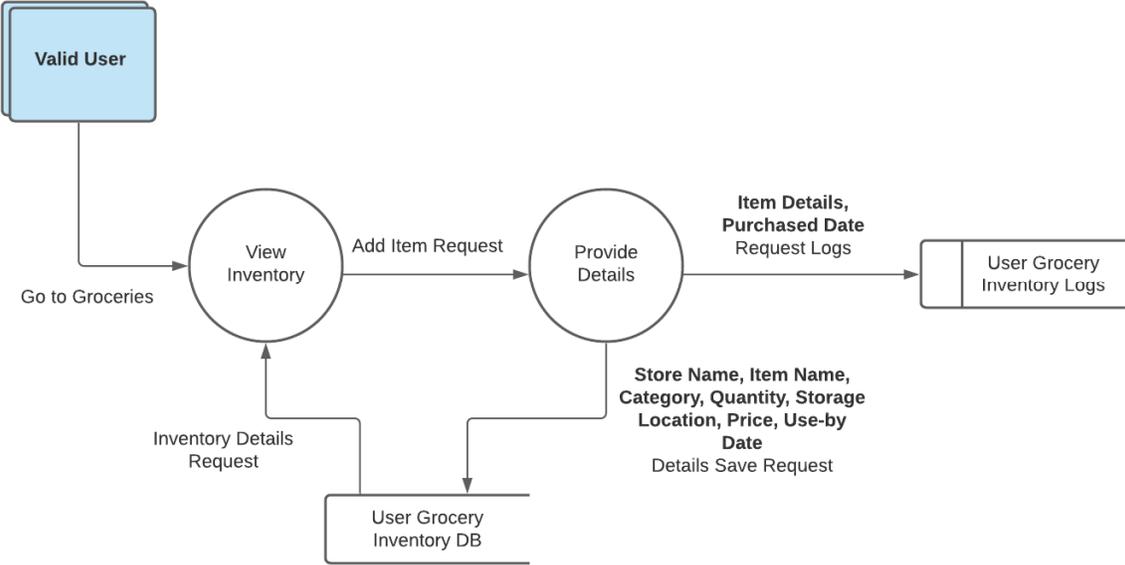Table 3.4 Ability to add grocery items to the inventory.

Figure 3.4 Data Flow Diagram of adding grocery items to the inventory

Unique Identifier	3.4.5
Title	Ability to add meal items to the inventory.
Description	The enrolled user can add current meals items and categorize them based on breakfast, lunch, snacks and dinner to the Track Your Food application.
Actor	Track Your Food users
Preconditions	The actor has signed in with an active session into the Track Your Food application.
Post conditions	The actor has specified one or more than one meal items along with servings, type (homemade or bought outside), price (only if bought outside), use-by date etc., allowing the actor to plan the meals, and decide what/when to consume food.

Triggers	A need to add meal items into the application from time to time to effectively track servings and use-by date whenever required.
Basic Flow	1. Navigates to the Inventory module of the application. 2. Selects the Meal submodule for recording or tracking meal items. 3. Selects the + (Add) button from the designated area to add a meal item. 4. Move into item name designated area. 5. Enter item name. 6. Move into item type (homemade or bought outside) designated area. 7. Choose one of the types from the list. 8. Move into item category (breakfast, lunch or dinner) designated area. 9. Choose one of the categories from the list. 10. Move into item servings designated area. 11. Enter item servings. 12. Move into item price designated area (if bought outside). 13. Enter item price (if bought outside). 14. Move into item use-by date designated area. 15. Select item use-by date from the date picker. 16. Activate the grocery item validation.
Alternative Flow	Alternate to step 16. 16. Meal item saved to the user's inventory after successful validation.
Exception Flow	Added after step 16. 17. Item cannot be saved to the user's inventory since the item name is not entered or not meeting the characters' minimum length. 18. Repeat steps 3 to 16. 19. Item cannot be saved to the user's inventory since the item type is not selected. 20. Repeat steps 3 to 16. 21. Item cannot be saved to the user's inventory since the item category is not selected. 22. Repeat steps 3 to 16. 23. Item cannot be saved to the user's inventory since the item servings is not entered or not meeting the minimum servings. 24. Repeat steps 3 to 16.

	25. Item cannot be saved to the user's inventory since the item price is not entered or not meeting the minimum price.
	26. Repeat steps 3 to 16.
	27. Item cannot be saved to the user's inventory since the use-by date is not selected or made invalid date selection.
	28. Repeat steps 3 to 16.
	29. Item cannot be saved to the user's inventory due to failure in more than one different combinations of validation.
	30. Repeat steps 3 to 16.

Table 3.5 Ability to add meal items to the inventory.
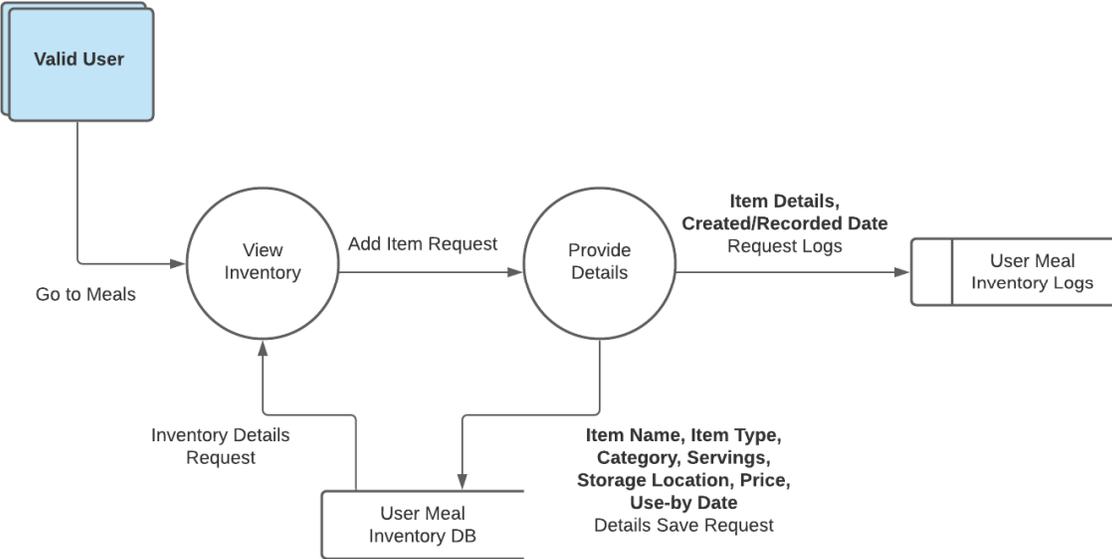

Figure 3.5 Data Flow Diagram of adding meal items to the inventory

3.5 Use Cases for recording consumption of food-on-hand, helping to plan future purchases

Unique Identifier	3.5.1
Title	Record the consumption of food-on-hand
Description	The enrolled user can record the consumption, which will update the current quantity or servings left, use-by date for grocery and meal items in the inventory.
Actor	Track Your Food users

Preconditions	Actor has been enrolled in the Track Your Food application and have at least one meal or grocery items in their inventory.
Post conditions	The actor has specified quantity or servings left, use-by date for meal and grocery items, which allows the application to track the actor's consumption and make relevant recommendations when searching for recipes.
Triggers	A need to log food consumption in real-time into the application from time to time to effectively track quantity or servings to anticipate purchase, use-by date to have food before it expires and get recommendations for recipe ideas based on foods-on-hand.
Basic Flow	1. Navigates to the Inventory module of the application. 2. Selects one of the Inventory submodules (Grocery or Meal) to view the items. 3. User has selected the Grocery or Meal submodule. 4. Selects one of the grocery or meal items from the list to log consumption or change use-by date. 5. Updates the consumption to either quarter (25%), half (50%), three-fourths (75%) or full (100%) of the current quantity or servings. 6. Update the use-by date from the date picker (if required).

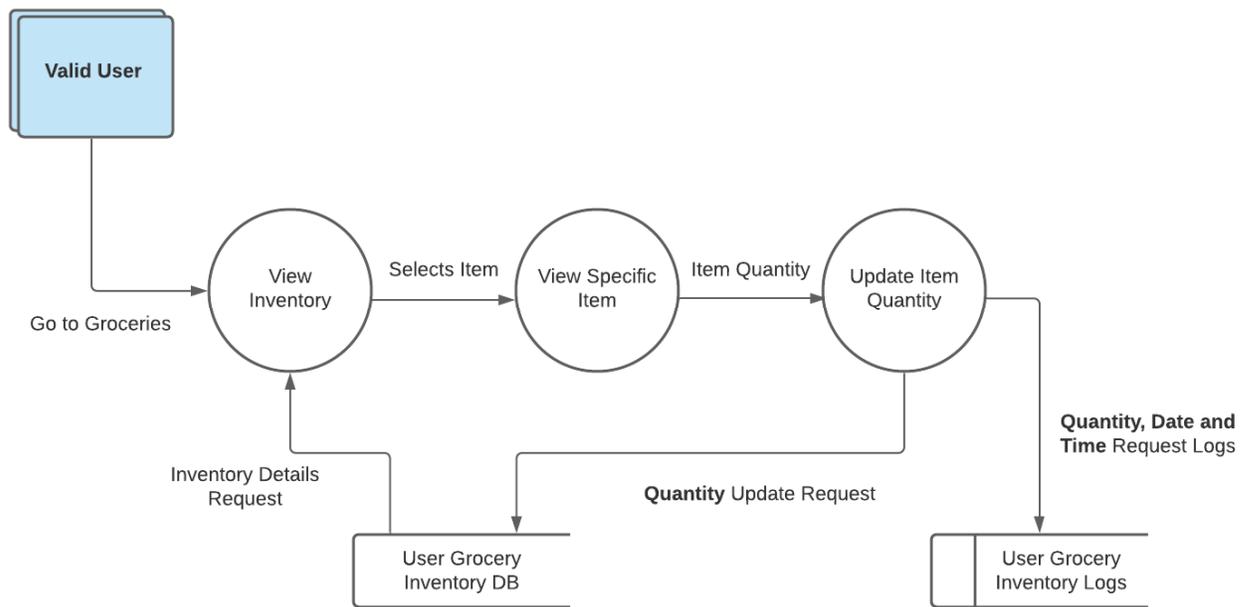Table 3.6 Record the consumption of food-on-hand

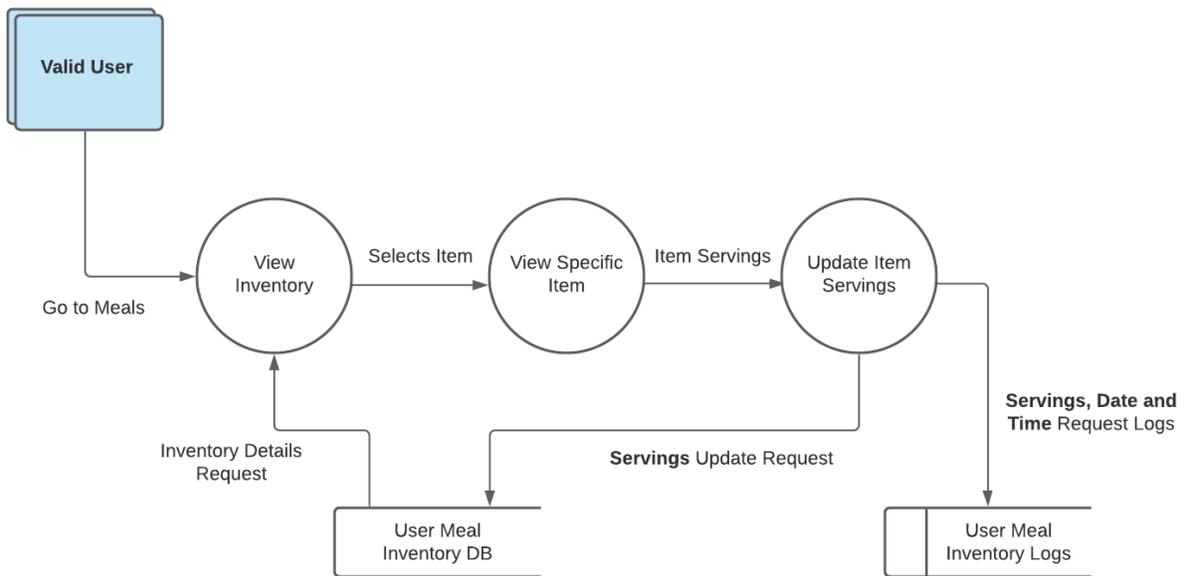Figure 3.6 Data Flow Diagram of recording consumption of grocery items

Figure 3.7 Data Flow Diagram of recording consumption of meal items

Unique Identifier	3.5.2
Title	Ability to plan future purchases of ingredients needed to cook a meal item.

Description	Planning future purchases helps make sure that the person will not be at the risk of running out of ingredients and estimate the appropriate amount of ingredients required to cook a meal.
Actor	Track Your Food users
Preconditions	Actor has been enrolled in the Track Your Food application and have at least one meal in their meal inventory.
Post conditions	For preparation of food at home, the actor can add list of items to be purchased. Foods-on-hand will be increased when purchases are recorded and reduced when foods are prepared.
Triggers	A user needs to be aware of what ingredients are currently available in the inventory and evaluate the appropriate amount of ingredients that need to be purchased for a meal or full serving in their meal plan.
Basic Flow	1. Navigates to the Meal module of the application. 2. Selects one of the meals from the list of meals. 3. Move into the ingredients designated area. 4. Enter the list of ingredients one-by-one and estimated quantity for each. 5. Validate the availability of all ingredients of that meal item. 6. One-click the ingredients to the shopping list that are marked "red" which signifies either not available or in less amount from the inventory. 7. Navigates to the shopping list, record the purchase (quantity, price, name etc.) when bought, which eventually gets added to the inventory.

