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DiDiMap

Diet Diary and Consumption Control for Monitoring Bowel Dysfunctions and low-FODMAP Diet App

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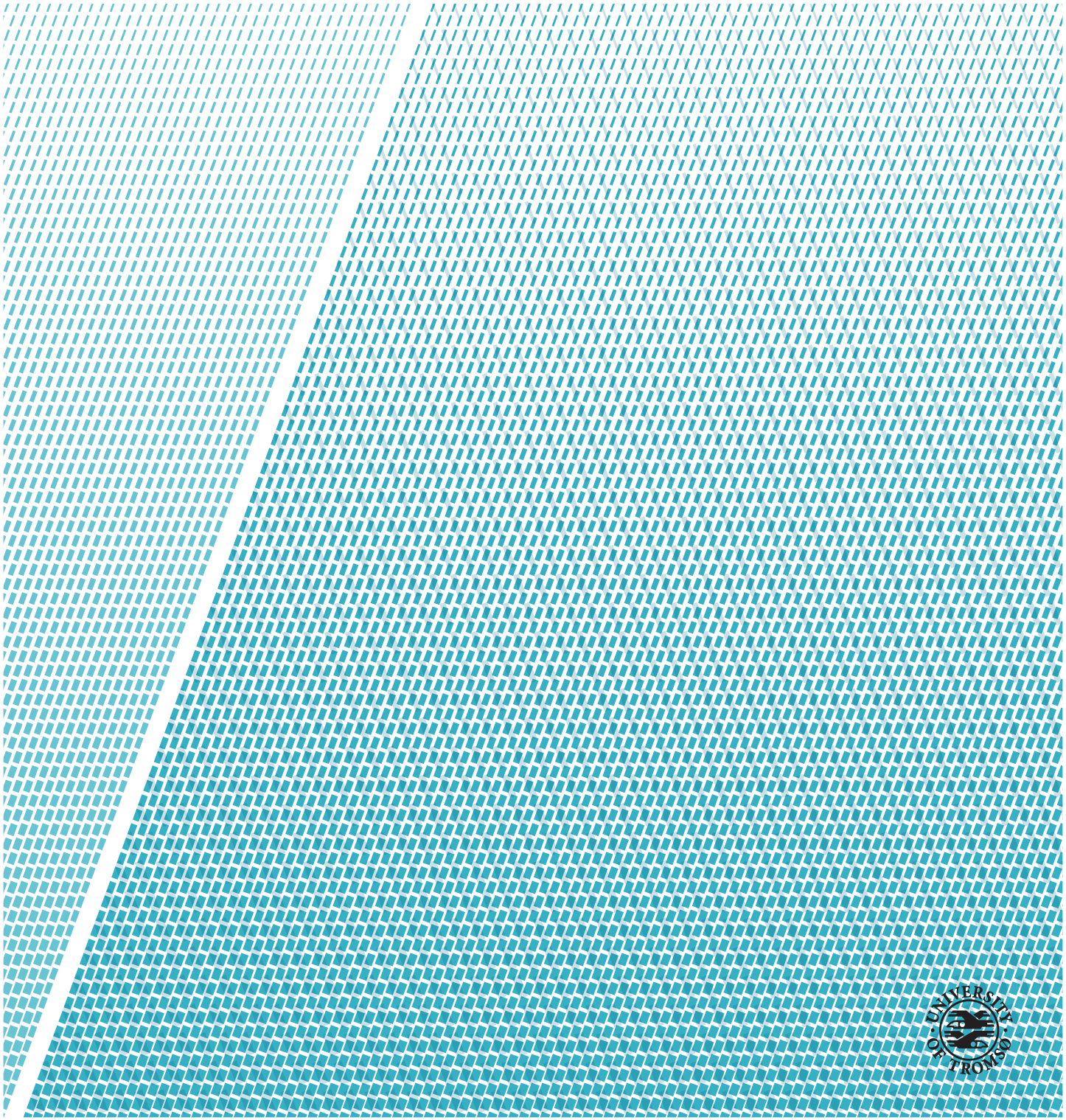


Abstract

The purpose of this project was to design and implement a mobile application for people with bowel dysfunctions, intolerances, and food allergies. The application was expected to provide all needed functionality for the target groups day to day challenges.

Irritable bowel syndrome, intolerances, and food allergies affect a significant portion of the population. On a world basis, 15% of the population are affected by IBS alone [1]. Although intolerances and food allergies are handled better than before in terms of adaptation from restaurants, food producers, and grocery stores, there's still a long way to go. Food producers and caterers must, by law, inform consumers of whether their products contain certain common allergens. If a person has an allergy or intolerance outside the standard, there's little information to get.

