Final Report

Enhancing the shopping experience in grocery stores of customers with dietary restrictions through technology

CM3203 - Individual Project
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Abstract

A dietary restriction (DR) is defined as a food limitation focusing on what ingredients a person cannot eat because of their health, moral/ethical, or religious reasons. Failing to follow certain DRs might lead to stress, anxiety, and (or) health issues. After conducting qualitative interviews with people who have dietary preferences or restrictions (such as vegetarianism, lactose intolerance, and religious beliefs) about their experience shopping in grocery stores - common problems such as anxiety, complex labeling of food products, and the long time it takes to research their ingredients have been noticed. In this project, I analyze how a mobile application could be used to enhance the shopping experience of people with dietary restrictions.

Acknowledgments

I would like to thank my project supervisor Dr. Nervo Verdezoto Días for supporting me in making my idea for the final year project come to life as well as for guiding me through the research process and for giving me great suggestions when in doubt.

Additionally, I would also like to thank my university friends for helping me stay motivated throughout the semester and making me laugh during all of the stressful events happening this year.

Table of Contents

Abstract **2**

Acknowledgments **3**

Table of Contents **4**

List of Figures **6**

Introduction **7**
- Aims and Objectives 7
  - Objectives 7
- Scope 8

Background **8**
- Dietary restrictions and requirements 8
- Issues with food labelling 8
- The Problem 8
- Existing Solutions 8

Approach **9**
- Outcome and deliverables 10
- Audience and beneficiaries 10

User Research **11**
- User Recruitment 11
- Data collection (research) methods 11
- **Results and Evaluation** **12**
  - Analysis of the data collected during user research 12
  - Evaluation 15

Design **16**
- Development Environment 16
  - Angular 16
  - Firebase 16
  - Ionic 16
  - IntelliJ IDEA 16
- Prototypes 16
  - Initial Sketches 17
  - Digital Sketches - Wireframes of the initial design 18
  - Middle to High-Fidelity prototypes 19
    - Splash & Log In Screens 20
    - Search 21
    - Product Information 21
    - Scanner 21
    - Sign Up 22
    - Forgot Password 22
    - Settings 22

Main page. 23
Justification 24

Implementation 25
Backend 25
Initial setup 25
Login and register page 26
Figure 15. Authentication service for logging into the application 27
Product search 27
For the search to work properly, I stored all of my products on the firebase database and used a simple query to filter through them. 27

Testing 29
User Experience Testing 29
Process 29
Results, feedback, and evaluation 30

Conclusion 33

Future Work 33

Reflection on learning 34
Collaboration with Supervisor 35

Acronyms 36

Bibliography 36

List of Figures

1. A food scanning and analysis process of Yuka as shown on the Google App Store.
2. Frequency of challenges participants deal with while shopping.
3. Frequency of identified useful features by the participants.
4. Lighting Demos
5. Initial sketches.
6. Wireframes.
7. The colour palette.
8. Splash & Login pages.
9. Search, product information, and scanner pages.
10. Sign up, forgot password, and settings pages.
11. Main page.
12. Firebase configuration keys set up.
13. Imported Firebase services.
14. User interface.
15. Authentication service for logging into the application.
16. Search module and imports for the search page.
17. Firebase query to filter products by name.
18. Password recovery.
19. User experience testing results - average score of each experience.
20. User Experience testing questions.

Introduction

According to a study conducted by The Harris Poll, an American market research and analytics company, over 60% of people in the USA say they monitor their consumption of at least one nutritional component ("Majority of US Households Have Someone With Diet Restrictions"). For example, up to 15% of northern Europeans, 80% of Blacks and Latinos, and up to 100% of American Indians and Asians suffer from the inability to digest lactose (Swagerty et al. 2002). Food restrictions can be caused by an individual's ethical beliefs (veganism, vegetarianism), health problems (Diabetes, gluten intolerance), or religious practices (The majority of Hindus tend to be lacto-vegetarian). Individuals with dietary restrictions may experience stress and anxiety due to their diet requirements, however, restricting certain foods has proven to lead to a longer life expectancy (Testa et al. 2014). While efforts are being made to inform people what ingredients the products they consume daily contain, it is still widely known that analysing every single food label in the grocery store is a tedious and exhausting process. Individuals with dietary restrictions mention that the terminology used in food labels is hard to interpret and that there is a lack of information about whether there are any allergens in food products (ACNielsen, 2005).

The objective of the research presented in this article focuses on learning what issues individuals with dietary restrictions face while shopping in grocery stores - what is currently being done right and where there could be improvements. In addition to that, we aim to find out how we could make the experience easier for the people monitoring their diets and find a solution to solve the existing problems they mention.

The results of this research have the potential to increase awareness on how businesses can adapt to help people with DRs purchase products easier, without wasting their time, however food labelling is a practice regulated by governmental institutions, and any misinformation or incorrect display of product information may lead to fines as well as health hazards. There are many policies mandating how food information is provided and it should be noted that there are differences in how this information is displayed between different countries (Cornelisse-Vermaat et al. 2008).

Aims and Objectives

The primary aim of the project is to research what struggles people with dietary restrictions face while shopping in grocery stores and to build a mobile application to help them overcome their everyday challenges.

Objectives

- Research and learn what main problems people often face regarding their dietary restrictions
- Realise how we can help people overcome their struggles while shopping in grocery stores using technology
- Design the required technology based on the information collected during the user research stage
- Learn how to effectively use technologies like Angular and Firebase while building mobile applications
- Build the designed technology according to good coding practices
- Test the built solution to make sure that our technology is error-free using a sample data set.

- Compare our built application to similar products on the market and discuss what value our project brings.

Scope

To avoid any miscommunication and misunderstandings, this section provides information on the topics that the project will not be focused on solving:

- Any ideas related to Calorie counting and anything related to diet in terms of losing weight and in general.
- Any social networks e.g., creating social media for people who have various dietary requirements.

Background

Dietary restrictions and requirements

A dietary restriction or requirement is easiest to describe as a limitation on what an individual can eat, whether that would be in moderation or at all. Even though most DRs come from allergies or intolerances such as milk or nuts, a lot of people base their diets and what food they eat every day on ethical, religious, or social choices. The most common found dietary restrictions are vegetarianism - when people do not eat meat products due to moral, religious, or health reasons, veganism - when people do not eat any animal by-products and pescetarianism - when people similarly to vegetarianism do not eat meat products, however, they do eat fish.

Although there are many opinions about food restricting diets, research has shown that oftentimes restricting certain food groups has been a cause of slower aging and longer life expectancy (Katewa SD, 2019). Data recommends minimizing the intake of animal-based ingredients and rather opting for plant-based alternatives.

The Problem

Now that we have identified the issues with dietary restrictions and food labelling, it brings us to the problem that this project is focused on solving: how to enhance the shopping experience of people with dietary restrictions through technology. For this, a good way to start would be to research what are the most often encountered struggles of grocery shoppers in the UK are by conducting a potential user research and analyse what technology and features would be the most beneficial to them based on their experience and needs.

Furthermore, the project will explore, evaluate and compare existing solutions with the application developed at the end as well as provide user feedback and further work needed. The problem that will be addressed at the end is whether a mobile application is a good solution for enhancing the shopping experience for people suffering from various dietary restrictions.

Existing Solutions

There have been little projects created by small businesses that tried to solve similar problems to enhance the shopping experience of people with dietary restrictions. However, none of these projects had features to include several members of the family or friends and were lacking in features that would support people with uncommon dietary requirements such as restrictions that avoid the use of avocados, chocolate, nut butter, etc. due to their unsustainable and unethical farming. At the moment, the most popular existing solutions that aim to help people with ingredient restrictions on the apple store as of April 2022 are Yuka (10+ million downloads) and ThinkDirty (1+ million downloads), however even though these applications provide information on what ingredients a scanned product contains, they do not have an option that would let the user enter information on their own on what ingredients can be harmful to their health and skip the label reading process. Furthermore, both of these applications are targeted more towards cosmetic products rather than food, which leaves space in the market for an application that is targeted specifically around food restrictions.

An example of what the food scanning process looks like on Yuka - a mobile application meant to provide information on the health impact of food and cosmetic products.

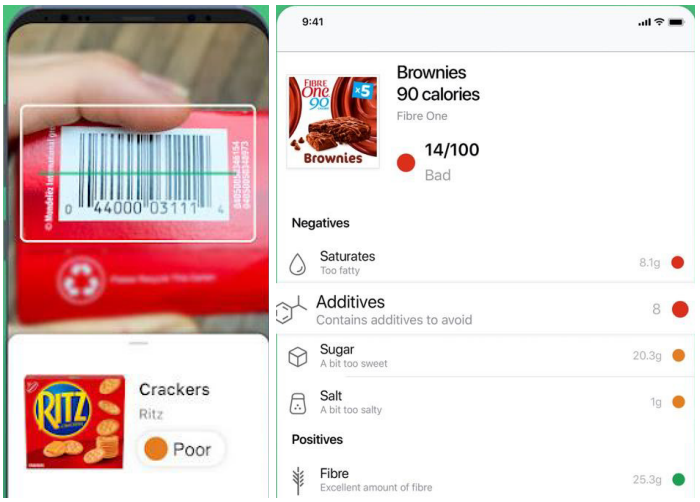

Figure 1. A food scanning and analysis process of Yuka as shown on the Google App Store.