Table 3.7 Ability to plan future purchases of ingredients needed to cook a meal item.
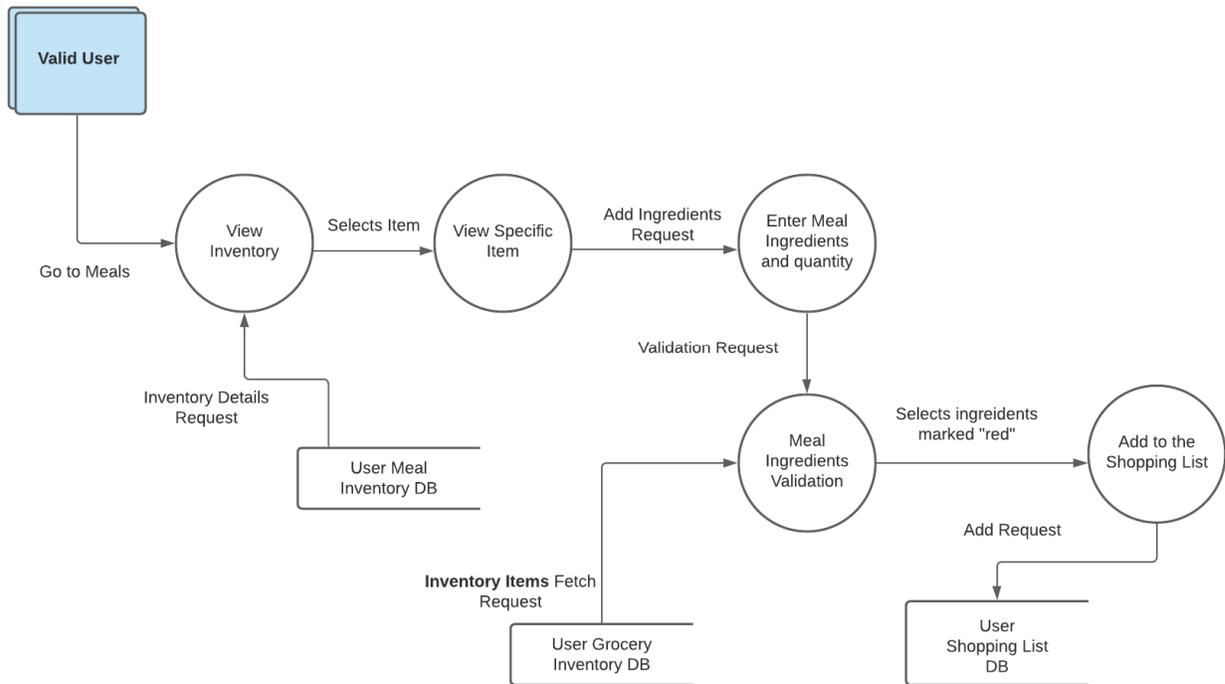
Figure 3.8 Data Flow Diagram of planning purchases of ingredients to cook a meal

3.6 Use Case for searching recipes, and saving recipes to the list of favorites

Unique Identifier	3.6
Title	Ability to search for recipes and saving recipes to the favorite list
Description	Recommending recipes that best match the user's diet preferences (if any), and the foods-on-hand.
Actor	Track Your Food users
Preconditions	Actor has been enrolled in the Track Your Food application, specified diet preferences and have at least one grocery item in their inventory.
Post conditions	The recipes are generated in the scrollable interface and categorized into preparation times, i.e., less than 30 minutes and more than 30 minutes, which takes into account of user's diet preferences and sorted based on the availability and close to the use-by date of foods-on-hand.
Triggers	A need to search for recipes in the application from time to time to get meal ideas and save the favorite recipes, which aids the user access them later whenever needed.

Basic Flow	1. Navigates to the Recipe module of the application.
	2. Move into search term input designated area.
	3. Choose one of the recipes from the scrollable list.
	4. Selects the Ingredients submodule for viewing the list of ingredients needed to prepare the food.
	5. Move into the mark favorite designated area.
	6. Saves the recipe to favorites list if favorite is marked.
Alternative Flow	Alternate to step 4.
	4. Selects the Instructions submodule for viewing the step-by-step instructions needed to prepare the food.
	Alternate to step 4.
	4. Selects the Availability submodule for viewing the list of ingredients available in user's inventory needed to prepare the food.
	Alternate to step 6.
	6. Recipe is not saved to favorites list if favorite is unmarked.

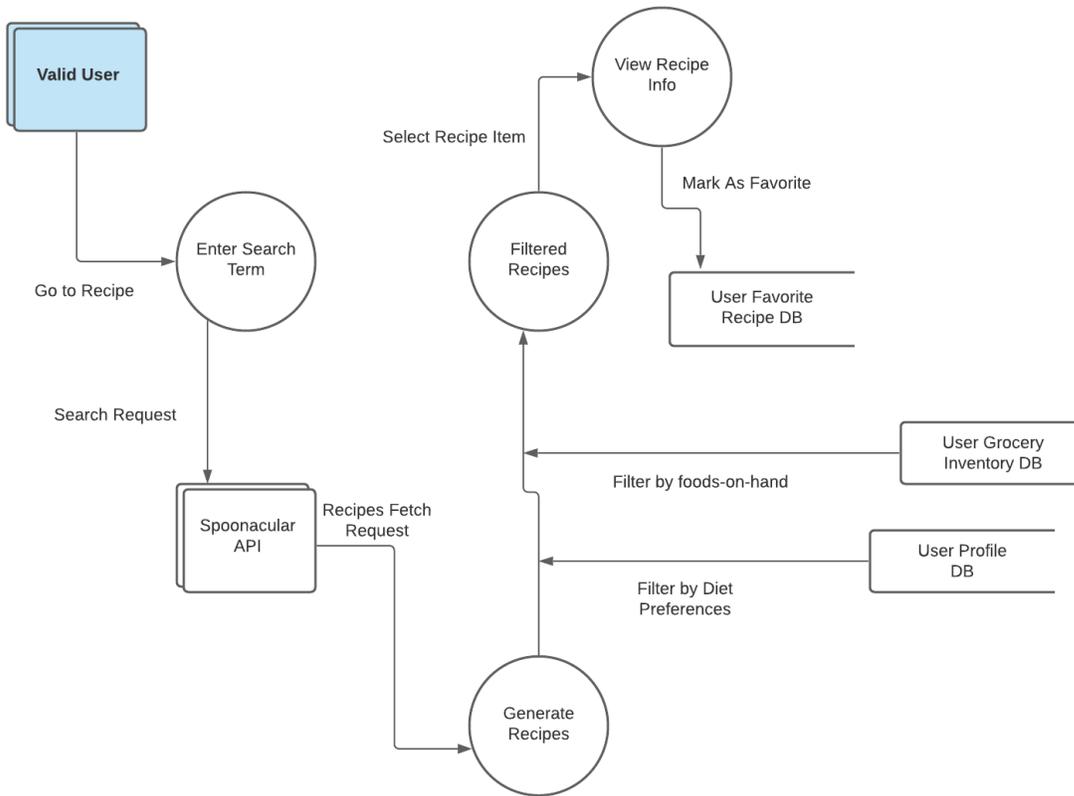Table 3.8 Ability to search for recipes and saving recipes to the favorite list.

Figure 3.9 Data Flow Diagram for searching and saving recipes

3.7 Use Case for discarding grocery/meal items

Unique Identifier	3.7
Title	Discard Grocery or Meal Items from inventory
Description	The enrolled user can discard one or more expired items from inventory, which will remove the item from inventory.
Actor	Track Your Food users
Preconditions	Actor has been enrolled in the Track Your Food application and have at least one expired meal or grocery items in their inventory.
Post conditions	The actor has discarded one or more expired items from inventory, which allows the application to track the actor's discard behavior.
Triggers	A need to log discard of food items in real-time into the application from time to time to effectively how much budget has been spent on discarded items.
Basic Flow	1. Navigates to the Inventory module of the application. 2. Selects one of the Inventory submodules (Grocery or Meal) to view the items.

| | 3. User has selected the Grocery or Meal submodule. |
| | 4. Selects one of the expired grocery or meal items from the list to discard from inventory. |

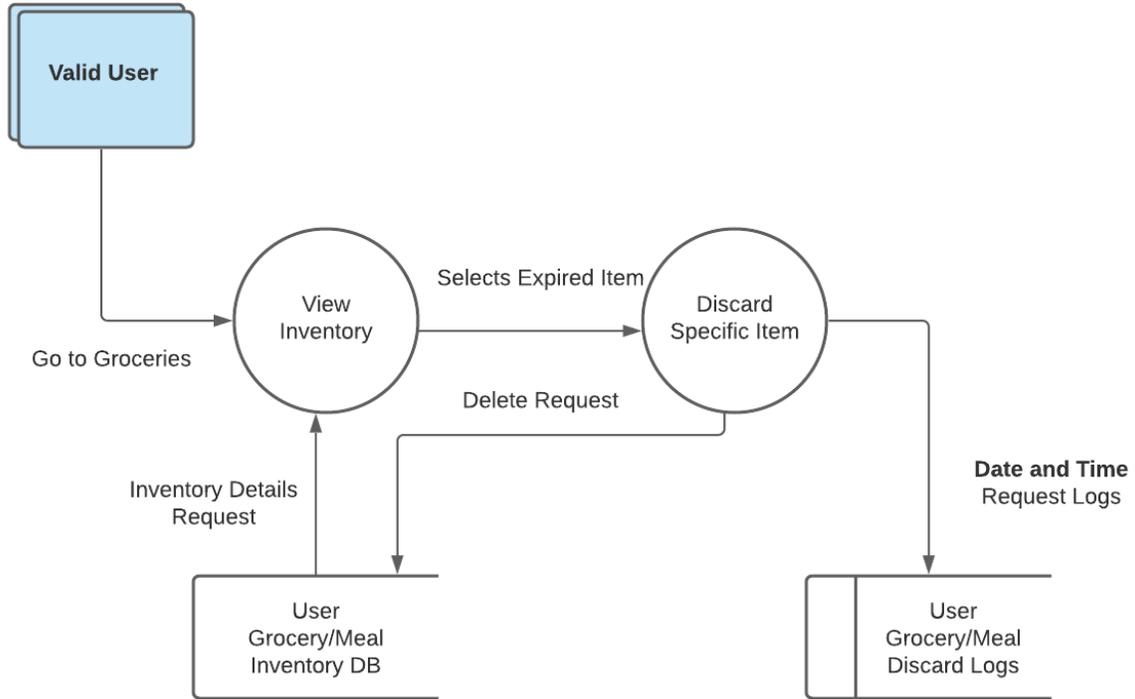Table 3.9 Discard Grocery or Meal Items from inventory.

Figure 3.10 Data Flow Diagram for discarding food items from inventory

4 Human Subjects Study

Sections 4.1 and 4.2 discuss methods. Sections 4.3 to 4.7 discuss the results of the study.

4.1 Recruiting human subjects and methods utilized for conducting the study

We recruited adult students who report living independently (and thus would shop and cook for themselves). We conducted all parts of the study online remotely: this involved recruiting students by email, obtaining consent (by utilizing a Qualtrics based form), conducting surveys, and distributing the application for download from the Google Play Store. We collected the following identifying information for the research: email, preferences, budget, inventory data, store category. This information was necessary to assess the user's software features in making certain decisions such as buying meals, purchasing foods, recording usage, diet preferences, recipe search, visualization of data with charts in the interface, etc. We have tabulated selection criteria for recruiting subjects and phases describing survey and field study in detail in **Appendix A and B.**

4.2 Determination of Frequency of Shopping, Proxy value for eating

Food and shopping behavior is tracked through the logs of the backend database. Whenever subjects record the purchase (and consumption) of either the grocery or meal items, the information is stored in the database server. Food purchases have an associated date field; food consumption has both a date and a time field. The time of day field for consumption is used to estimate which type of meal (breakfast, lunch, or dinner) the user had or missed. Both event types have an associated quantity.

At the end of the pilot, we analyzed the overall average consumption for each subject based on each study participant's type of meal to determine if it's either normal eating or overeating. We then further categorized the users based on their shopping frequency, to find possible correlations

with their mode of preparation of meal (i.e., prepared fresh, leftovers, purchased restaurant or online).

4.3 Demographical Information of subjects based on initial survey

Overall, 30 participants were recruited for the study and completed the initial survey. We did a demographical study for the participants, and all of them reported their weekly food budget, shopping frequency, weekly discard percentage. We then calculated the consumption percentage of meats and produce of the participants by categorizing them based on their weekly budget. The results are shown in Table 4. 90% of participants reported spending $100 or less on food each week. 10% of participants reported spending more than $100 on food each week, which is more than the average amount spent by an individual but less than a typical household, according to data collected by the U.S. Bureau of Labor Statistics, Consumer Expenditure Surveys [12]. After the initial survey (refer **Appendix B**), 13 participants didn't participate in the field study, citing reasons of not having an Android-based smartphone (even though the recruitment mail mentioned the requirements), not being able to commit each day for the study, and others just stopped participating after 2-3 days.

	Count	Percentage
Weekly Food Budget (in U.S dollars)		
(food budget ≤ 50) Less than or equal to 50	9	30%
(50 < food budget ≤ 75) More than 50, Less than or equal to 75	9	30%

	Count	Percentage		Count	Percentage
(75 < food budget ≤ 100) More than 75, Less than or equal to 100	9	30%			
(100 < food budget ≤ 125) More than 100, Less than or equal to 125	1	3.33%			
(food budget > 125) Greater than 125	2	6.67%			

Table 4.1 Percentage of subjects based on weekly food budget

We examined the reported frequency of shopping (see Table 4.2, column 3) percentage of each subject's budget spent on food that was discarded rather than used (Table 4.2, column 6). From the initial survey, we found that the most subjects reported that they discard less than or equal to 10% of their food budget.

	Count	Percentage		Count	Percentage
Shopping Frequency (weekly food budget ≤ 50)			**% of Food budget that goes discarded weekly**		
Weekly	6	66.67%	Discard % ≤ 10	5	83.33%
			11 ≤ Discard % ≤ 30	1	16.67%
			Discard % > 30	0	0%
Bi-Weekly	1	11.11%	Discard % ≤ 10	1	100%
			11 ≤ Discard % ≤ 30	0	0%

30

			Discard % > 30	0	0%
Monthly	2	22.22%	Discard % ≤ 10	2	100%
			11 ≤ Discard % ≤ 30	0	0%
			Discard % > 30	0	0%
Shopping Frequency (50 < weekly food budget ≤ 75)					
Weekly	5	55.56%	Discard % ≤ 10	4	80%
			11 ≤ Discard % ≤ 30	1	20%
			Discard % > 30	0	0%
2-3 times per week	3	33.33%	Discard % ≤ 10	2	66.67%
			11 ≤ Discard % ≤ 30	1	33%
			Discard % > 30	0	0%
Bi-Weekly	1	11.11%	Discard % ≤ 10	0	0%
			11 ≤ Discard % ≤ 30	0	0%
			Discard % > 30	1	100%
Shopping Frequency (75 < weekly					

food budget ≤ 100)					
Weekly	5	55.56%	Discard % ≤ 10	3	60%
			11 ≤ Discard % ≤ 30	1	20%
			Discard % > 30	1	20%
2-3 times per week	2	22.22%	Discard % ≤ 10	1	50%
			11 ≤ Discard % ≤ 30	1	50%
			Discard % > 30	0	0%
Bi-Weekly	2	22.22%	Discard % ≤ 10	1	50%
			11 ≤ Discard % ≤ 30	1	50%
			Discard % > 30	0	0%
Shopping Frequency (weekly food budget > 100)					
Weekly	2	66.67%	Discard % ≤ 10	2	100%
			11 ≤ Discard % ≤ 30	0	0%
			Discard % > 30	0	0%
2-3 times per week	1	33.33%	Discard % ≤ 10	0	0%
			11 ≤ Discard % ≤ 30	1	100%
			Discard % > 30	0	0%

Table 4.2 Percentage of subjects based on shopping frequency and food budget that goes discarded

Table 4.3 shows the proportion of consumed produce and meats, as a proportion of budget, for each size of budget.