A systematic review and an app review mapping existing knowledge and implementations for similar apps were conducted. A mobile application was implemented for a low-FODMAP (Fermentable oligosaccharides, disaccharides, monosaccharides, and polyols) use case based on the conducted reviews features and shortcomings. The app contains features such as optical character recognition to identify potential trigger foods, barcode scanning of food products to retrieve nutritional and intolerance information, and a log to track meals, events during the day, and symptoms. The application also includes a communication platform for connecting and communicating with peers, which can later be expanded into discussion and motivation groups. Unlike other similar applications in the market, the app provides, in addition to peer communication, all needed functionality in a single platform, which enables utilization of log data for consumption control.

We conducted a trial of the application with 65 users who were currently following a low-FODMAP diet. Of these 8 people responded to an anonymous survey asking users to rank the system's usability on a scale, and to answer a few application-specific questions. Feedback from user testing indicated a

1. https://www.monashfodmap.com/

great interest in the app. Through the survey the app gained a system usability score of 85/100, and 75% thought the app would greatly simplify the process of following the low-FODMAP diet.

Preface

In 2017, I was referred to the web page of Helse Bergen on their section on FODMAPs after a period of declining health. After taking a quick look at their site, the low-FODMAP diet was deemed too absurdly complex even to attempt. After some time, and with limited options, the diet was tested all the same, and some factors became apparent. It was very complicated and comprehensive, challenging to follow, and the information that existed was difficult to navigate. To begin with, grocery shopping for low-FODMAP items could easily take an hour and a half. Since I knew nothing on the matter, each ingredient on every single item I wanted to buy had to be cross-checked against some pdf, Google or app, often after I had translated the ingredient into English. After manually checking thousands of ingredients There was no doubt, the process should have been simpler. Most people following the low-FODMAP diet has some sort of unexplainable bowel dysfunction, and are often neatly put into the irritable bowel syndrome category. Irritable bowel syndrome is estimated to affect 15% of the world's population, which leaves the question: Why hasn't someone simplified the low-FODMAP process through the use of mobile technology to a satisfying degree yet? Once I had the opportunity to invest time and effort into attempting to solve the issue, there was no doubt in my mind that I needed to step up and do my part.

This project would not be possible without the help and guidance from my supervisors Gunnar Hartvigsen, Ashenafi Zebene Woldaregay, and Eirik Årsand. Especially thanks to Gunnar, who believed in my project and gave me the possibility to develop a tool which I strongly believe can help myself and others overcome some of the challenges related to bowel dysfunctions. My supervisors' input and knowledge have been of tremendous help. I want to thank the medical informatics and telemedicine group for the great feedback on the mobile app. I also want to thank my co-students at my office Marius Wiik, Vebjørn Haugland, Sverre Coucheron and Valter Berg for the input, discussions, and laughs. Thanks to Pontus Aurdal for helping me learn frontend development. Thanks to Jørgen Lund for reviewing my thesis. Thanks to Petter Tunstad for the cooperation throughout the study. Thanks to both Petter and Håkon Wallan for great climbing sessions and reducing my stress levels. Thanks to Landsforeningen mot fordøyelsessykdommer for their support and help with spreading the news

of the app to the community, thereby greatly helping the testing process. Thanks to Matinfo.no for providing product data for the app. Special thanks to Monash University for being the world leader on FODMAPs and providing the public with valuable FODMAP information. Thanks to Helse Bergen and Frisk forlag for translating FODMAP values to Norwegian and creating searchable Norwegian lists and providing other useful information on bowel dysfunctions and intolerances. I want to thank all participants of the test phase of the project, especially thanks to those who answered the questionnaire. Lastly, I need to thank my family and friends for their support over the years.

Tromsø - 01.06.2019

Contents

List of Figures

List of Tables

1

Introduction

1.1 Motivation

Bowel dysfunctions and allergies are on the rise. These problems are affecting more people than ever before and causing more challenges than earlier for the people affected as well as their family and friends. Although a significant amount of people are affected by bowel dysfunctions and allergies, there is little data on how and why a person gets these problems, and there are no cures available. For this group of people, controlling food intake by staying clear of trigger foods are one of the few remedies capable of reducing their symptoms. When it comes to bowel dysfunctions, reducing stress can also significantly lessen the symptoms. The number of trigger foods a person with a bowel dysfunction can gain symptoms from is often too large to keep track of manually, therefore, technical aid such as mobile-apps or Google is often used to aid in this endeavor.