Approach

10 participants were recruited to participate in a short qualitative research interview, where they were asked questions about their experience and habits of shopping at their preferred grocery store. All of the participants were asked whether they have at least one dietary requirement before the interview started. Each participant had to sign a consent form to agree with the processing of their given answers for research purposes. The recruitment and interview process was held between April 2022 and May 2022.

The data collected from the qualitative research interviews were used to analyse behavioural patterns of customers shopping in grocery stores and provided us with information on what the interviewees do to make sure that the products they buy comply with their diets when trying to protect their health or ethical & religious beliefs.

This data was then reflected on while brainstorming tools that could be used for solving the most common problems that people encounter while shopping at grocery stores. After a quick evaluation of existing tools and technologies, it was decided that the most appropriate approach to solving the issues would be to develop a smartphone application that is focused on enhancing their shopping experiences by creating a platform that can analyse the ingredient lists of food products to determine whether they are suitable for the users or their family members diet.

An agile SCRUM methodology was used to plan the development work into iterations focused on implementing various features of the application e.g., login functionality, user profiles, product search, product scanner, etc.

The Angular framework was used to implement frontend features of the application and Firebase was used for developing the backend.

Software backups were saved after successfully implementing each feature and applying integration & unit testing to make it possible to roll back into the previous version if any errors occur while implementing further features.

Outcome and deliverables

This section describes the list of outcomes and deliverables that are expected at the end of this project:

Part 1:

- An analysis of the issues related to grocery shopping and food consumption of people who suffer from dietary restrictions.
- Market research and a comparison of the initial mobile application idea with the current applications available on the market.
- Initial sketches and wireframes of the proposed mobile application design.

Part 2:

- A functional mobile application that has basic functionalities to help the user find information on what ingredient a product in a grocery store contains.
- A database containing a basic dataset about the most common products and their ingredients.

Part 3:

- Comments and results which were gathered throughout the user experience testing.

Audience and beneficiaries

A mobile application that stores ingredient information about a vast number of grocery store products can be widely used both on an everyday basis by people suffering from various illnesses or intolerances as well as in education - for example, people who study nutrition, food engineering, or even food chemistry.

According to a 2009 research on the diagnosis of food intolerance, around 20% of the population in industrialised countries suffer from food intolerances or allergies, the most common being lactose and wheat (Zopf et al. 359-370). This creates a huge audience that can be potentially interested in making their life easier by using an application that will make their shopping experience quicker and easier by notifying the users which products may be harmful to their bodies. Besides food intolerances and allergies, a rising trend of highly

restrictive diets has been noticed during the past several years. In the United Kingdom alone, approximately 600,000 people identified as ‘vegan’ at the beginning of 2019, and a record number of 250,000 people took the ‘Veganuary’ pledge to go vegan throughout the January month of 2019 (Smithers 2019).

A new platform that would provide the users with the ability to quickly find out which products are available to them based on their dietary preferences, store their favourite products in a favourites list for future reminders, and provide additional information about what the product consists of, would benefit both people interested in plant-based diets and people who suffer from dietary restrictions.

User Research

During the months of April and May 2022, I conducted 18 qualitative interviews with 10 different people on the topics of dietary restrictions and their shopping habits. The aim of the research was to gain more insight into what problems people with dietary restrictions face on a daily basis. The people who were interviewed were asked about what requirements they have implemented in their lives, what routines they follow while shopping and what worries them as well as what could be improved in the shopping process. All of the interviews were conducted online based on the preferences of the people interviewed.

User Recruitment

All of the users were recruited online using social media - Facebook, and specifically through the public social groups: ‘Vegan UK’, ‘Lactose Intolerance UK’, ‘Gluten-Free UK’, and ‘Tibetan Buddhism in the UK’.

Data collection (research) methods

The data was collected using two interviews which consisted of four parts in total.

The goal of the first interview was to understand what difficulties the participants of the interview face while shopping at grocery stores and what best experiences they have had to help them find products that are suitable for their diets. Each interview took around 30 minutes and consisted of two parts. In the first part, the participants were asked open-ended questions about their overall experiences while shopping with dietary requirements, what challenges they face and how the overall situation could be improved from their point of view. The questions were as follows:

1. How often do you visit grocery stores every week?
2. What grocery stores do you prefer and why?
3. Do you have any shopping routines, and can you describe them? Example: Shopping in the morning, making a to-do list, picking up your glasses or reusable shopping bags with you, etc.
4. What are some important things that you look for in a product when you shop?
5. Do you have any dietary preferences while shopping? (If not, the interview will end here)
    a. How do you identify that a product does not have any ingredient that you cannot consume?

b. While shopping, have you looked at the label of the product for information on what it contains?
c. Tell me more about your dietary habits and restrictions?
    i. How important is it for you to not consume certain ingredients? What are the consequences of consuming them?
d. What are some of the challenges you face while grocery shopping?
e. What are some of the things that make your life easier (best practices that you have noticed) while shopping and making sure that you do not buy products containing certain ingredients?
f. f. Are there any things that would help you with your shopping that you would like the stores to implement?

6. From your point of view, do you have any suggestions on how to improve your shopping experience in general?
7. Any other comments you would like to add regarding your dietary restrictions or experience in grocery stores?
8. May I please have your email for the second interview focused on user experience testing?

In the second part, the participants were asked to comment about features that have been identified in the most popular smartphone applications that focus on dietary restrictions and allergies. They had to think about which features they would like to have in a smartphone application that would enhance their grocery shopping experience. Some of the features included were:

- **Food diary** – a feature that allows users to record their daily meals.
- **Restriction tracker** – A feature that provides the user the ability to save restrictions of other people as a reminder for them.
- **Create meals and recipes** – A feature that allows users to create custom meals and recipes which can then be easily recorded in a food diary.
- **Food database –** A feature that stores a range of foods and their nutritional content for use in recording foods and creating recipes.
- **Shopping lists –** A feature that generates the shopping list for the corresponding weekly diet plan.

After evaluating the presented features, the interviewees were introduced to the initial prototype of the application and were asked to discuss their likes and dislikes as well as what improvements could be made.

The initial prototype of the application can be found in the Completed Prototypes section of this report under Design.

Results and Evaluation

Analysis of the data collected during user research

In total, ten individuals participated in the research - all of them participated in the first interview of the research process, however only eight of them participated in the second one. All of the participants confirmed that they have at least one dietary restriction before participating in the research.

The analysis of the results of part one of the first interview:

1. Eight out of ten participants said that they visit a grocery store at least once every single day - mostly to either grab something small for their dinner or lunch. Two out of ten participants said that they prefer to shop once per week as they do not like wasting their precious time after work or studies.
2. Five out of ten participants said that they prefer to shop at Tesco or Sainsburys - mostly because it is close to their home and has enough product offering to suit their diets. Two of the participants mentioned Lidl and Aldi as one of the stores due to their low prices. One of the participants mentioned Waitrose as it is the closest to their home and one other participant mentioned that their favorite store is Marks and Spencers due to the quality of their products as well as the distance to their home.
3. Six out of ten participants revealed that they do not have any shopping habits, one of the participants mentioned that they shop on the weekends, two participants said that they always pick up their reusable shopping bags, and one participant said that they make to-do lists.
4. All ten participants said that when they are shopping, the most important things that they are looking for are whether the product they want to buy suits their diet, the quality of it, and the price.
5. At the time of the interviews, all ten participants taking part in the research had at least one dietary preference.
    a. All of the participants mentioned that they identify whether a product does not have any ingredients they cannot consume by looking at its label. Three of the participants also mentioned that they buy products recommended by social media influencers who promote a lifestyle similar to theirs.
    b. All of the participants said that they do look at the product labels regularly while shopping.
    c. All of the participants said that it is very important to them to not consume certain ingredients that do not suit their lifestyle.
        i. Seven of the participants said that most of their dietary restrictions are related to their lifestyle choices so there are no specific consequences if they consume a certain ingredient, however, they feel that it is morally wrong. Three of the participants identified themselves as vegan, one as vegetarian, and one as Buddhist.
        ii. Three of the participants said that their dietary requirements are due to allergies or intolerances so it is very important for them not to consume certain ingredients in order to avoid feeling or becoming ill.
    d. When it comes to the challenges the participants face while shopping, eight participants said that they spend more time shopping and reading labels than they normally expect to, especially if they are looking for something that they do not usually buy. Five people mentioned that stores often do not have enough variety of products to satisfy their needs. More of the statistics on the challenges people face while shopping are provided in Figure 9.