* For a weekly food budget less than or equal to 50, there were only 8 subjects out of 9 who consumed meat.

	Count	Percentage		Count	Percentage
Weekly food budget ≤ 50					
Produce Consumption % < 40	1	11.11%	Meat Consumption % < 40	*8	*88.89%
40 ≤ Produce Consumption % ≤ 50	6	66.67%	40 ≤ Meat Consumption % ≤ 50	0	0%
Produce Consumption % > 50	2	22.22%	Meat Consumption % > 50	0	0%
50 < Weekly food budget ≤ 75)					
Produce Consumption % < 40	4	44.44%	Meat Consumption % < 40	8	88.89%
40 ≤ Produce Consumption % ≤ 50	3	33.33%	40 ≤ Meat Consumption % ≤ 50	1	11.11%
Produce Consumption % > 50	2	22.22%	Meat Consumption % > 50	0	0%
75 < Weekly food budget ≤ 100)					

Produce Consumption % < 40	4	44.44%	Meat Consumption % < 40	6	66.67%
40 ≤ Produce Consumption % ≤ 50	5	55.56%	40 ≤ Meat Consumption % ≤ 50	3	33.33%
Produce Consumption % > 50	0	0%	Meat Consumption % > 50	0	0%
Weekly food budget > 100					
Produce Consumption % < 40	2	66.67%	Meat Consumption % < 40	3	100%
40 ≤ Produce Consumption % ≤ 50	1	33.33%	40 ≤ Meat Consumption % ≤ 50	0	0%
Produce Consumption % > 50	0	0%	Meat Consumption % > 50	0	0%

Table 4.3 Percentage of subjects consumption of produce and meat based on weekly food budget

4.4 Subject's log on accessing grocery inventory

We examined the number of queries requested by the subjects each week to determine the correlation between accessing grocery inventory and then performing other actions such as adding items, recording consumption, and discarding expired grocery items. From the logs, we can see that the subjects made most of the queries related to purchases and recorded consumption of grocery items related to bakery, milk, eggs, cornflakes, cheese, etc., each week. However, none of the subjects discarded those items. Produce items were found to be discarded most as compared to meats, possibly because meat items could be stored in freezer to increase the shelf life.

Correlation between accessing grocery inventory and then adding items	Average number of users utilized per day (based on new purchases made)	Average number of multiple queries made every week
Correlation 1: Accessing grocery inventory and adding ingredients	2 out of 17	Week 1: 42 Week 2: 16
Correlation 2: Accessing grocery inventory and adding produce	4 out of 17	Week 1: 68 Week 2: 76
Correlation 3: Accessing grocery inventory and adding meats	2 out of 17	Week 1: 28 Week 2: 31
Correlation 4: Accessing grocery inventory and adding others (i.e., bakery, milk, eggs, etc.)	6 out of 17	Week 1: 103 Week 2: 112

Table 4.4 Correlation between accessing grocery inventory and then adding items

Correlation between accessing grocery inventory and then recording consumption (before use-by date)	Average number of users utilized per day	Average number of multiple queries made every week
Correlation 1: Accessing grocery inventory and recording usage of ingredients	9 out of 17	Week 1: 205 Week 2: 207
Correlation 2: Accessing grocery inventory and recording consumption of produce	12 out of 17	Week 1: 345 Week 2: 389
Correlation 3: Accessing grocery inventory and recording consumption of meats	7 out of 17	Week 1: 189 Week 2: 186

Correlation 4: Accessing grocery inventory and recording consumption of others (i.e., bakery, milk, eggs, etc.)	15 out of 17	Week 1: 415 Week 2: 402

Table 4.5 Correlation between accessing grocery inventory and then recording consumption (before use-by date)

Correlation between accessing grocery inventory and then discarding expired grocery items	Average number of users utilized per day	Average number of multiple queries made every week
Correlation 1: Accessing grocery inventory and discarding expired ingredients	1 out of 17	Week 1: 2 Week 2: 4
Correlation 2: Accessing grocery inventory and discarding expired produce	5 out of 17	Week 1: 27 Week 2: 14
Correlation 3: Accessing grocery inventory and discarding expired meats	2 out of 17	Week 1: 11 Week 2: 7
Correlation 4: Accessing grocery inventory and discarding expired others (i.e., bakery, milk, eggs, etc.)	0 out of 17	Week 1: 0 Week 2: 0

Table 4.6 Correlation between accessing grocery inventory and then discarding expired grocery items

4.5 Subject's log on accessing meals inventory

Similarly, we also examined the number of queries requested by the subjects each week to access meals inventory and then performing other actions such as adding items, recording consumption, and discarding expired meal items. From the logs, we can see that the subjects made most of the queries related to purchases and recorded consumption of homemade items each week. Only two users discarded homemade meals in the morning time, which we determined from the date-time field when the discard was made in the two weeks.

Correlation between accessing meal inventory and then adding items	Average number of users utilized per day	Average number of multiple queries made every week
Correlation 1: Accessing meal inventory and adding homemade items	7 out of 17	Week 1: 152 Week 2: 155
Correlation 2: Accessing meal inventory and adding bought outside items	2 out of 17	Week 1: 12 Week 2: 7

Table 4.7 Correlation between accessing meal inventory and then adding items

Correlation between accessing meal inventory and then recording consumption (before use-by date)	Average number of users utilized per day	Average number of multiple queries made every week
Correlation 1: Accessing meal inventory and recording consumption of homemade items	15 out of 17	Week 1: 371 Week 2: 374
Correlation 2: Accessing meal inventory and recording consumption of bought outside items	1 out of 17	Week 1: 3 Week 2: 3

Table 4.8 Correlation between accessing meal inventory and then recording consumption (before use-by date)

4.6 Difference in behaviors of Frequent Shoppers vs Infrequent Shoppers vs Average Shoppers

To examine the deviation in behaviors among our study participants, we aggregated them into three groups: Frequent Shoppers, Infrequent Shoppers, and Average Shoppers. 47% were Infrequent Shopper (shopped for less than 4 times on an average in 2 weeks), 29% were Frequent Shopper (shopped for more than 4 times on an average in 2 weeks), and the remaining 24% were

Average Shopper (shopped for 4 times on an average in 2 weeks). From the logs in the application server, we found that infrequent shoppers had most skipped meals and overeating episodes. Frequent shoppers were found to have the most discards in grocery inventory (50%, 7 out of 14) in two weeks, followed by Average shoppers (35.71%, 5 out of 14).

Shopper	Mode of Preparation (in 2 weeks)	Count of skipped meals episodes (in 2 weeks)	Count of Overeating episodes (in 2 weeks)	Count of discard episodes (in 2 weeks)
Frequent Shopper	**Prepared Fresh**: average of 7 times **Leftovers**: average of 6 times **Purchased Restaurant:** average of 2 times **Purchased Online:** average of 1 time	Breakfast: 1 Lunch: 3 Dinner: 0	Breakfast: 0 Lunch: 2 Dinner: 4	Meals Inventory: 1 Grocery Inventory: 7
Infrequent Shopper	**Leftovers**: average of 6 times **Prepared Fresh:** average of 6 times **Purchased Restaurant:** average of 2 times **Purchased Online**: average of 1 time	Breakfast: 7 Lunch: 7 Dinner: 2	Breakfast: 0 Lunch: 3 Dinner: 8	Meals Inventory: 0 Grocery Inventory: 2
Average Shopper	**Leftovers:** average of 7 times **Prepared Fresh:** average of 6 times **Purchased Restaurant:** average of 3 times **Purchased Online:** average of 1 time.	Breakfast: 5 Lunch: 3 Dinner: 0	Breakfast: 1 Lunch: 1 Dinner: 7	Meals Inventory: 1 Grocery Inventory: 5

Table 4.9 Count of episodes of skipping meals, overeating and discard among shoppers

4.7 System Usability Scale Assessment

For the final survey (refer Appendix G), we made use of the System Usability Scale (SUS) [9]. The SUS comprises ten questions, where odd-numbered questions reflect approving usage, and even-numbered questions are negatively worded. 16 out of 17 subjects (refer Table 4.10) responded to the survey, which reported an average score of 76.25 out of 100. A SUS score above 68 would be considered above average [10], which suggests that the subjects were comfortable interacting with the Track Your Food application. Although the scores were normalized in the range of 0-100, it doesn't reflect the result in actual percentages and must be evaluated in terms of percentile ranking [10].

Subject No.	SUS Final Score
Subject 1	72.5
Subject 2	80
Subject 3	70
Subject 4	70
Subject 5	75
Subject 6	82.5
Subject 7	72.5
Subject 8	75
Subject 9	85
Subject 10	77.5
Subject 11	80
Subject 12	75
Subject 13	65
Subject 14	80
Subject 15	75
Subject 16	85

Table 4.10 SUS Final Scores from the subjects

We also devised five additional questions (refer **Table 4.11**) to the usability questionnaire (refer **Appendix G**) which focused on certain aspects of our application ranging from providing data, chart visualization to screen navigation.

Additional Questionnaire	Strongly Agree to Agree
I found it hard to find the screens or functions I was looking for.	**26%** of Participants
I think the navigation of the application from launch to finish makes sense.	**81%** of Participants
I found that providing the various types of data requested seemed relevant and easy to do.	**65%** of Participants
I had to spend a lot of time providing data that did not seem useful.	**35%** of Participants
The charts helped me to understand how well I was doing at keeping a budget, using foods, and not throwing away much.	**84%** of Participants

Table 4.11 Additional Questionnaires based on application's interface

5 Conclusion

The primary goal of this work was to develop software that would allow us to see the association between meal planning, shopping, consumption, and discarding in real-time, to make these behaviors more observable. The application supports self-introspection to help people to review their history of food purchases, consumption and discard, using both scrollable inventories and visualizations of their aggregated behavior. This allows users to easily see how their choices distribute across different broad categories of food. This information provides a basis for them to make more informed decisions on their future purchases, while being mindful of the most and least frequently discarded foods. In our study, we examined correlations among several behaviors as a proof-of-concept that the app would enable a more detailed understanding than provided by current software.

5.1 Limitations

One major limitation to the current implementation is that we haven't yet evaluated the impact of application features among ADHD cohorts. We wanted to be sure that we have a good tool. We found a total of six recipe search request queries by the subjects in 2 weeks of field study from the logs. We did track the user's count of food discard episodes based on shopping frequency. However, we couldn't find concrete affirmation on the tool's impact regarding discard behavior based on the initial survey (see **Appendix D**) and the field study (subject's log).

5.2 Future Work

A long-term study on the Track Your Food application's usability would be needed to assess the usefulness and acceptance over time. Another possible extension for the study is to examine the utilization of the application features among ADHD cohorts vs. control group and then see if there is any impact on their habits and behavior. We are currently taking into account user's diet

preferences and foods-on-hand for recipe search implementation. To increase usability and avoid information overload, we need to refine the user interface with time and instrument a collaborative filtering-based recommendation algorithm to make the relevant recipe and food purchase suggestions based on users' past consumption and discard behavior.

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Appendix A: Phases conducted during the study

Phases/Steps	Explanation	Estimated time spent by subjects
1. Online Recruitment	We emailed Engineering Graduate students and asked if they have Android OS (Version 5.0 and up) based smartphone.	N/A
2. Obtaining Consent	We emailed the subjects the Qualtrics Link to the Informed Consent Form, and asked them to complete it.	2 minutes
3. Initial Survey	Subjects were expected to complete an initial survey about their typical eating and meal preparation habits.	10 minutes
4. Field Study	1. Downloading the software from Google Play Store or from the Expo Servers. 2. Creating an account (identifying email and specify an independent password). 3. Using the software over a two week period to: record preferences for selecting recipes (including types of food and preferred food budget), search for recipes that will be sorted based on preferences, create shopping lists, record foods on hand, purchased, or discarded,	10-15 minutes per day for two weeks.

	review status of foods on hand, eaten, or discarded.)	
5. Experience Sampling	Answering a quick daily Qualtrics survey (about food related activity)	5 minutes per day for two weeks.
6. Final Survey	Completing a closing Qualtrics survey regarding impressions of the usefulness and usability of the app.	10 minutes

Appendix B: Recruitment Criteria

Selection Criteria	Justification
At least 18 years old.	They should be able to consent by themselves for the participation in study.
Ability to read and understand English.	The interface for the application is in English.
Are living independently and able to buy own groceries and cook.	Core functionality of the application we are testing.
Own Android OS (Version 5.0 and up) based smartphone.	The software can support Android OS with version 5.0 and up.

Appendix C: Online Consent Form

Study title: Supporting self-management of food and related expenses.

Researcher[s]:   1. Dr. Susan W. McRoy, PhD, Computer Science Department

2. Apoorv Prasad, Computer Science Department

We're inviting you participate in our research of novel software. This study is completely voluntary. There are no negative consequences if you don't want to participate. If you start the study, you can always change your mind and stop at any time.

What is the purpose of this study?

The purpose of the study is to assess the usability and the acceptance of software that helps users manage their diet and food budget to eat a good balance of foods and avoid waste.

What will I do?

1. You will need to complete an initial online survey about your typical eating and meal preparation habits. (10 minutes).

2. You will need to download the software from either Google Play Store or from the Expo Servers. (see training document).

3. Once you get the software, you will need to create an account (identifying email and specify an independent password).

4. You will use the software over a two week period to: record preferences for selecting recipes (including types of food and preferred food budget), search for recipes that will be sorted based on preferences, create shopping lists, record foods on hand, purchased, or discarded, review status of foods on hand, eaten, or discarded.)

5. Each day, you will be asked to answer a quick daily online survey (about food related activity). (5 minutes)

6. At the end of 2 weeks, you will be asked to complete a closing online survey regarding your impressions of the usefulness and usability of the app. (10 minutes)

Risks

1. Low risk, involved. Confidential data securely stored in Qualtrics contracted by UWM, and in Firebase Cloud Server (provided by Google).