1.2 Problem statement

Keeping track of food intake and intolerances as well as the resulting symptoms is difficult, especially when following complex medical diets such as the low-FODMAP diet. This challenge is mainly felt by the individuals suffering from intolerances or digestive disorders, but controlling intake is a challenge also met by family, friends, and caterers. Although there are information and lists

available for cross-checking meals against a diet, it's a slow and manual process which requires experience, and is unsuitable for persons who have newly developed intolerances as well as others with little knowledge such as friends, family, and caterers. There exist some excellent apps for logging, but having a standalone log-app increase the effort needed from the user compared to having an all-in-one solution. Having one app for logging and one for controlling intake also means that the data on symptoms from earlier consumption cannot be used in the application when controlling intake. Analyzing ingredients for values such as FODMAPs is a slow process conducted at few laboratories worldwide. This creates a clear limitation on the amount of analysis done. Sharing experience and collaborating on exploring new ingredients between users would further increase the knowledge, and simplify the process for the target group.

We express these issues in four questions which we will set out to answer.

Research problem 1: Which characteristics does a mobile application for simplifying the daily life of people with bowel dysfunctions, intolerances or food allergies need?

Research problem 2: Which work has been done in the field, and which apps are available in the market?

Research problem 3: Which functionality is needed to help the target group with their daily challenges?

Research problem 4: How is the application described and implemented in this thesis received by the target group?

1.2.1 Assumptions

For the application to provide the best experience, we assume users have a basic understanding of their diagnosis, intolerance, or allergy.

1.3 Nature and scope of problem

The scope of the project is limited to a mobile application which provides the user with the functionality needed on a daily basis, and a backend supporting the mobile application. The project does not attempt to build a platform for linking such apps to any health provider.

1.4 Method

The app was created from an iterative approach where first, a systematic and app review was conducted to establish needed and expected functionality. A long-term follower of the low-FODMAP diet with IBS was consulted concerning which functionality was wanted, which was not available in the Norwegian market. The idea was communicated to the Norwegian national federation against bowel diseases which were positive to the app. Once the idea of functionality and design was in place, and a rough implementation was created, the federation spread the idea to their members through a Facebook post. Before the official testing phase, a pilot test was conducted within the medical informatics and telemedicine research group at UIT as well as with co-students, friends, and family. The pilot test revealed small bugs and inconsistencies which were corrected before the user test. Through the Facebook post ca. 100 testers were recruited who received the app once the testing period started, of which 65 installed it. Once the testing stage was completed, the testers were asked to fill out an anonymous questionnaire containing the system usability scale [1] as well as some app-specific questions concerning functionality. The questionnaire results were analyzed manually and through the scoring system of the system usability score model.

1.5 Significance and contributions

The project has reviewed studies and apps representing the state of the art within the field. The reviews has given insight into both available and proposed applications, as well as their features and shortcomings. Combined with consulting the target group, needed functionality as well as the characteristics for a mobile application covering the needs of the intended users has been mapped. The proposed application has been implemented and distributed for a pilot test and a user test. Through a questionnaire distributed to the test users, the app has received a system usability score and general feedback. The application, displayed in figure 1.1 on the following page was well received by the testers.

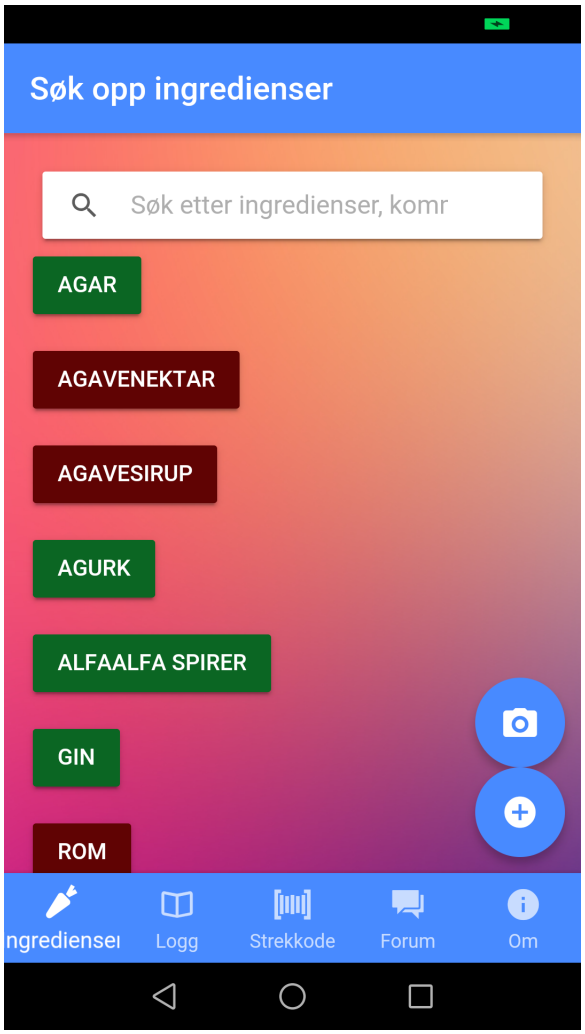


Figure 1.1: Implemented application

1.6 Organization

The thesis is divided into 11 parts. Chapter 1 contains the introduction. Chapter 2 examines the theoretical background for the project, including a systematic review and an app review. This section lays the groundwork for the project. Chapter 3 examines the methods used in the development process. Chapter 4 explain the requirements of the project, which has been based on the theoretical background as well as requests and needs received from the target group. In chapter 5, we look at the design of the application, followed by the implementation in chapter 6. Chapter 7 display the results of the user test.