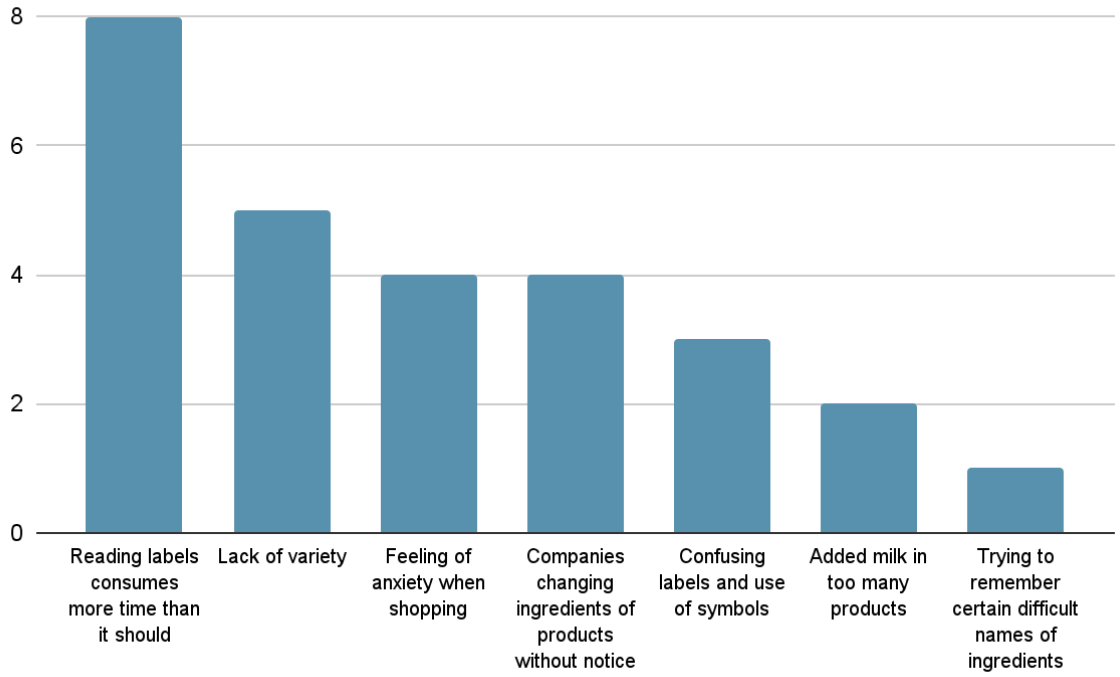

Figure 2. Frequency of challenges participants deal with while shopping

e. When it comes to the things that people mentioned that help them while shopping the most, five of the participants said that it becomes easier to shop with time and experience. Five of the participants mentioned social media - social groups on Facebook and influencers they follow recommending products suitable for their diets. Two of the participants mentioned dairy-free and gluten-free sections in stores. One participant mentioned magazines. Two of the participants had no answers.

6. When asked about what improvements could be made to improve their experience in grocery stores in their personal opinion, seven out of ten people said that a clearer labelling format would solve most of their problems. One of the suggested ways was to put a special symbol on every single product that says what diet a product suits (Omnivore, vegetarian, vegan, etc.) or what allergens it has. Two people also mentioned that products should be sectioned in a better way so that products for omnivores would not be mixed with products that suit vegetarian diets and two out of ten people could not give a clear answer and said that they need more time to think about it.

After introducing the participants to the idea of a mobile application to enhance their shopping experience, I asked them to identify which features would be useful.

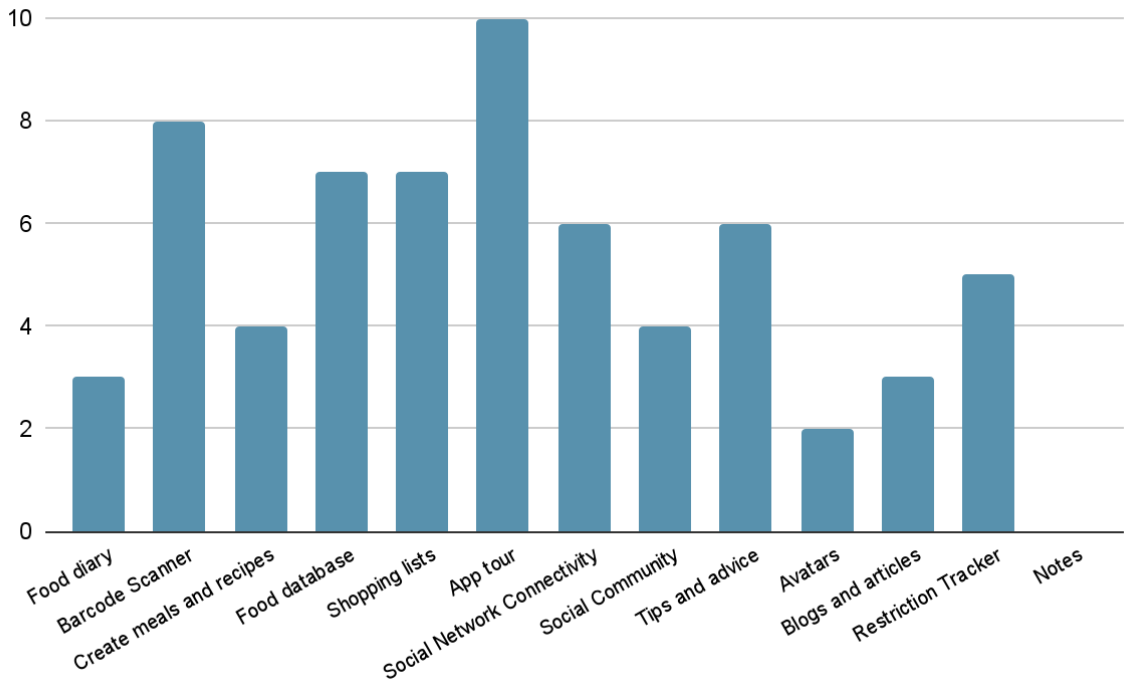

Figure 3. Frequency of identified useful features by the participants

No answers were received when asked whether the participants had any extra features in mind that could be implemented.

Evaluation

After the first part of the interview, I could clearly identify the pattern between the answers and the issue that most people had when grocery shopping, which is food labelling. Almost every single person I had the opportunity to talk to mentioned that it takes too long to read ingredient labels, that they are confusing, the font is too small, or that the symbols provided on them are misleading.

The second part of the interview revealed that the three most useful features, according to the participants would be an app tour - a feature that shows users how to use the app and where certain features can be found, barcode scanner - a feature that allows users to scan the barcode of a product to view its ingredients, food database and shopping lists.

Based on the results of this research, I decided to focus on implementing the barcode scanner and food database features on the mobile application developed during this project. Unfortunately, due to lack of time and resources, I decided to skip the development of an app tour, the reason being that it is more of an aesthetic feature that is found in most applications and which can be developed later.

Design

Development Environment

Angular

The frontend of the mobile application was built using Angular 13.1.1. Angular is a free and open-source web framework led by a team at Google and built by a community of individual developers and corporations. This specific framework was chosen since it has a large development community able to provide support when required as well as due to its stability and fast performance. Furthermore, it is easy to implement Angular with Firebase and Ionic which makes it hassle-free when developing native mobile applications.

Firebase

The data used by the application was stored in databases provided by Firebase. Firebase is a platform developed by Google that focuses on providing features such as hosting, authentication, and real-time databases as backend services which saves time while building mobile applications. The reason why this platform was used in this project was due to its simplicity, low price, and an established user community that is always ready to help with any issues.

Ionic

To ease the process of building the mobile application without having to test it multiple times throughout the development on a mobile phone, I decided to use Ionic. Ionic is a platform used for building mobile experiences with the web (Ionic Article: What is Ionic: Learn the essentials of what you can do with Ionic and how it works., 2022).

IntelliJ IDEA

To increase my productivity writing code and keep up to date with the latest best practices, I decided to use the IntelliJ IDEA integrated development environment developed by JetBrains. The reason why I chose to use IntelliJ compared to other IDEs such as Eclipse or Netbeans, was because I already had experience using it during my previous projects and because it is free to use for University students.

Prototypes

To make it easier to develop the frontend design of the application I have decided to prototype some parts of the application using a sketchbook and Figma - a graphics tool editor and prototyping tool by Figma, inc.

Lighting Demos

At the beginning of my prototyping process, I decided to look into the current trends of the user experience design - particularly minimalism and mostly used color patterns in current mobile application design. Besides that, I tried to look into how some of the functionalities I

need to implement in my project already are implemented in the different mobile applications available on the Apple app store and Google.