2. Breach of confidentiality: There is a chance your data could be seen by someone who shouldn't have access to it. We're minimizing this risk in the following ways:

   a. Upon installation, the software doesn't require any sort of additional permissions that could pertain to access critical information such as Camera, Location, Contacts, Documents, Record Audio, Access to External Storage.

   b. We'll store all electronic data on a password-protected, encrypted computer. (Qualtrics, Firebase Cloud Server)

   c. We'll keep your identifying information separate from your research data, but we will be able to link it to you. We'll destroy this link after we finish collecting and analyzing the data.

Possible benefits: The software would help people remember their food spending and consumption and see whether they represent balanced choices. This would especially help individuals with memory problems lead more independent and healthful lives by supporting their efforts to manage their nutrition and finances. The software also helps people avoid food waste, which is a problem in the U.S., where up to 40 percent of food is reportedly never eaten.

Estimated number of participants: 20 people.

How long will it take? 15-20 minutes per day over the period of 14 days.

Costs: You must have active network connectivity (either WiFi or Cellular data) to download the app and to store or retrieve data while using it; standard data charges (based on your provider) will apply.

Compensation: Electronic Gift Card totaling $50 ($25 after the first week, another $25 at the end of the final survey). To receive compensation you must complete at least 70% (5 of 7) of the daily surveys.

Future research: Your data won't be used or shared for any future research studies.

Funding source: TOMMY G. THOMPSON CENTER ON PUBLIC LEADERSHIP, University of Wisconsin – Madison

Confidentiality and Data Security

We'll collect the following identifying information for the research: your email, preferences, budget, inventory data, store category. This information is necessary to assess the software features being utilized by the user in making certain decisions such as buying meals, purchasing foods, recording usage, diet preferences, recipe search, visualization of data with charts in the interface etc.

Where will data be stored? Survey data will be in the filespace of the online survey software (Qualtrics) and user's data related to software usage will be on Firebase Cloud Server within the filespace of the cloud database program, with an encrypted identifier.

How long will it be kept? Data will be kept till 31st December 2020.

Who can see my data?

We (the researchers) will have access to the user's information and all responses entered into the app, online survey responses, key linking study id to subject identifiers i.e. subject's specific data: email, preferences, budget, inventory data, store category. This is so we can analyze the data and conduct the study.

Agencies that enforce legal and ethical guidelines, such as

1. The Institutional Review Board (IRB) at UWM

2. The Office for Human Research Protections (OHRP)

We may share our findings in publications or presentations. If we do, the results will be aggregate (grouped) data, with no individual results.

Profits from the research N/A

Conflict of Interest N/A.

Questions about the research, complaints, or problems: Contact Dr. Susan W. McRoy, 414-229-6695 & mcroy@uwm.edu.

Questions about your rights as a research participant, complaints, or problems: Contact the UWM IRB (Institutional Review Board) at 414-662-3544 / irbinfo@uwm.edu.

Please print or save this screen if you want to be able to access the information later.

IRB #: 20.368

IRB Approval Date: June 24, 2020

Agreement to Participate

Your participation is completely voluntary, and you can withdraw at any time.

To take this survey, you must be:

1. At least 18 years old.

2. Ability to read and understand English.

3. Are living independently and able to buy own groceries and cook.

4. Own Android OS (Version 5.0 and up) based smartphone.

If you meet these criteria and would like to take the survey, click the button below to start.

Appendix D: Initial Survey

1. What is your preferred weekly food budget?

2. How often do you typically shop for groceries?

   - Weekly

   - Other

3. How often do you order meal from restaurant, meal service or online food order?

   - Daily

   - Weekly

   - Other

4. What is your preferred distribution of spending among Produce, Meats, Others (Dairy, Bakery and Bread, Cereal, Eggs)?

   (For Example, Produce: 40%, Meats: 30%, Others: 30%)

5. How much of your food budget do you think goes wasted (unconsumed or discarded) weekly?

Appendix E: Application Manual for Subjects

WHEN YOU FIRST OPEN THE SOFTWARE

The new user may want to start creating their account by selecting **Switch To Sign Up**.
If you are the returning user, you can log in with their username and password by selecting **Login**.

Once **Switch to Sign Up** is selected, the button's mode will be changed to **Sign Up**.
The new user can now enter the email and password and then select sign up.

WHEN YOU ARE AUTHENTICATED SUCCESSFUL, AND HOW TO SET YOUR DIET PREFERENCES (IF ANY)
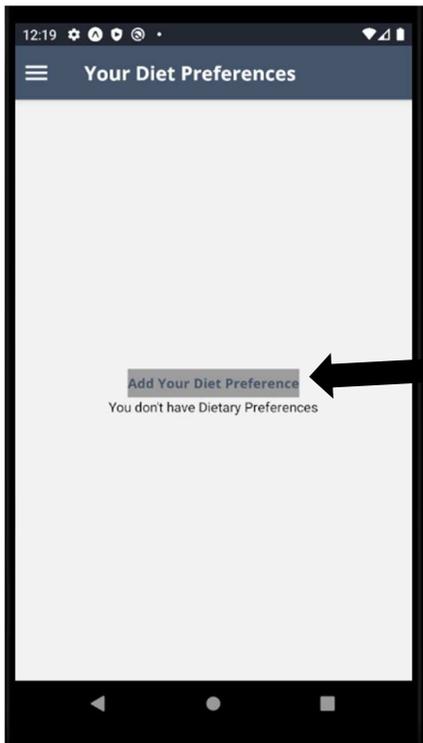
The new user may want to start by setting up their diet preferences.
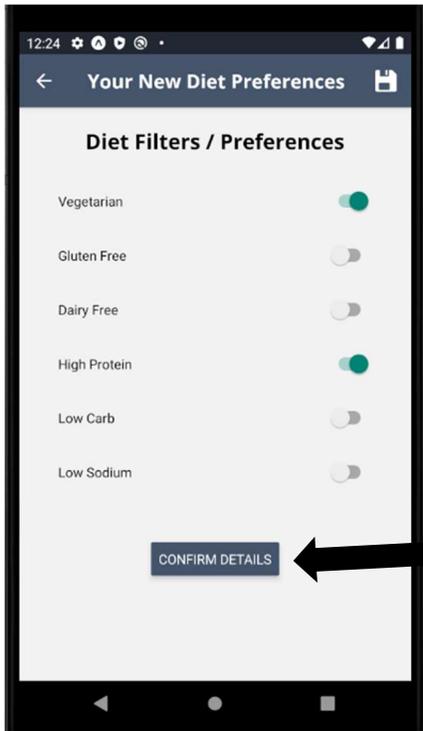
Once the new user has given their diet preferences, the user needs to select **Confirm Details**
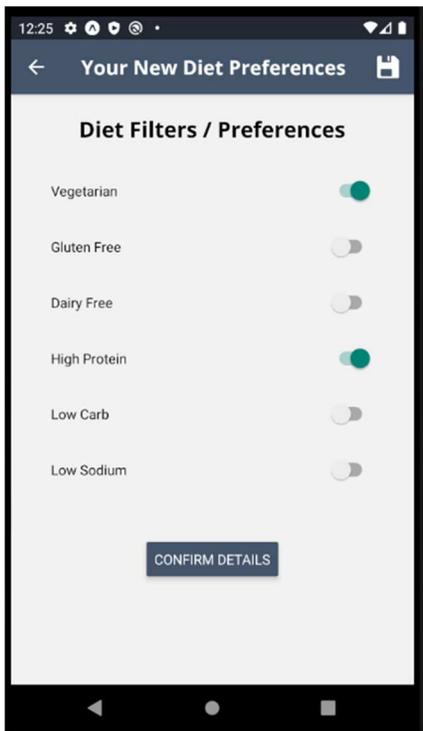
The new user, after selecting **Confirm Details**, then need to save their preferences by choosing the "**Floppy Disk icon**" at the top right of the interface.
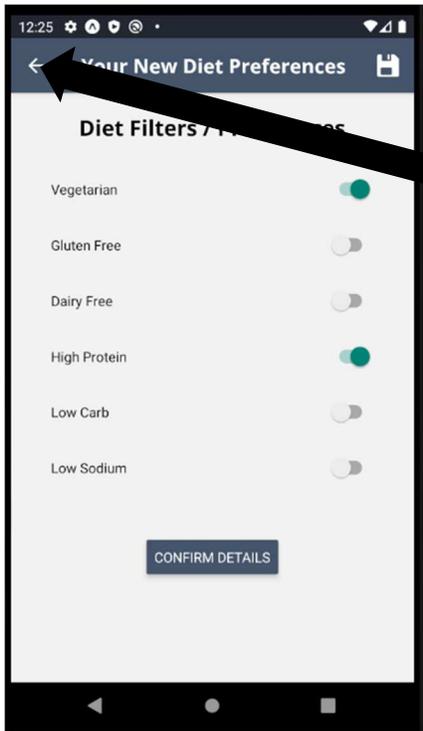
After the user has confirmed and saved the diet preferences, the user can go back to view their preferences.
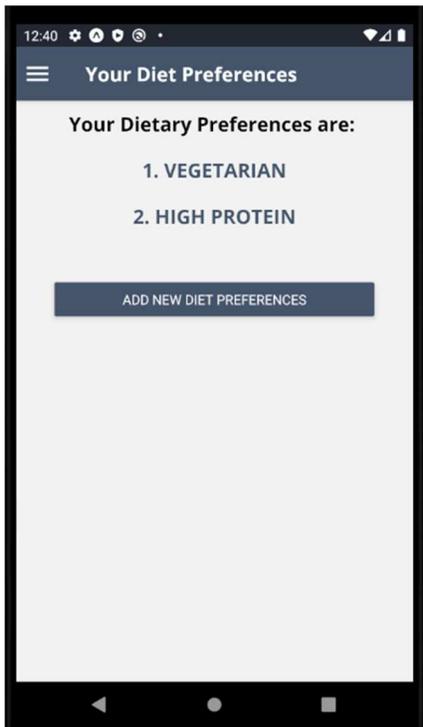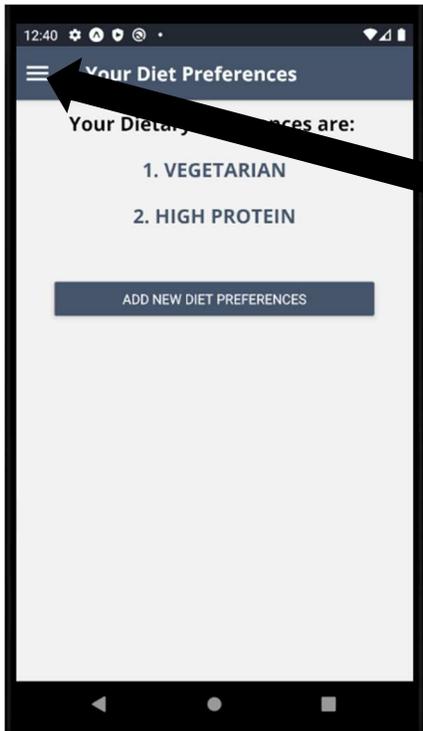
The user can navigate to the drawer menu by selecting the "**Hamburger icon**" at the top left.
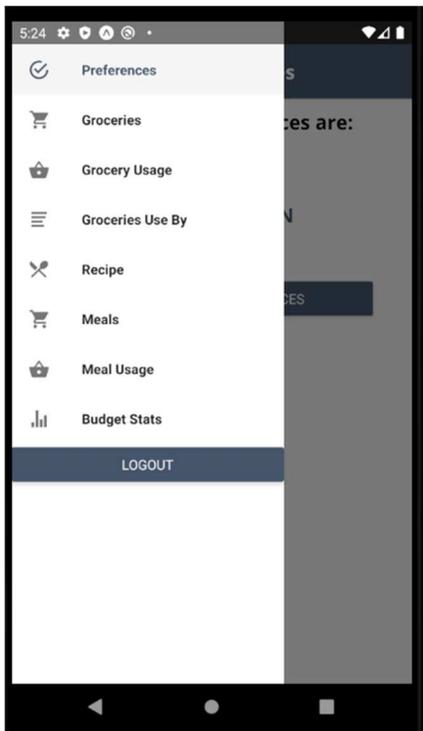
WHEN YOU WANT TO VIEW YOUR INVENTORY, AND SHOPPING LIST
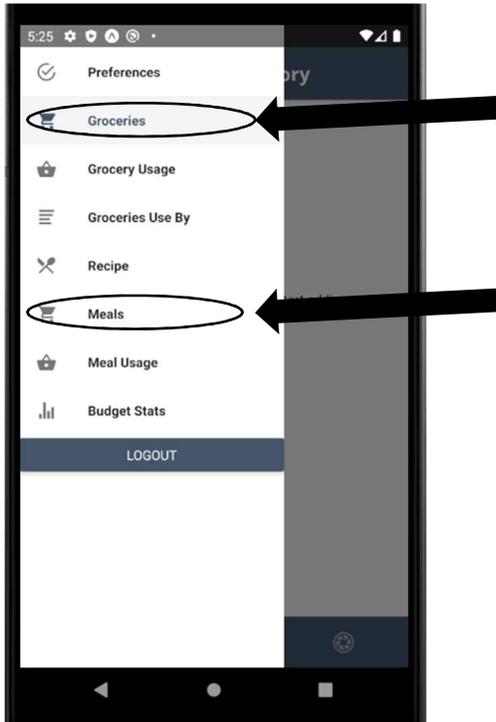
From the drawer menu, the new user can choose
either **Groceries** or **Meals**, to access the inventory or plan for shopping.

Groceries include ingredients, produces, meats, others (i.e., bakery, milk, eggs, etc.) that the user can utilize to prepare food at home.