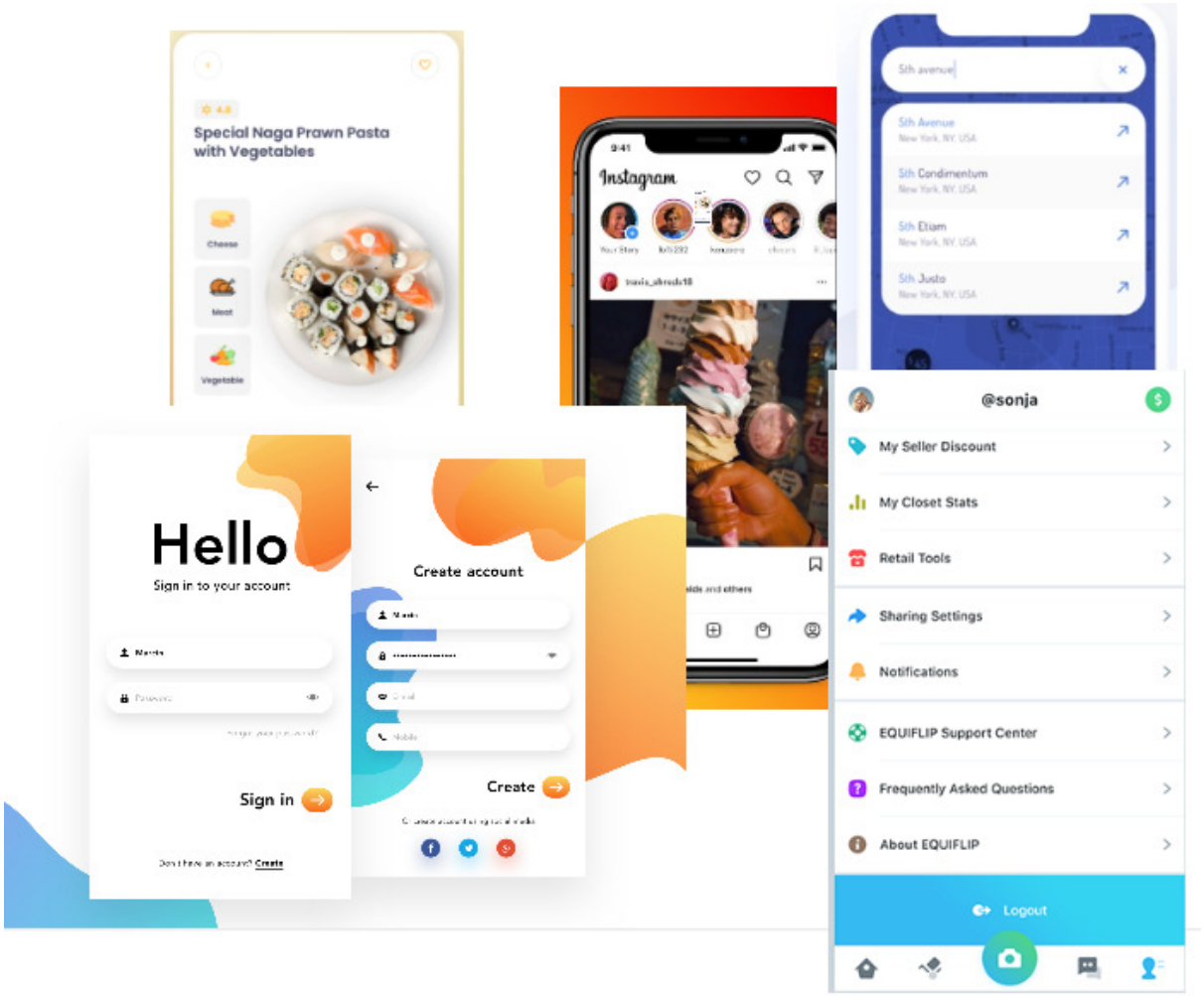

Figure 4. Lighting Demos

Initial Sketches

After researching the current trends in user experience design and browsing through mobile applications which are designed to support individuals with dietary restrictions, I have quickly created the initial sketches of the potential design prototype. The sketches include the following pages: (1) Log In, (2) Scanner, (3) Search, (4) Search Results, (5) User Profile, (6) Settings, (7) Forgot Password, (8) Sign Up, (9) Home.

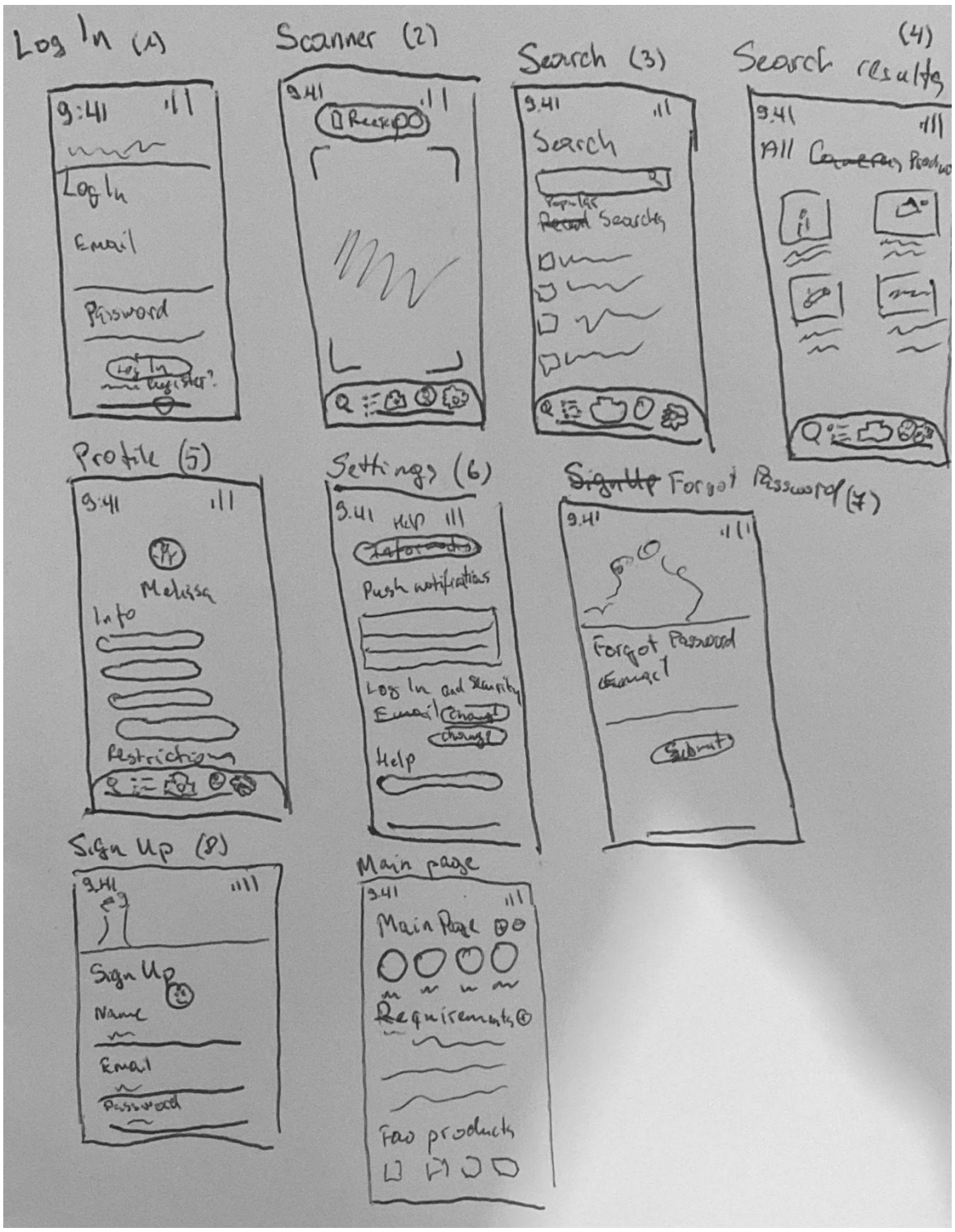

Figure 5. Initial sketches of the mobile application.

Digital Sketches - Wireframes of the initial design

After sketching the initial designs, I used wireframes to represent the arranged elements of the mobile application and help visualise the functionality of the different pages and elements. Wireframes were designed using Figma.