Meals include the food items that the user buys from restaurant or orders online.
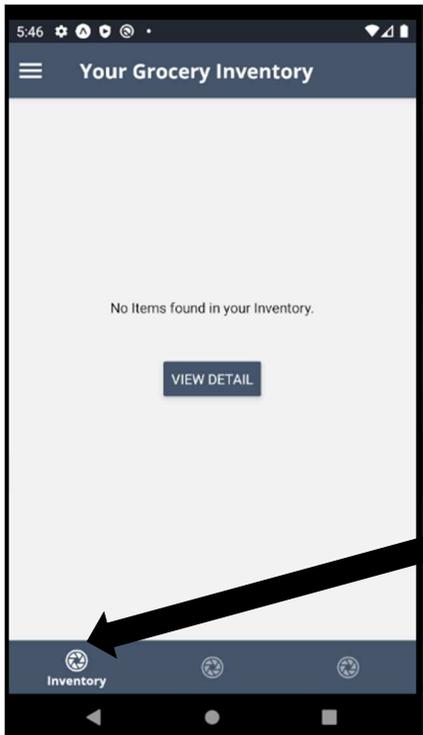
The new user will not have any grocery items in their Inventory. The user can access the Inventory by selecting the **Inventory** tab located at the bottom of the screen.
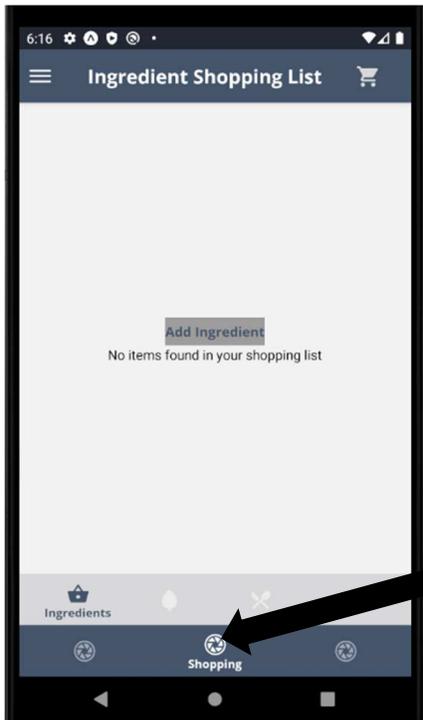

To access a shopping list, the user selects the **Shopping** tab at the bottom of the screen and then selects one of the four purchase categories (ingredients, produce, meat, and other)
The new user will not have any items in their shopping list.

If the user wants to see the current shopping list of ingredients, they can select the **Ingredients** bottom tab.

Ingredients include spices, garnishes, oils, and other items typically not eaten separately.
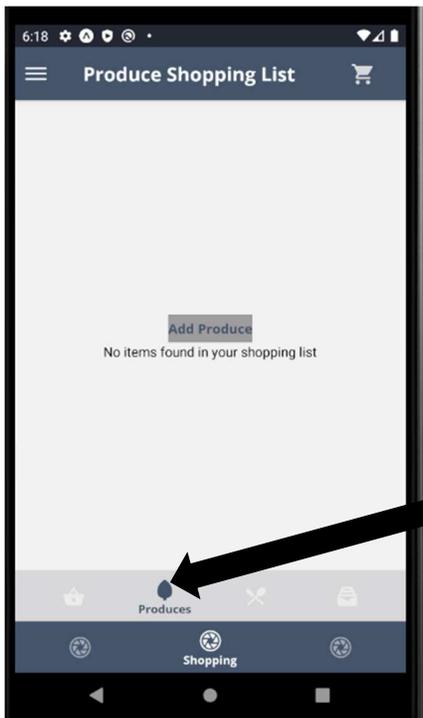
If the user wants to see the current shopping list of ingredients, they can select the **Produces** bottom tab. Produces include fruits and vegetables.

In the same manner, user can advance to **Meats** and **Others** from the bottom tab.
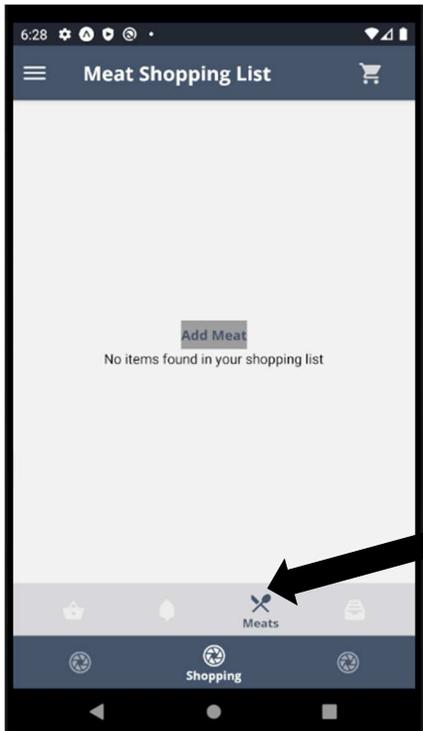
Meats include chicken, turkey, beef, pork, seafood, etc.
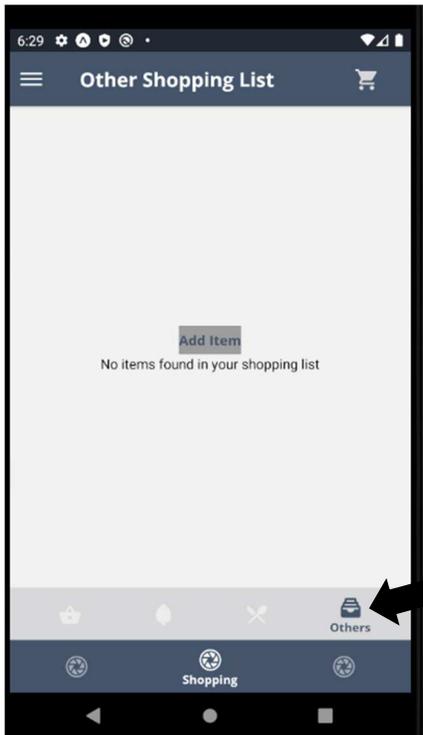
Others include bakery, bread, milk, eggs, etc.
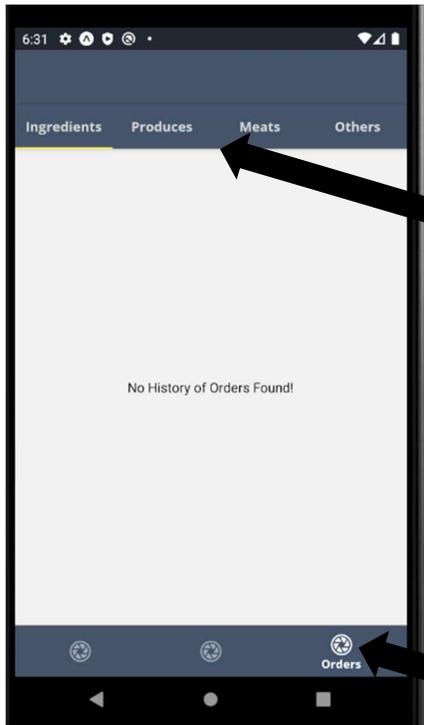
The user can check their history of orders by selecting either of the categories from the top tabs.

The user can access the history of orders by selecting the **Orders** tab located at the bottom.
The new user will not have any history of orders.

ADDING FOOD ITEMS TO YOUR INVENTORY, AND SHOPPING LIST
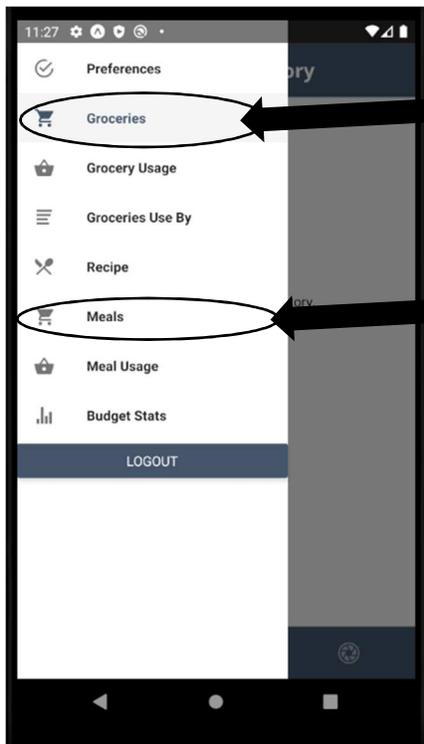
From the drawer menu, the user can choose
either **Groceries** or **Meals**, to access the inventory or shopping list, and then add the food items.

Groceries include ingredients, produces, meats, others (i.e., bakery, milk, eggs, etc.) that the user can utilize to prepare food at home.

Meals include the food items that the user buys from restaurant or orders online.

ADDING FOOD ITEMS TO THE INVENTORY
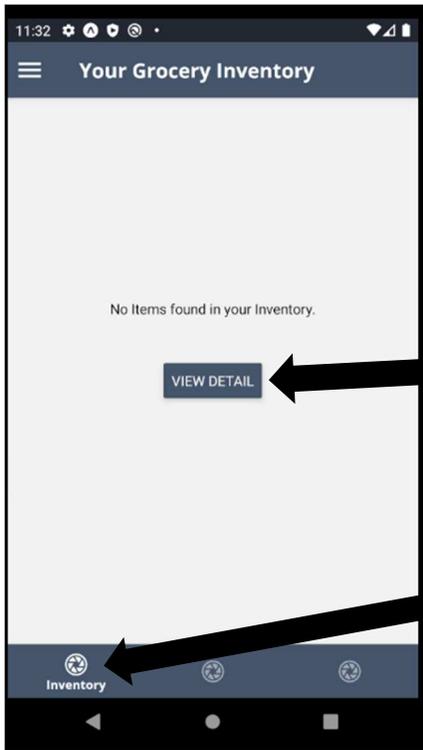
Select the **View Detail**

In order to add food items to your Inventory, make sure the **Inventory** tab is selected

The new user may wish to record items previously purchased to their inventory of a certain category (ingredients, produce, meat, and other).

For instance, user have selected to record purchased items of **Produce** category in my inventory.

When the user clicks on **Record What You Have** button, he/she is then asked to fill the information about their past grocery item in their inventory.
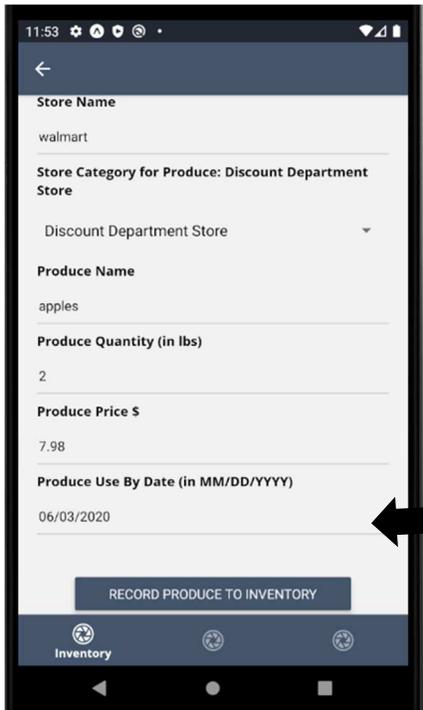
User can then specify the **use-by date** of the produce item with the help of date picker in the interface.
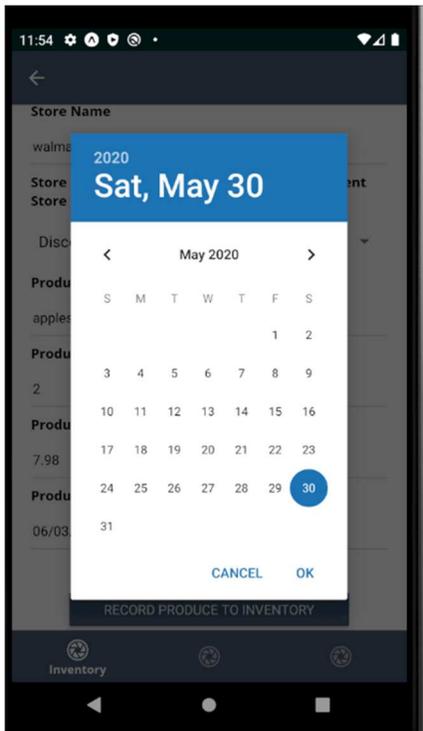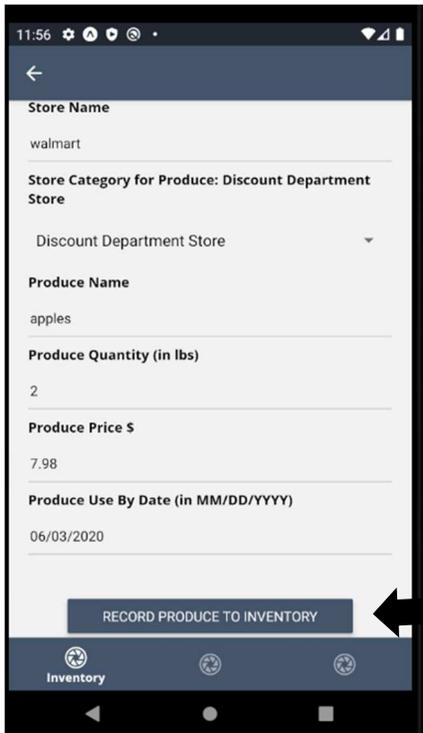
After completing the form for a produce item, the user can save this information by clicking on **Record Produce to Inventory**
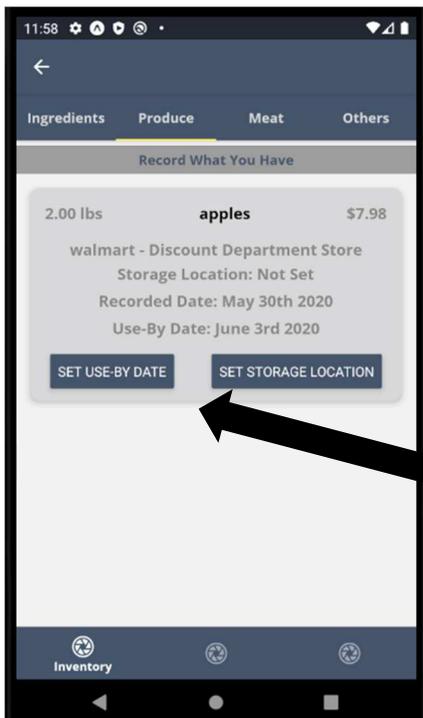
Once the information of a particular item is recorded, user can then edit the **use-by date** as well as the **storage location**.