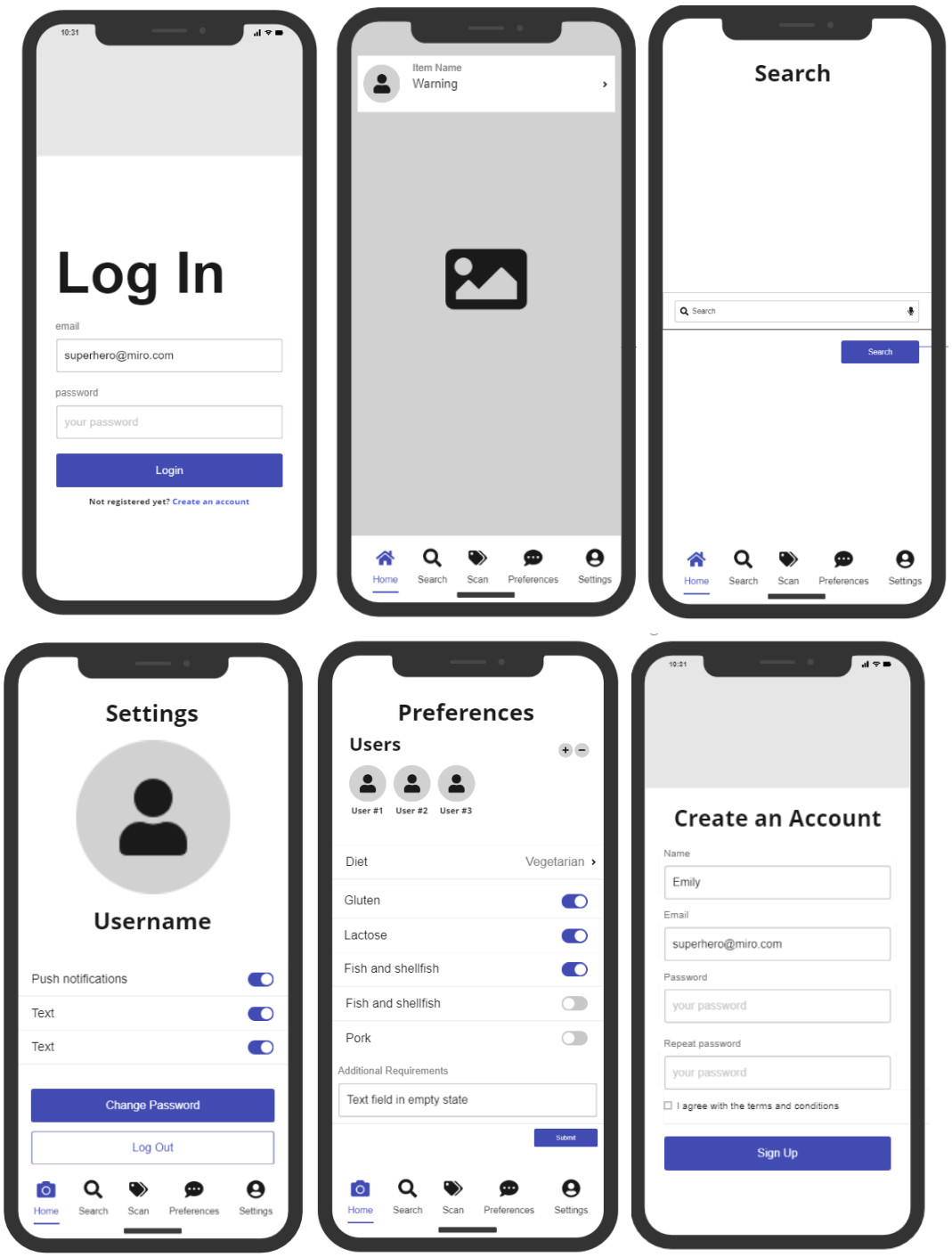

Figure 6. Wireframes of the mobile application.

Middle to High-Fidelity prototypes

Finally, I designed the middle to high-fidelity prototypes using Figma. I opted to make the prototypes of 10 different pages of the mobile application as that seemed to be most reasonable considering the time given to build the application.

The icons used in this project were taken from the open-source MUI Material Icon design package created by Google. The designs are open-sourced and available for free for personal and commercial use.

The chosen colour scheme consists of five primary colours: Baby Powder (HEX: #FEFDF9), Opal (HEX: #A0C9C5), Baby Pink (HEX: #F0C3C0), Blue Sapphire (HEX: 00627F) and Vegas Gold (HEX: CEAF5F).

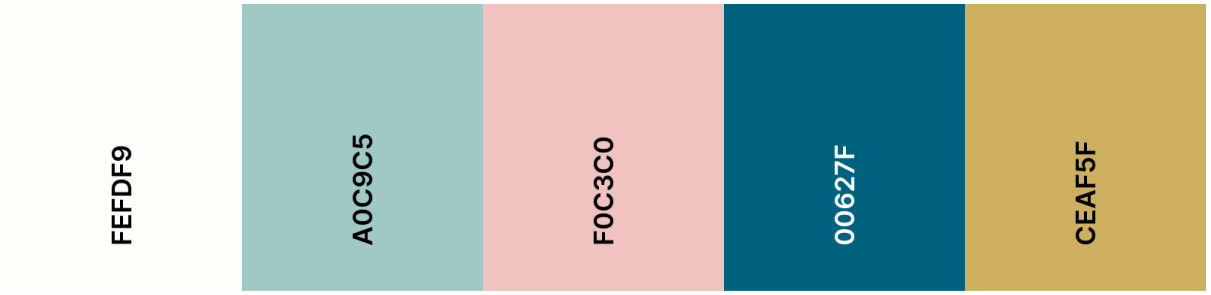

Figure 7. The color palette of the mobile application.

The prototype designs of the different pages are provided below.

Splash & Log In Screens

For the splash screen, I put a simple ‘Hello’ text and a pattern background. For the login screen, I used two text fields for the Email and Password information and a login button on the bottom.

After the splash screen, my initial idea was to implement a short tutorial guiding the user on how to use the application and what its functions are, however, due to the lack of time, I decided not to proceed with this idea.

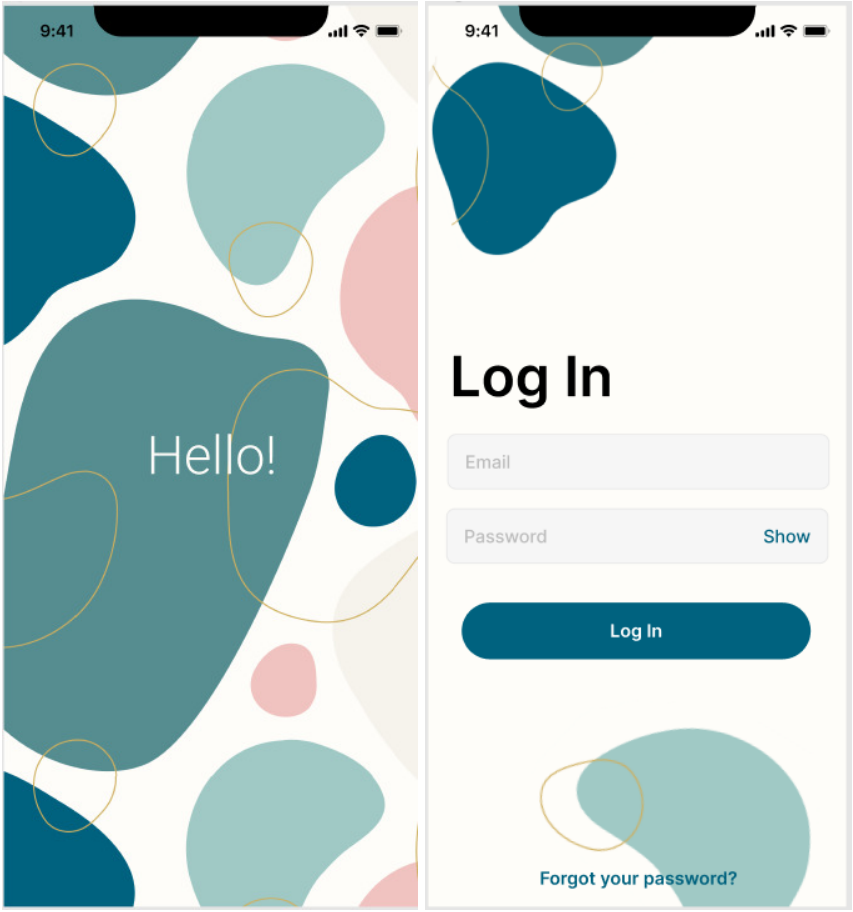

Figure 8. Splash & Log in pages

Search

The purpose of the search page is to be able to find information about certain products without using a camera. I chose a simple design where after a user types out a part of the product search results will appear accordingly. A filter should also be implemented to help the user quickly find the product they are looking for.

Product Information

After the user clicks on one of the provided search results, they will be taken to a product information page where an ingredient list of the product will be displayed. This page also has a field for product images and a function for the user to save their favourite products for future reference.

Scanner

The purpose of the scanner page of the application is to be able to take a picture of a product's barcode and immediately have information displayed on whether or not the product fits the user's diet. It should also have a button for more information and a text-to-speech button.

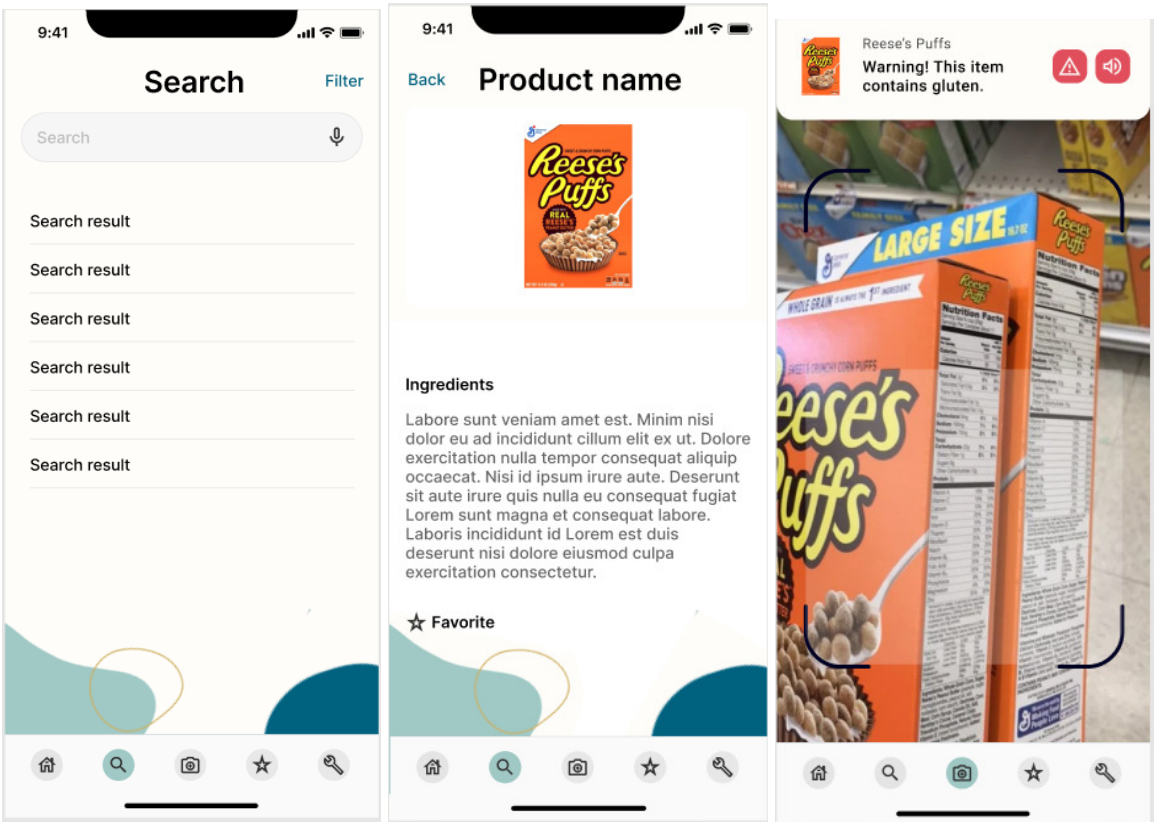

Figure 9. Search, product information, and scanner pages.