After the user selects **Set Use-By Date**, user will be able to edit the use-by date with the help of date picker modal in the interface
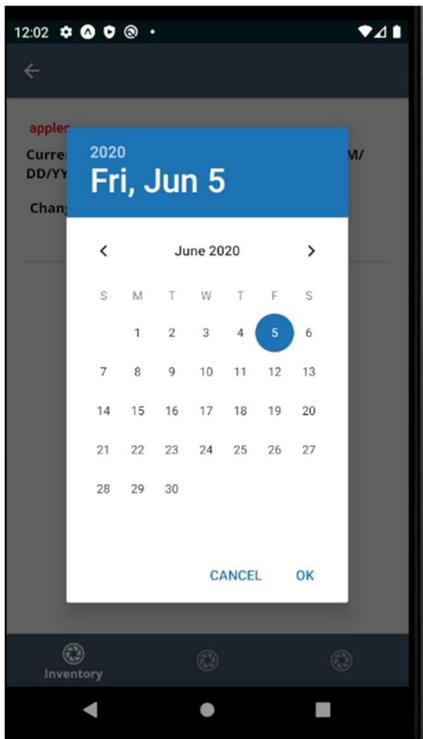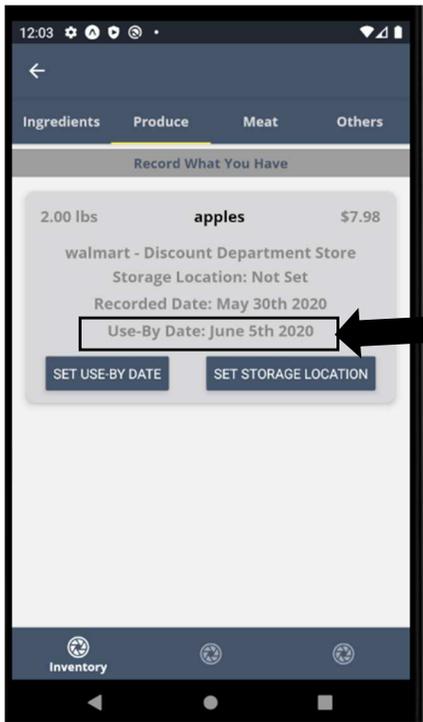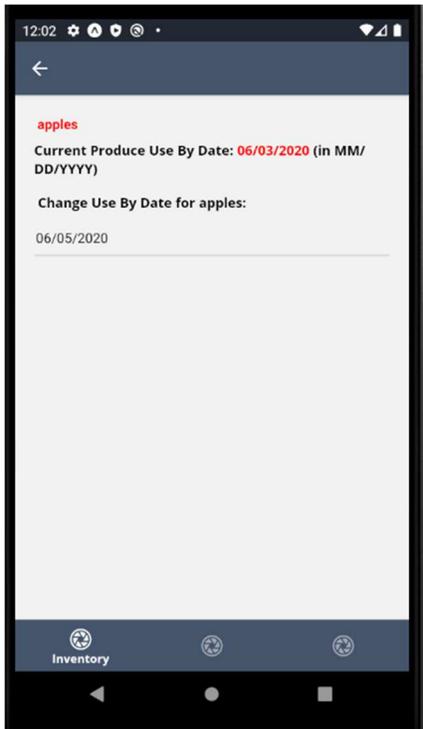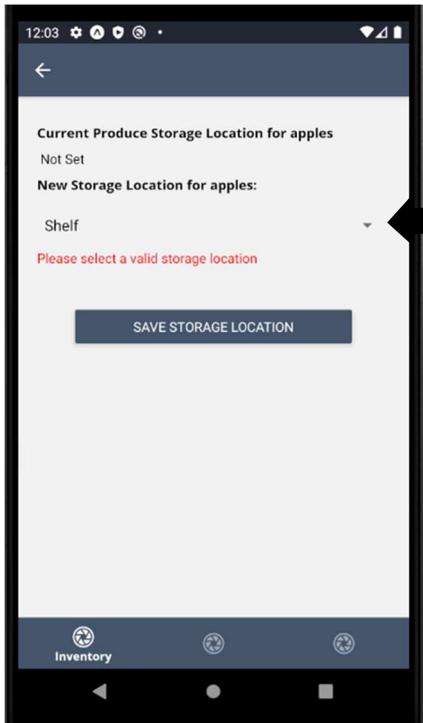
After the user selects **Set Storage Location**, user will be able to edit the storage location of the food item.
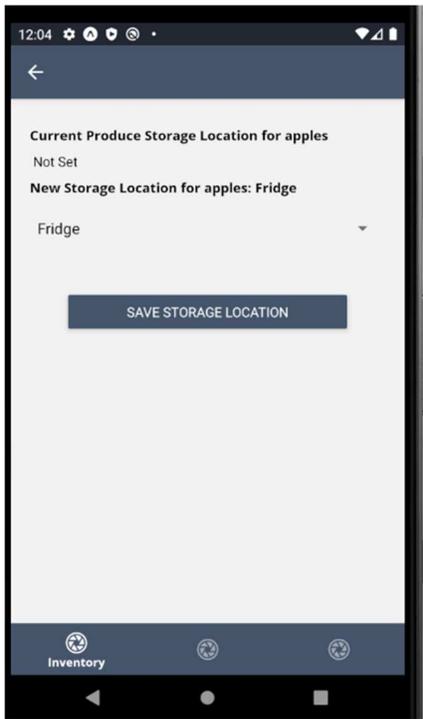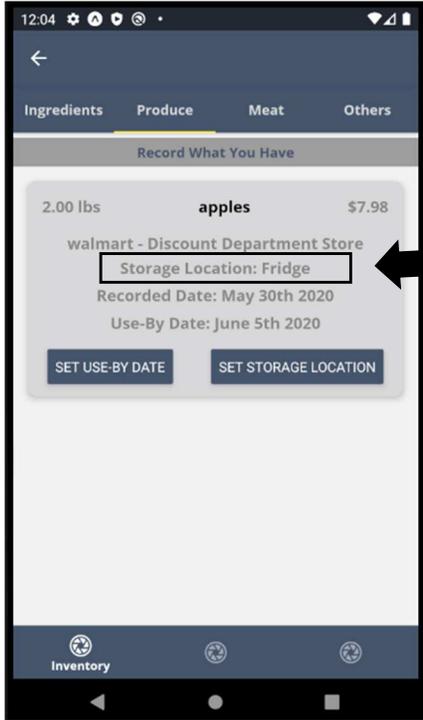
ADDING FOOD ITEMS TO THE SHOPPING LIST, AND THEN RECORDS TO THE INVENTORY
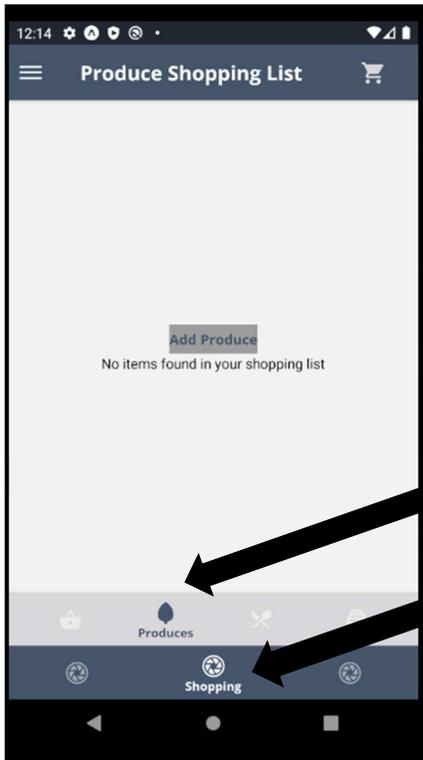
To access a shopping list, the user selects the **Shopping** tab at the bottom of the screen and then chooses one of the four purchase categories (ingredients, produce, meat, and other).

For example, in this case, the user has first selected **Shopping** tab, and then accessed the Produce Shopping List, by selecting **Produces** bottom tab.
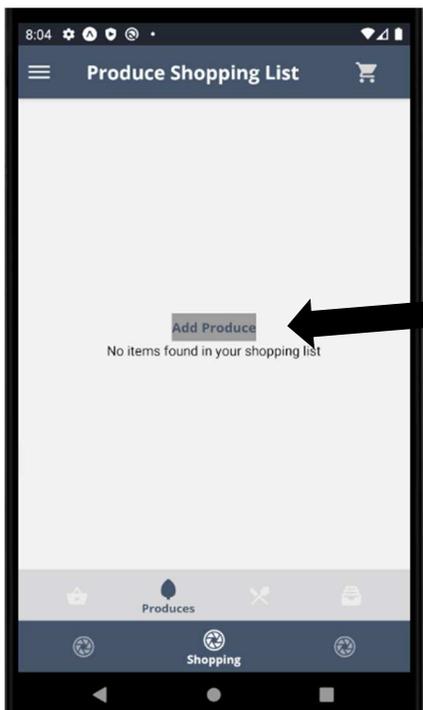
The new user will not have any items in their shopping list. The user can add items as they plan for shopping by selecting **Add Produce.**
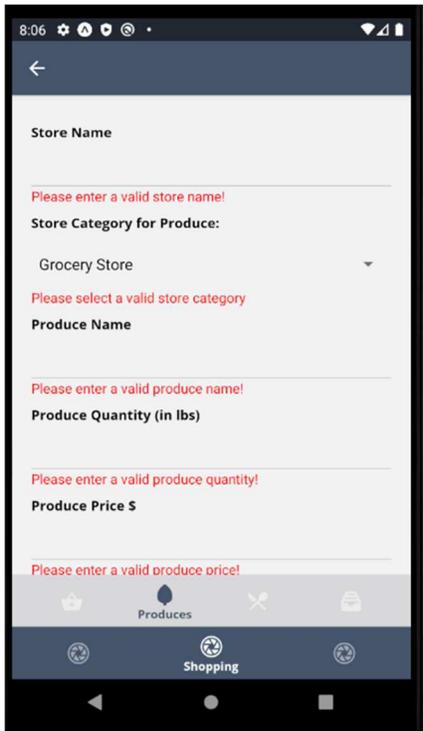
When the user clicks on **Add Produce** button, he/she is then asked to fill the information about the produce item to be added to the shopping list.
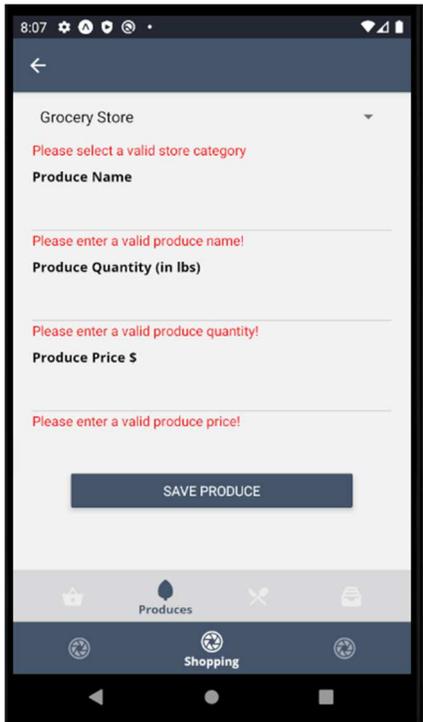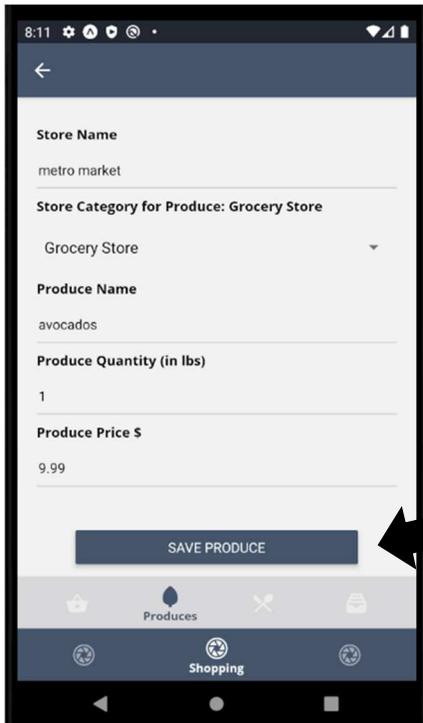
After completing the form for a produce item, the user can save this information by clicking on **Save Produce**. The item will then get added to the user's shopping list.
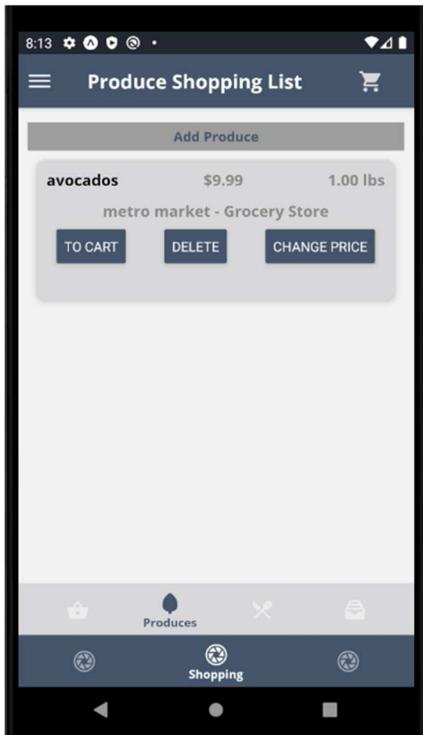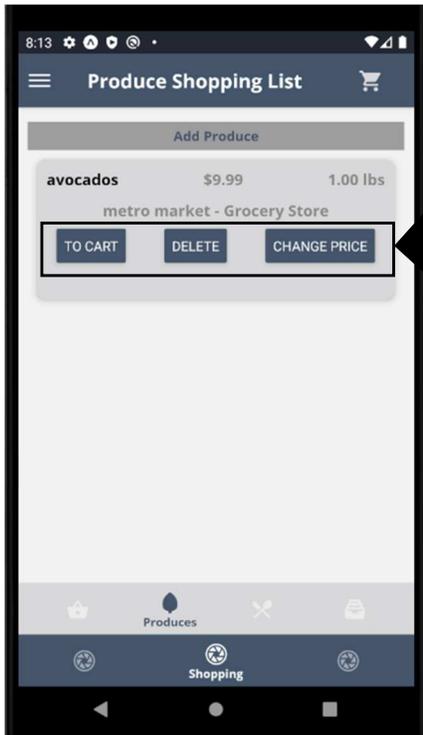
After, the user adds the item to their shopping list, they can view that item in the interface. They can add the item to the **Cart** and then to their **Inventory**.

To Cart button: User needs to select this button to add an item from the shopping list to the Cart. If the user wants to add more quantity of the same item, he/she can press the button multiple times.

Delete button: User can delete the item from the shopping list, if not required.

Change Price button: User can change the price of the item as well if there happens to be a price change of the item in the store.
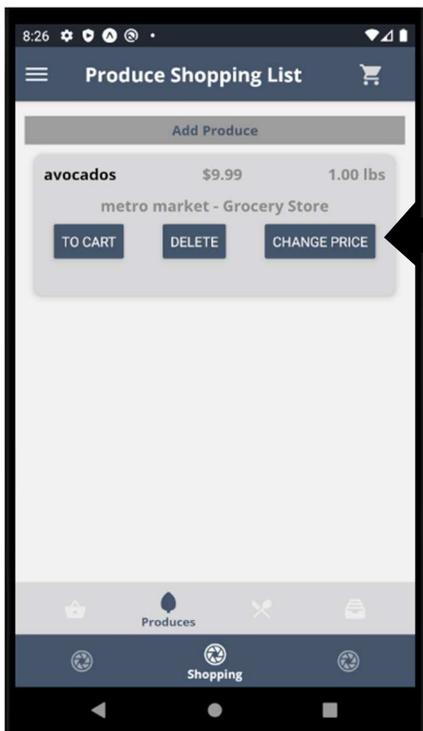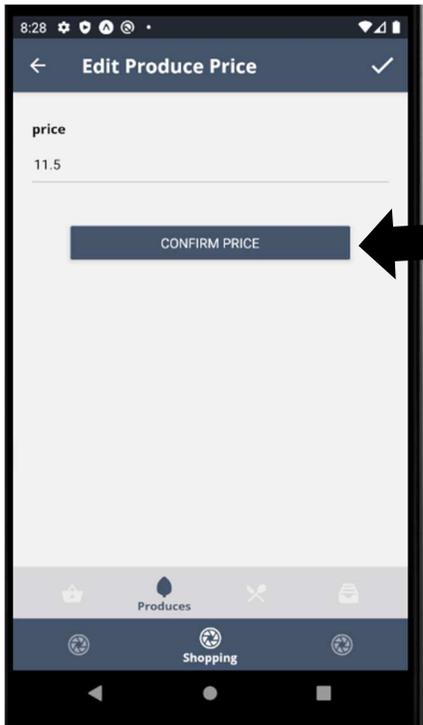
After the user, provides the exact price of the item in the store, he/she need to first select **Confirm Price,** and then the "**Tick icon**" at the top right of the screen.
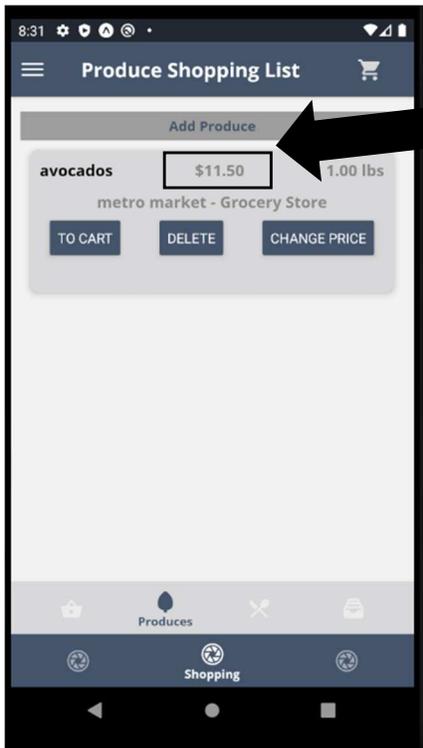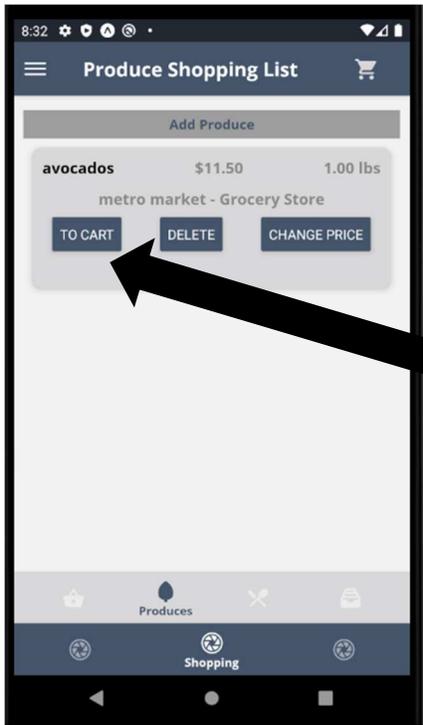
To add the item to the cart, the user will need to select the **To Cart** button. If the user wants to add more quantity of the item to Cart, he/she can press the To Cart button multiple times.

For instance, the user wants to add 2 lbs of avocados to the cart. Then, the user will need to press the button two times.
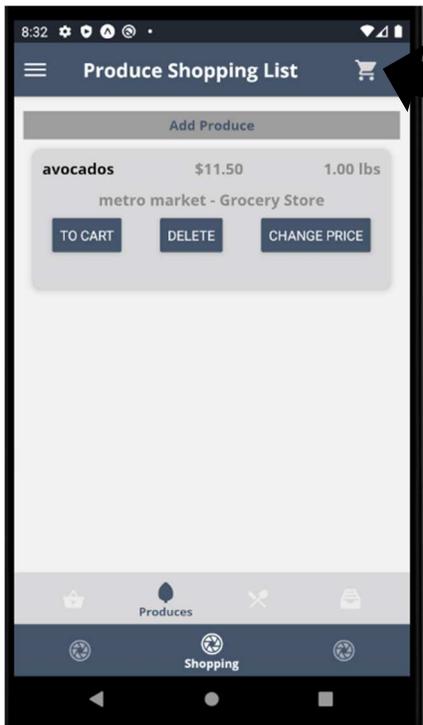
User will then want to access the Cart, by selecting "**Cart Icon**" located at the top right of the screen
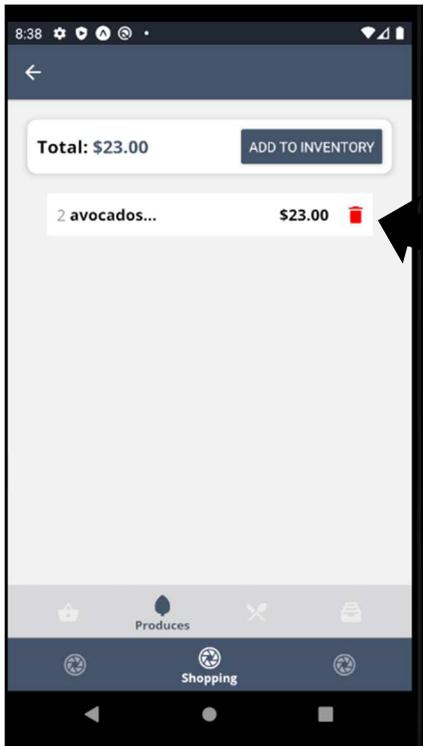
Users can reduce the quantity of the item by one by pressing the "**Trash icon**" the number of times they want to reduce.
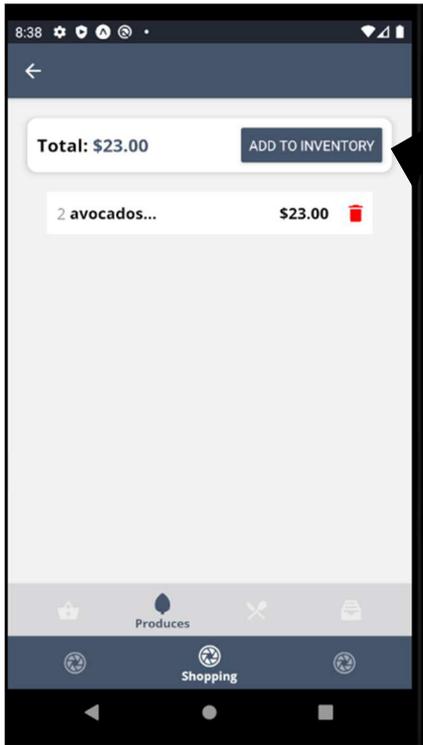
After the user makes the final purchase of the item from the store, the user might want to add the item to the inventory. Users can do so by selecting **Add To Inventory** button.
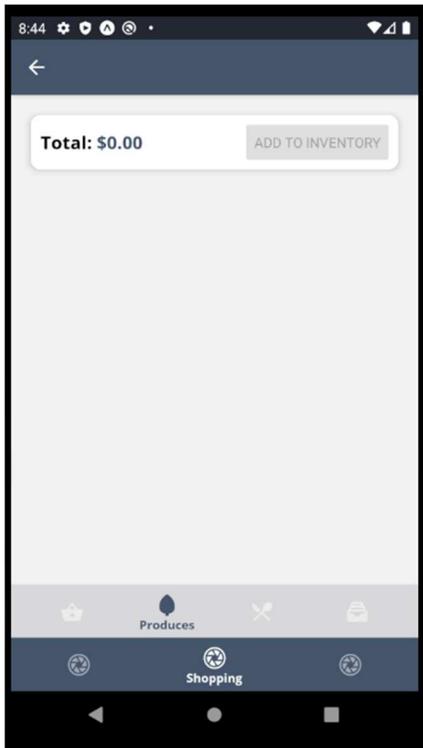
Once the user has clicked on **Add To Inventory**, the items are removed from the Cart and added to the Inventory.

The user might want to access the **Inventory** by selecting it at the bottom tab of the screen.
A bar chart will display the percentage of items available in the user's inventory based on category.
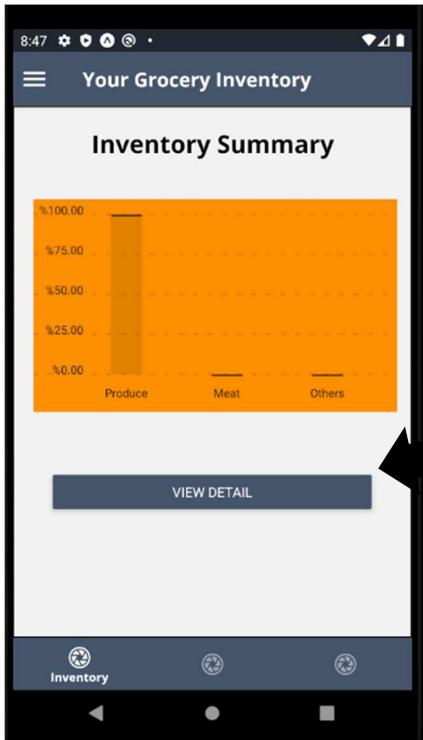
The user will need to select **View Detail** button to see the list of items in their inventory.
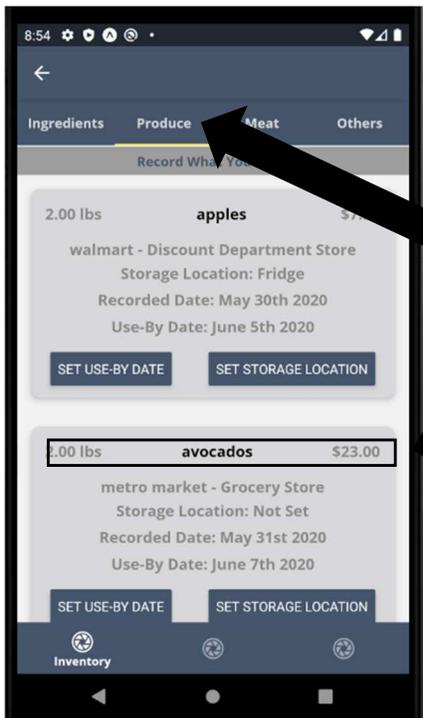
The user is now able to view the items present in Inventory (Produce category).
Recorded Date: is the date when the user records the purchase of the item.
Use-by Date: by default, the software adds seven days to the recorded date. Users can edit the use-by date, by selecting **Set Use-By Date**.

RECORDING FOODS THAT HAVE BEEN USED OR EATEN
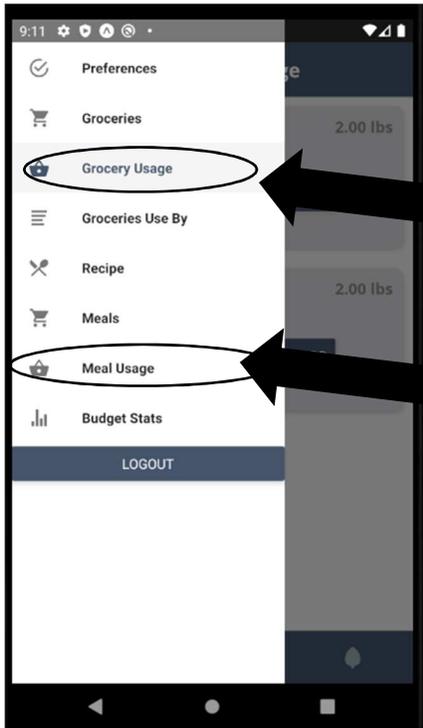
User can record their consumption of a grocery or meal item by selecting either **Grocery Usage** or **Meal Usage** from the drawer menu.
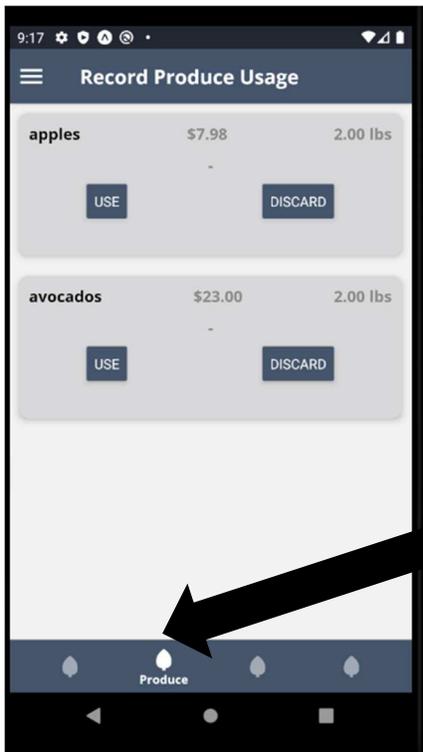
For instance, user would want to record the usage of item in produce category, by selecting **Produce** at the bottom tab of the screen.

After selecting record grocery usage, the user will choose the type of food and then see two options: **use** (to record items used or eaten) and **discard** (to record items that were discarded, not eaten).

Discarding an item will allow the user to track which foods go unused (so they can avoid this in the future) and remove the item from the inventory.
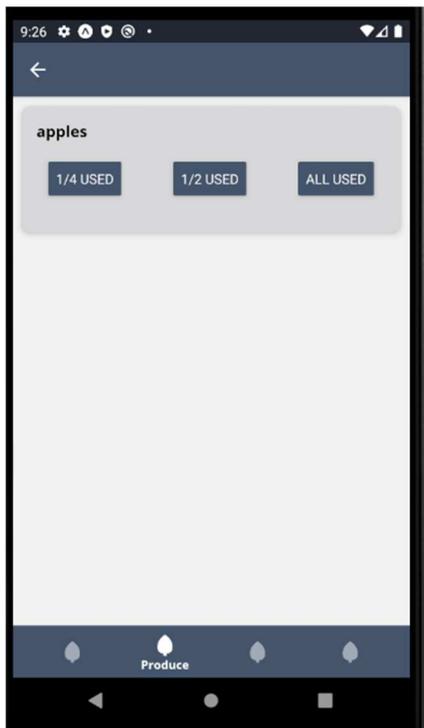
If the user selects **use** option, then the user will have three options to record the consumption i.e. 1/4th Used, 1/2 used, or All Used.