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Sign Up

The sign-up page will have three text input fields for the user to fill out the information where the user can set up the password and email for their account. The user will also have to agree to the terms and conditions.

Forgot Password

The forgot password page will have only one input field for the user's email and will send an email directly to the email provided with password recovery information.

Settings

The settings page of the application will include several customization options of the application to fit the user's accessibility needs better. These will include: changing the theme (contrast), text size, and language. It will also provide the options to change the password, profile picture, or the name of the account they have logged in to. Under the profile and ID number will be displayed. This number will be able to be used in the future when adding another person and their preferences to your account.

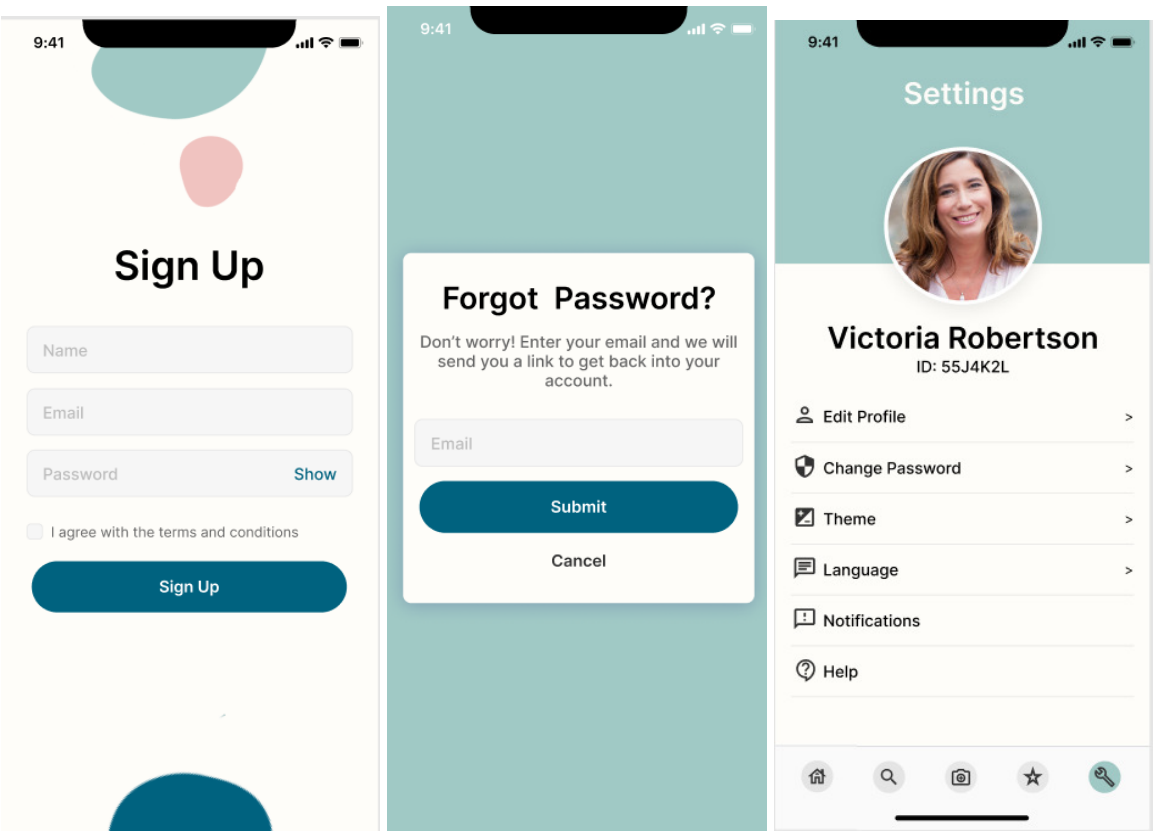

Figure 10. Sign up, forgot password, and settings pages.

Main page.

The main page of the application is the place where the user will choose their own dietary restrictions. Some of these restrictions are put as selection lists and the user can quickly click on them and choose whether or not they want to restrict these ingredients from their diet, however, I also put a text field so that the user could input their own ingredients from an ingredients array in the application. After clicking the submit button, the chosen requirements will be generated as tags and put on the bottom of the page. They represent the restricted ingredients that will be searched for when a product label is scanned. The user can delete the requirements by clicking the X button next to the tag.

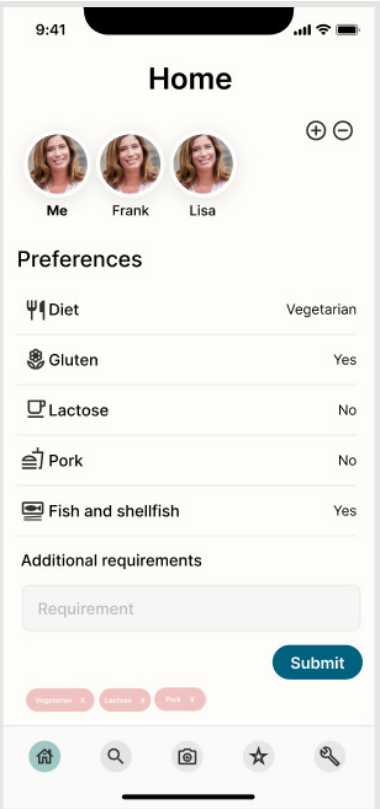

Figure 11. Main page.

Justification

To make the design of the application consistent throughout all pages, I wanted to create simple patterns that I could use as images and put as a background. For these patterns, I used circles and blobs that I painted with Adobe Photoshop. I used an Inter font type for the text to make the application feel modern.

The images used (such as profile pictures) were taken from Unsplash.com - a website that provides royalty-free images and are edited using Adobe Photoshop to fit the design of the application.

The colours were chosen to match each other according to the colour theory.

Implementation

Backend

Initial setup

To set up my local development environment, I had to install Angular on my device, create a Firebase database and connect it to the angular application that I have created. To set up an angular application, the process is fairly simple:

- I installed the latest version of Node.JS
- Installed the Angular CLI by running a terminal window and entering the command: `npm install -g @angular/cli`
- Installed the Ionic CLI by running in the terminal window the following command: `npm install -g @ionic/cli.`
  I chose to use Ionic for this project mainly due to the fact that it helps speed up the process of developing the mobile application environment on itself.
- Created a new app using Ionic by typing the command: `ionic start dietary-app blank --type=angular`
- Set up Angular in the Ionic project that I am working on: `npm install firebase @angular/fire --save`
- Imported and registered firebase configuration keys and services so that the firebase database would be accessible by the application:
  In the environment.ts file:

```
export const environment = {
  production: false,
  firebaseConfig: {
    apiKey: 'AIzaSyD64j4Q33vjnjQuvcf8hSOwZKnN9mX9OXA',
    authDomain: 'dietaryfire.firebaseapp.com',
    databaseURL: 'https://dietaryfire-default-rtdb.europe-west1.firebasedatabase.app',
    projectId: 'dietaryfire',
    storageBucket: 'dietaryfire.appspot.com',
    messagingSenderId: '668916833574',
    appId: '1:668916833574:web:ec3d1ee10b999e3bea75e7',
    measurementId: 'G-JN3ZTP1SJY'
  }
};
```

Figure 12. Firebase configuration keys set up.

In the app.module.ts file:

```
import { AppRoutingModule } from './app-routing.module';
import { AppComponent } from './app.component';
import {AngularFireModule} from "@angular/fire/compat";
import {AngularFireDatabaseModule} from "@angular/fire/compat/database";
import {AngularFirestoreModule} from "@angular/fire/compat/firestore";
import {AngularFireStorageModule} from "@angular/fire/compat/storage";
import {AngularFireAuthModule} from '@angular/fire/compat/auth';

@NgModule({
  declarations: [AppComponent],
  entryComponents: [],
  imports: [BrowserModule, IonicModule.forRoot(), AppRoutingModule,AngularFireModule.initializeApp(environment.firebaseConfig),
    AngularFireAuthModule,
    AngularFirestoreModule,
    AngularFireStorageModule,
    AngularFireDatabaseModule,
  ],
  providers: [{ provide: RouteReuseStrategy, useClass: IonicRouteStrategy }],
  bootstrap: [AppComponent],
})
export class AppModule {}
```

Figure 13. Imported Firebase services (The red lines highlight ESlint errors)

- Finally, to run the freshly installed application all I needed to do was to navigate to my workspace folder and run the ng serve command:
  `cd dietary-app`
  `ionic start`
- The ng serve command launches the application and rebuilds it every time a new change has been made in one of the files.

Login and register page

To implement the login and registration pages, I used Firebase authentication.

I created a User interface with the following attributes: id, email, display name, and photo URL.

```
export interface User {
  uid: string;
  email: string;
  displayName: string;
  photoURL: string;
  emailVerified: boolean;
  password: string;
}
```

Figure 14. User interface

Later I use this interface when creating functions for the user to log in and register to the system.

```
export class AuthenticationService {
  userData: any;
  constructor(
    public afStore: AngularFirestore,
    public ngFireAuth: AngularFireAuth,
    public router: Router,
    public ngZone: NgZone
  ) {
    this.ngFireAuth.authState.subscribe( next: (user : User | null ) => {
      if (user) {
        this.userData = user;
        localStorage.setItem('user', JSON.stringify(this.userData));
        JSON.parse(localStorage.getItem( key: 'user'));
      } else {
        localStorage.setItem('user', null);
        JSON.parse(localStorage.getItem( key: 'user'));
      }
    });
  }
  // Login in with email/password
  SignIn(email, password) {
    return this.ngFireAuth.signInWithEmailAndPassword(email, password);
  }
  // Register user with email/password
  RegisterUser(email, password) {
    return this.ngFireAuth.createUserWithEmailAndPassword(email, password);
```

Figure 15. Authentication service for logging into the application

Product search

For the search to work properly, I stored all of my products on the firebase database and used a simple query to filter through them.

```
import { Tab2PageRoutingModule } from './tab2-routing.module';
import {Ng2SearchPipeModule} from "ng2-search-filter";

@NgModule({
  imports: [
    IonicModule,
    CommonModule,
    FormsModule,
    ExploreContainerComponentModule,
    Tab2PageRoutingModule,
    Ng2SearchPipeModule

  ],
  declarations: [Tab2Page]
})
```

Figure 16. Search module and imports for the search page.

```
firebase.database().ref( path: '/products') Reference
  .orderByChild( path: "name").equalTo( value: "0") Query
  .on( eventType: 'value', callback: (data: DataSnapshot) => {
    data.forEach((child: DataSnapshot) => {
      console.log(child.key, child.val());
    });
```

Figure 17. Firebase query to filter products by name.

Recover password

To recover the password, after the user types out an email to the password recovery box, the system connects to the database using the Firebase authorize module and sends a password reset email to the provided email.

```
// Recover password
PasswordRecover(passwordResetEmail) {
  return this.ngFireAuth
    .sendPasswordResetEmail(passwordResetEmail)
    .then(() => {
      window.alert(
        'Password reset email has been sent, please check your inbox.'
      );
    })
    .catch((error) => {
      window.alert(error);
    });
}
```

Figure 18. Password recovery.

Testing

User Experience Testing

Process

User experience testing meetings were held a couple of weeks after the initial user research interviews and after the development of the initial application had finished. These meetings focused on UX testing and collecting general feedback on the chosen designs and features. Each interview took approximately 30 minutes and consisted of two parts - general feedback and manual testing.

In the first part of the meeting, the mobile application was shown to the participants and their task was to evaluate it based on their first impression. Questions were asked to help get more information about what their first impression was:

- What is your first impression of the application?
- What do you think when you look at this application? What feelings do you get?
- What do you think this project will do?
- What do you think about the design of the application?
- What do you think about the features that are on this application? Do you think they fit the purpose of the application?
- Do you find the text in the application easy to read and understand? • Where and when do you think you would use this application?
- What do you think would keep you from using this application?
- Have you ever used similar tools before?
- Would you trust this application?
- Is there anything you would like to see improved on the application?

In the second part of the meeting, the participants were asked to perform several activities using the application e.g., registering a new user for the application, adding dietary requirements to the created user, looking for products they are interested in, and using the application to determine whether the product is suitable for their diet.

After performing all the actions, the participants were asked to evaluate their experience based on the questions provided below on a scale of one to five with five being strongly agreed and one strongly disagreeing.

No.	Description	1	2	3	4	5
1.	The application performed as expected					
2.	The user interface is easy to understand					
3.	It was easy to learn how to navigate and use the application					
4.	I was able to successfully complete the provided tasks					
5.	The tasks were easy to accomplish					
6.	The tasks took a short time to accomplish					
7.	The text, font and colours were balanced and consistent					
8.	The text in the application is easy to read					
9.	I think that most people would be able to use this application easily					
10.	The application has all the features I need to successfully complete every task					
11.	I felt good using this application					
12.	The visuals did not distract me from the purpose of the application					
13.	The application design is attractive					
14.	It is clear how the application can help people with dietary requirements					
15.	I would recommend this application to my friends and family					

Figure 20. User Experience testing questions.

Results, feedback, and evaluation

A total of 8 participants took part in the user experience testing process. Unfortunately, two of the other participants from the initial ten went missing and I could not manage to contact them in the end.

The people who took part in the research had a fairly good first impression of the application - the experience was different because the mobile application was run on a browser rather than a mobile phone, so instead of tapping with their fingers, the participants found it funny that they had to use their mouse. The reason for testing on a browser rather than a mobile phone was because I wanted to save time so that every participant would not have to download their application on their mobile phone before the interview and also

because I was scared to run into incompatibility OS errors if the participants were using different phones.

When looking at the application, the research participants noted that it looks very simple and minimalistic, however after browsing around it was easy for them to understand what is the purpose of the application as it did not have many different functionalities. This is since I had a minimal time limit so I could only implement a few basic features throughout the time.

The users found the information displayed on the app easy to read and understand. Overall, there were no issues when it comes to using the application as all of the participants have used similar mobile applications before, and navigating the application was very straightforward for everyone.

The main issue that all of the participants noted while using the application was that it looks a bit boring and unfinished and that would keep them from using the application. Four of the participants said that the app needs visual improvements as it gives them a feeling of distrust on whether this application is reliable and works the way it is intended to.

All of the eight participants noted that the application still needs visual improvements and more features. Although the users were able to use the application - register, log in, find the products they needed and find the information they required with ease, they all felt as if the application was lacking personalization and that it was boring.

The average time it took for the participants to complete a simple task - register, log in to their account, enter dietary restrictions, and find whether a product - cereal contains them, took on average two minutes and forty-nine seconds with the highest time being three minutes and thirty-eight seconds and the slowest time being one minute and fifty-four seconds. Most of the participants in the research felt that this is a pretty quick time to register a completely new account and check the ingredients list of a product, compared to what it would take them to check every single label. Therefore, the application succeeded in saving time and effort for people when it comes to reading product labels.

After performing the steps the users were asked to perform, the participants were asked to evaluate their experience based on a scale of one to five with five being strongly agreed and one strongly disagreeing.

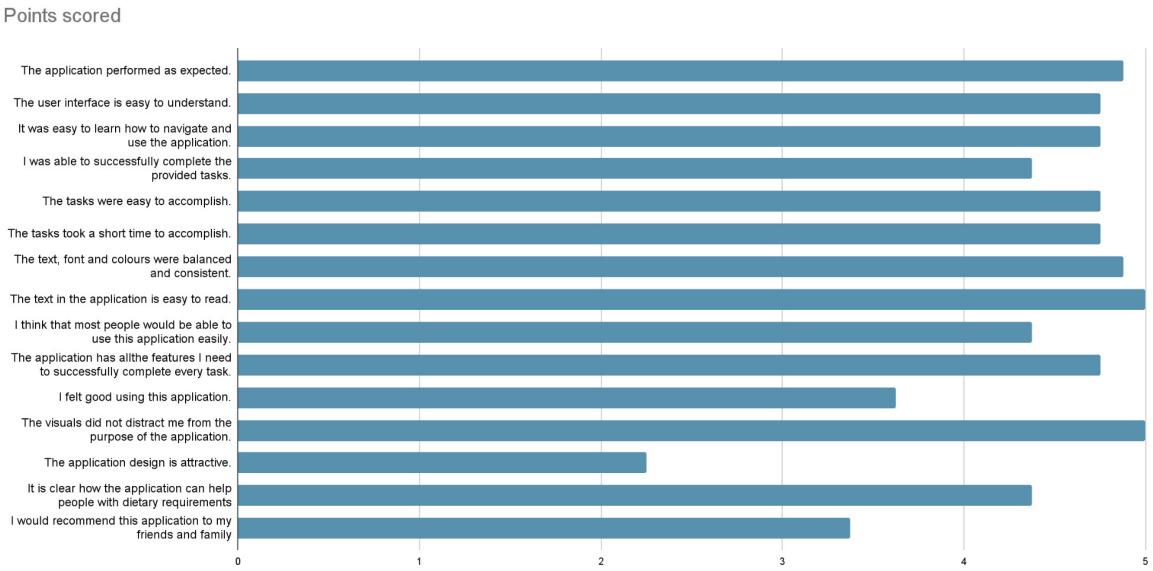

Figure 19. User experience testing results - average score of each experience.