All Used will simply denote that user has consumed the item, and at the same time gets deleted from their inventory.
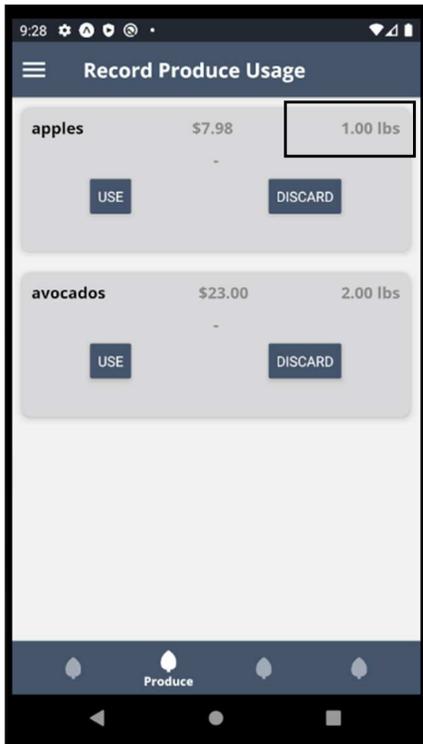
Here, in this screenshot, user has consumed 1/2 of the apples that he/she had before in their inventory.

After recording the consumption of item, the same amount is then reflected back to the user's inventory.

For example, in this case, user has consumed 1/2 of the 2.0 lbs apples. As a result, after consumption, the updated value is now 1.0 lbs.
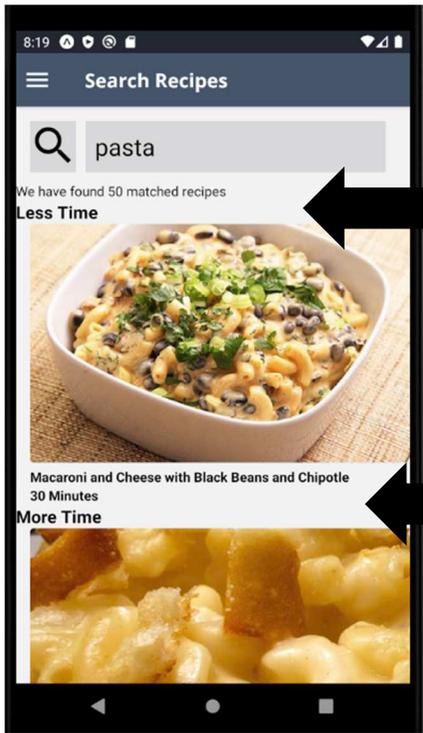
SEARCHING FOR A RECIPE
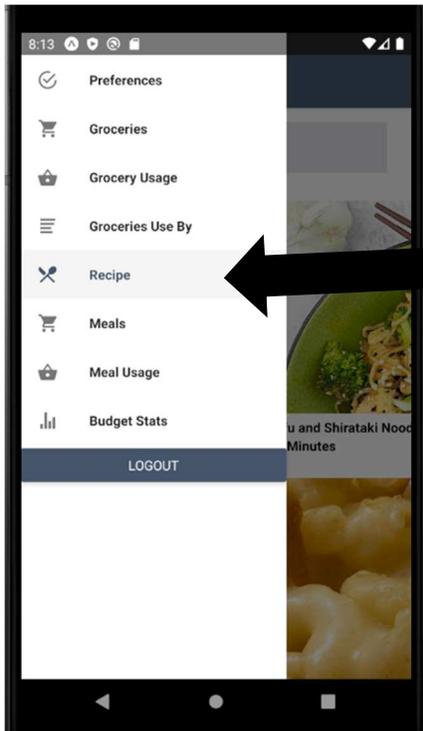
The user may want to search for food recipe. From the drawer menu, user can select **Recipe. Note:** The user's diet preferences are taken into account, and only those recipes that fit preferences will be shown.
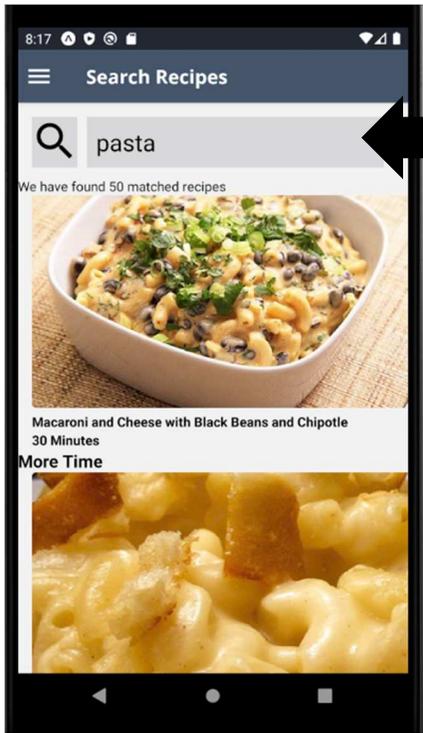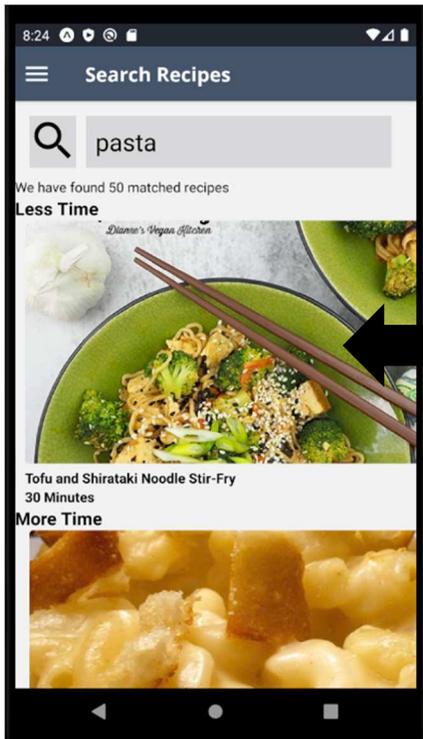
The user has provided "**pasta**" in the recipe search input.

The recipe search results are filtered into two categories: **Less Time** (less than or equal to 30 minutes to prepare) and **More Time** (more than 30 minutes to prepare)
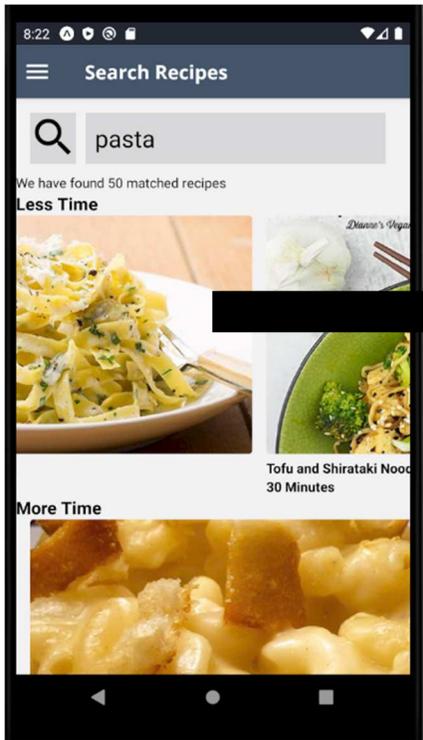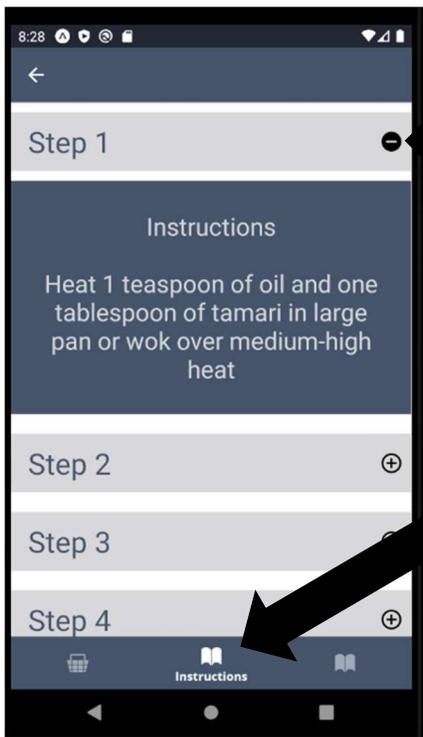
To access the recipe search results, user will need to do horizontal scrolling.

The user can access a particular food recipe, by selecting on the food's image.
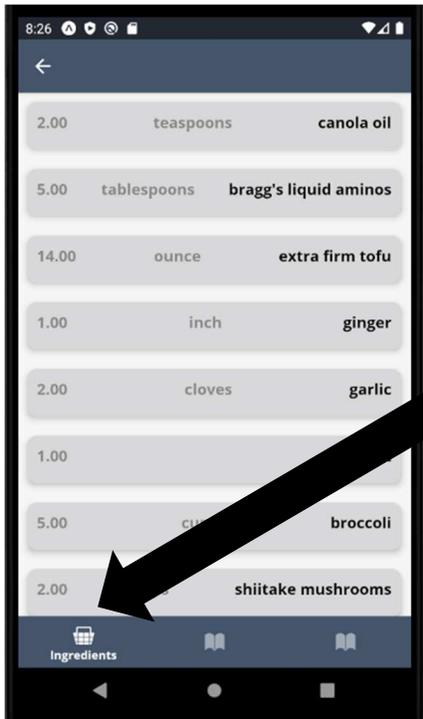
The user may want to view the **ingredients** for the food recipe selected.
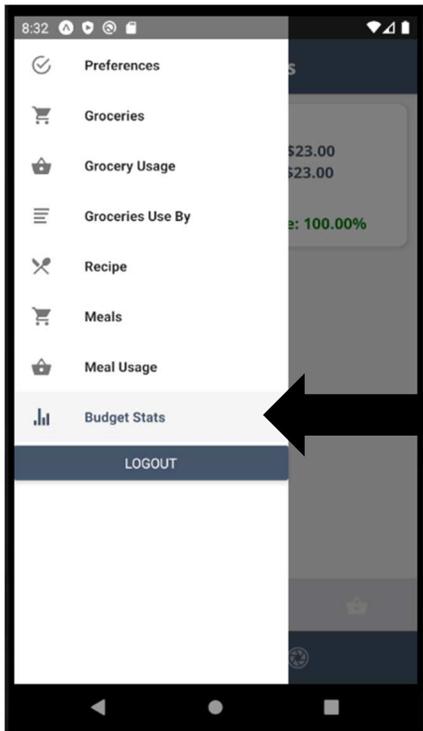
The user may want to view the step-by-step **instructions** for the food recipe selected.
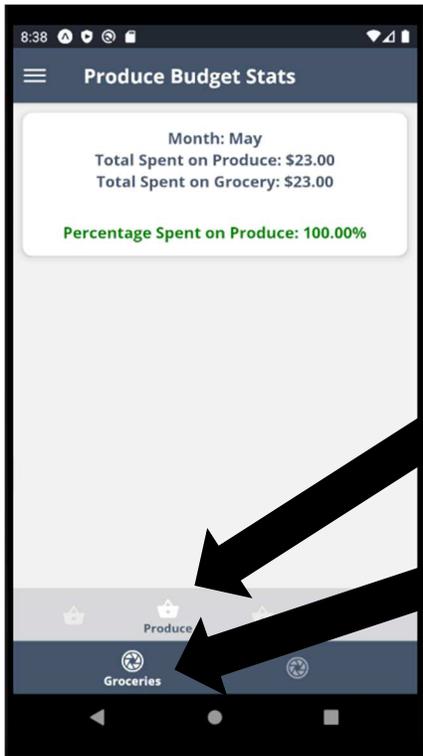
The user may want to view **availability** of ingredients in the inventory for the food recipe selected.
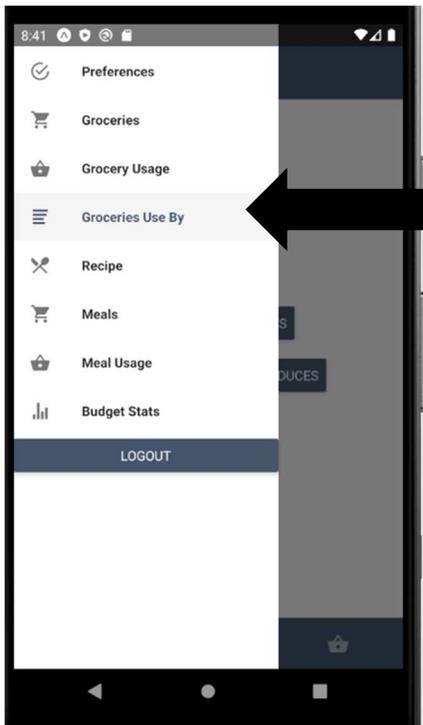
REVIEW BUDGET

The user might want to review their expenditure on **Groceries** and **Meals.**
Groceries include: Ingredient, Produce, Meat, Other (bread, milk, bakery etc.)
Meals include: Breakfast, Lunch and Dinner.

REVIEW GROCERY ITEMS CLOSE TO USE-BY-DATE OR ALREADY EXPIRED

The user may want to review the grocery items that are close to use-by-date or are already expired. Close to use-by-date: takes in account of 1 or 2 days prior to the today's date.

The user will need to select either **View Expired Produces** or **View Near Use by Date Produces** to access the relevant list of produce items.

Appendix F: Experience Sampling

1. Did you shop for groceries today?
   - Yes
   - No

2. How did you choose your meal?
   - Leftovers
   - Prepared Fresh
   - Purchased-Restaurant
   - Purchased -Online

3. What types of food did you eat today?
   - Produce
   - Dairy
   - Bakery and Bread
   - Cereal
   - Eggs
   - Meat
   - Others (please specify)

4. Did you discard any un-used/un-consumed food items (meals or groceries)?
   - Yes
   - No

Appendix G: Usability Questionnaire

STATEMENT	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I think I would like to use this system frequently.					
I found the system unnecessarily complex.					
I thought the system was easy to use.					
I think that I would need the support of a technical person to be able to use this system.					
I found the various functions in this system were well integrated.					
I thought there was too much inconsistency in this system.					
I would imagine that most people would learn to use this system very quickly.					
I found the system very cumbersome to use.					
I felt very confident using the system.					
I needed to learn a lot of things before I could get going with this system.					
I found it hard to find the screens or functions I was looking for.					
I think the navigation of the application from launch to finish makes sense.					

I found that providing the various types of data requested seemed relevant and easy to do.					
I had to spend a lot of time providing data that did not seem useful.					
The charts helped me to understand how well I was doing at keeping a budget, using foods, and not throwing away much.					