After reviewing the collected results I can conclude that the participants were happy with how the application worked, but not with how it looked at the moment in time.

Conclusion

This project demonstrates how technology and especially modern mobile applications can enhance the shopping experience of customers and encourage innovation in the retail industry. Overall, based on the user feedback, I would consider the project a success as the main features I opted to complete at the start of the project were implemented successfully and I achieved all of my deliverables while also obtaining positive feedback from potential users.

Firstly, after conducting user research with people with various dietary restrictions, I learned how much potential there is in using technology and especially mobile applications in retail. Even though there is progress being made to modernise retail technology, there is still plenty of room for improvement as most of the applications currently in the market only focus on selling products and not enhancing the shopping experience. When it comes to conducting user research, I had a difficult time attracting people to participate. Unfortunately, I had to make around 30 different posts on various Facebook groups and spam everyone with invitations as most people just ignored my posts. However, in the end, I still managed to gather the amount of people I aimed to interview and victoriously received their precious input.

Secondly, based on the input gathered, I was able to sketch, wireframe and prototype the first pages of the application. After a quick evaluation during the user research, I would say that my prototypes were successful as I received mostly positive feedback. From the sketches and prototypes I designed, I was surprised that it was fairly straightforward to implement the features I needed into the application. Luckily, I previously had experience using Angular and Firebase so I did not need to learn much in order to begin writing code for the application. After I conducted performance testing and received feedback from the users, I can firmly conclude that my implementation was effective and performed as expected, however it still needs visual improvements and more features.

Finally, I believe this is a perfect project to continue developing as after an in depth market research at the beginning of the project, I realised that, surprisingly, this niche of mobile applications is under-saturated and there is much potential to stand out from a business perspective.

Future Work

To maximise the potential of the application there should be more work done to optimise the way the databases receive information about a product's ingredient lists. Currently, I have to manually enter the information about each product into the application’s database, which would take a lot of time if I were to populate the product database with every single food product currently sold in grocery stores. However, it would not take a long time to implement an automated REST API that takes information from regularly updated online databases such as Tesco or Sainsbury's delivery service so that the process of gathering every new ingredient and product would be automated and would not require much supervision. Unfortunately, due to time and resource restrictions, I was not able to implement this feature myself.

Improvements should also be made to the barcode scanning functionality of the application using the camera of the mobile phone. Fortunately, I was able to implement the scanning feature on the app, however, at the moment it still works pretty slow and performance improvements should be done.

There is also a need to make some changes regarding the frontend part of the application, however, these are minor and could be fixed pretty quickly. At the moment, the application that I have written is very minimalistic and does not look like the application prototyped, however, visual improvements can be done fairly quickly.

When it comes to user research, more people should be invited to the research. A total of ten people is not a big audience for research, however, it was enough to see certain behavioural patterns in their answers.

Reflection on learning

Throughout the four months of working on this project, I have learned a lot about how to write an academic report, conduct user research, manage time and write code efficiently.

Throughout the three years of my Computer Science studies, I have written a few academic reports, however, none of them were as explicit and detailed as this one. I had to research and read around twenty research papers only to understand the problem that people with dietary restrictions face and what actions I can take to help ease this issue. Besides that, describing every single step I performed while working on my code was a tedious and tiring job as I had to learn and precisely describe every single technology and terminology I used. Furthermore, as a person whose native language is not English, it took me a lot of time to review every single sentence I typed to ensure that the text I produced suits the standards of academic English.

While conducting user research, I learned a lot more about research ethics, how to ensure ethical practices and what it is like to apply your project for an Ethics committee review. Luckily, I did not have to struggle while writing my Ethics application because I have previously learned about the procedure during the Design thinking and Prototyping for User Experience module I attended the previous semester, however, this time I have learned a lot about people's while conducting user research with people outside of my University group. During the past couple of months, I held 18 individual interviews with people I recruited through social media. Unfortunately, it took me a much longer time than I expected to recruit people and remind them to attend their interviews - I had to reschedule a lot of times, some people went missing and did not attend the times they were assigned and many people struggled understanding what the purpose of user research is in general. This helped me learn that it often takes a much longer time to do simple tasks when external people are involved.

To manage my time efficiently, I set up a Kanban board, which was useful to remember deadlines. I have worked with Kanban-based project management before so this was not a new experience, however, this was the first large project that I had to manage on my own and it often felt overwhelming. To tackle overwhelm and perfectionism, which is a struggle I faced throughout my three years of University, I forced myself to work on a single task at a time, until I finished it, which helped me feel accomplished and motivated to work on the project more each day as I saw actual progress.

Finally, while developing the application, I learned more about the functionalities of Angular, Ionic, JavaScript, Firebase, and other technologies I had the opportunity to use. During the development process, I had to remind myself to make sure that my code is easy to read by providing short comments with explanations of what the specific lines of code are responsible for. Even though I had a lot of experience writing code while working on personal and university projects, this was the first time I had to develop a project of this size. Unfortunately, I believe that three months to develop a fully functional application was not

enough as I did not finish all of the tasks I have planned to. This is mainly due to the fact that I had little experience working with technologies such as Firebase or Ionic and because it took me a long time to fix bugs without having any help from more experienced developers, which I would have if I was working at any company as a software engineer.

To sum up, I learned a lot of new technical and soft skills throughout the duration of the project. In my opinion, this experience of developing an application on an idea I have picked myself has been the best way to learn not only what it is like to be a full-time software engineer, but also a software tester, project manager, UX/UI designer, and user experience researcher. It has been a great opportunity to use all of the knowledge I gained throughout my studies and I am very happy with the results I have achieved.

Collaboration with Supervisor

While working on this project I had the great pleasure to work with Dr. Nervo Verdezoto Días as my supervisor. In the first half of the semester, we had a lot of insightful meetings where Nervo advised me on how to progress with my project and what key areas I should focus on while writing the initial plan and report. I have learned plenty about literature reviews, academic project research structure, and research ethics from the tips that Nervo has given me throughout weekly progress reviews.

All in all, I am very grateful for the help Nervo has given me while reviewing my work and the time he has spent helping me understand the purpose and characteristics of my research. He has been a delight to work with as he did not micromanage me and embraced my independence while I wrote my report and developed the application.

Acronyms

DR / **DRs** - Dietary requirement / Dietary requirements.
IDE - Integrated development environment.
CLI - Command - line interface.

Bibliography

Google Developers. 2022. *Building a web application with Angular and Firebase | Google Developers*. [online] Available at: <https://developers.google.com/codelabs/building-a-web-app-with-angular-and-firebase#1> [Accessed 5 February 2022].

Vegan Food & Living. 2022. *A vegan's guide to reading food labels - Vegan Food & Living*. [online] Available at: <https://www.veganfoodandliving.com/features/a-vegans-guide-to-reading-food-labels/> [Accessed 5 February 2022].

Toptal Design Blog. 2022. *The Power of Figma as a Design Tool*. [online] Available at: <https://www.toptal.com/designers/ui/figma-design-tool> [Accessed 7 February 2022].

Kissflow. 2022. *What is Kanban Methodology | Introduction to Kanban Framework*. [online] Available at: <https://kissflow.com/project/agile/kanban-methodology/> [Accessed 7 February 2022].

"Majority of US Households Have Someone With Diet Restrictions." Manufacturing.net, 10 June 2014, https://www.manufacturing.net/operations/news/13176655/majority-of-us-households-have-someone-with-diet-restrictions. Accessed 24 January 2022.

Swagerty, Daniel L., et al. "Lactose Intolerance." AMERICAN FAMILY PHYSICIAN, vol. 65, no. 9, 2002, pp. 1845 - 1850. AAFP, https://www.aafp.org. Accessed 24 01 2022.

Testa, Gabriella, et al. "Calorie Restriction and Dietary Restriction Mimetics: A Strategy for Improving Healthy Aging and Longevity." Current Pharmaceutical Design, vol. 20, no. 18, 2014, 2950-2977(28). IngentaConnect. Accessed 24 01 2022.

ACNielsen (2005) Global Food Labeling Survey. The Nielsen Company & VNU Business, New York

Ionic.io. 2022. *Ionic Article: What is Ionic: Learn the essentials of what you can do with Ionic and how it works.*. [online] Available at: <https://ionic.io/resources/articles/what-is-ionic> [Accessed 5 May 2022].

Zopf Y, Baenkler HW, Silbermann A, Hahn EG, Raithel M. *The differential diagnosis of food intolerance*. Dtsch Arztebl Int. 2009;106(21):359-370. doi:10.3238/arztebl.2009.0359

Sexton, A. E., Garnett, T., and Lorimer, J. (2022) 'Vegan food geographies and the rise of Big Veganism', Progress in Human Geography, 46(2), pp. 605–628. DOI: 10.1177/03091325211051021.

Katewa SD, Kapahi P. Dietary restriction and aging, 2009. Aging Cell. 2010;9(2):105-112. doi:10.1111/j.1474-9726.2010.00552.x