In chapter 8, we discuss and evaluate the app and the project as a whole. In chapter 9, we take a look at future work and the path going forward. In chapter 10, We wrap things up with a conclusion. Lastly, an appendix is presented, including user documentation for the app.

2

Theoretical framework

2.1 Medical background

2.1.1 IBS and IBD

Irritable bowel syndrome is an umbrella term for unexplainable bowel dysfunctions. Common symptoms from IBS are constipation, diarrhea, abdominal pain and bloating. From what can be seen with today's methods of diagnostics and technology, there is nothing physically wrong with a person with IBS, although there is no doubt that there exists a problem which causes physical symptoms. IBS might be rooted in psychology, might be a physical issue, but is most likely a combination of both. There is no doubt that both food intake and psychological factors play a part in the symptoms and general well being of a person with IBS. IBS affects a person's ability to digest food, making foods which are already difficult to digest for a fully functional bowel especially problematic. There is no cure available for IBS patients, but the medical low-FODMAP diet has proven effective to reduce symptoms for 3/4 of the patients[1]. Reducing stress, anxiety, depression, and generally better the mental health of the patients has also been proved effective [2].

1. https://www.monashfodmap.com/ibs-central/i-have-ibs/starting-the-low-fodmap-diet/
2. https://helse-bergen.no/avdelinger/medisinsk-avdeling/gastroenterologisk-seksjon/nasjonal-kompetansetjeneste-for-funksjonelle-mage-tarmsykdommer/irritabel-tarm-syndrom-ibs

Inflammatory bowel disease is an umbrella term for diseases involving chronic inflammation of the patients' digestive tract. IBD includes the diseases Chrons and Ulcerative Colitis. IBD often includes symptoms such as diarrhea, abdominal pain, fatigue, and weight loss, and can cause life-threatening complications. Treatment of IBD includes medication, surgery, and dietary changes.

2.1.2 FODMAP

To ease the symptoms of bowel dysfunctions such as IBS, the low-FODMAP diet has been created at Monash University [3]. Fermentable oligosaccharides disaccharides and polyols (FODMAP) are hard to digest and are not properly absorbed in the gut, making them a common source of problems and discomfort for individuals with IBS. Decreasing the amount of FODMAPs in the diet has proved to reduce symptoms for a significant amount of IBS sufferers. FODMAPs are a collection of carbohydrates and are therefore included in thousands of food items. The large amount of food containing a high amount of FODMAPs makes keeping track of which food to avoid difficult.

2.2 Technical background

2.2.1 Optical character recognition

Optical character recognition consists of recognizing text or objects in images and is a field within pattern recognition and artificial intelligence. For an OCR engine to be effective, it has to utilize machine learning to be trained with images of known content. To additionally better the accuracy, advanced pre-processing of the images can be done to simplify the recognition process itself. This could include, but is not limited to changing the image's color and contrast, or crop the image. OCR engines are tuned explicitly for the use case, and a programmer must as such know the use case well for it to provide the best result.

2.2.2 JSON Web Tokens

JSON web Tokens or JWT for short is a URL-safe compact credential system used to authenticate users. In systems using JWTs, a JWT is typically generated on user registration and refreshed periodically for security reasons. If the JWT falls into the hands of anyone else than the user, they will have access to the

3. https://www.monashfodmap.com/about-fodmap-and-ibs/

users account until the JWT is refreshed. The token is saved at the client, and sent with requests to authenticate the user at the server. For token based authentication, Jason Web Tokens is the industry standard. [4]

2.3 State of the art

2.3.1 Systematic review

The database search was conducted on Scopus [5], which is the largest database on abstracts and citations of peer-reviewed literature. The following search query was used:

```
TITLE-ABS-KEY((((meal OR symptom) AND (logging OR tracking) AND (bowel OR food intolerance OR IBS OR food allergies OR Crohn's OR ulcerative colitis OR celiac disease)) OR IBS OR fodmap OR (Intolerances OR (food AND allergies)) OR (bowel OR food intolerance OR IBS OR allergies OR Crohn's OR ulcerative colitis OR celiac disease))AND (app OR mobile application)) AND ( LIMIT-TO ( LANGUAGE,"English" ))
```

The search yielded 113 papers, of which 15 has been included in this thesis. Papers excluded were either within the wrong scientific field, or too broad/narrow to be applicable. Figure 2.1 on the next page displays the process through a Prisma [2] flow chart.

4. https://jwt.io/introduction/
5. https://www.scopus.com/

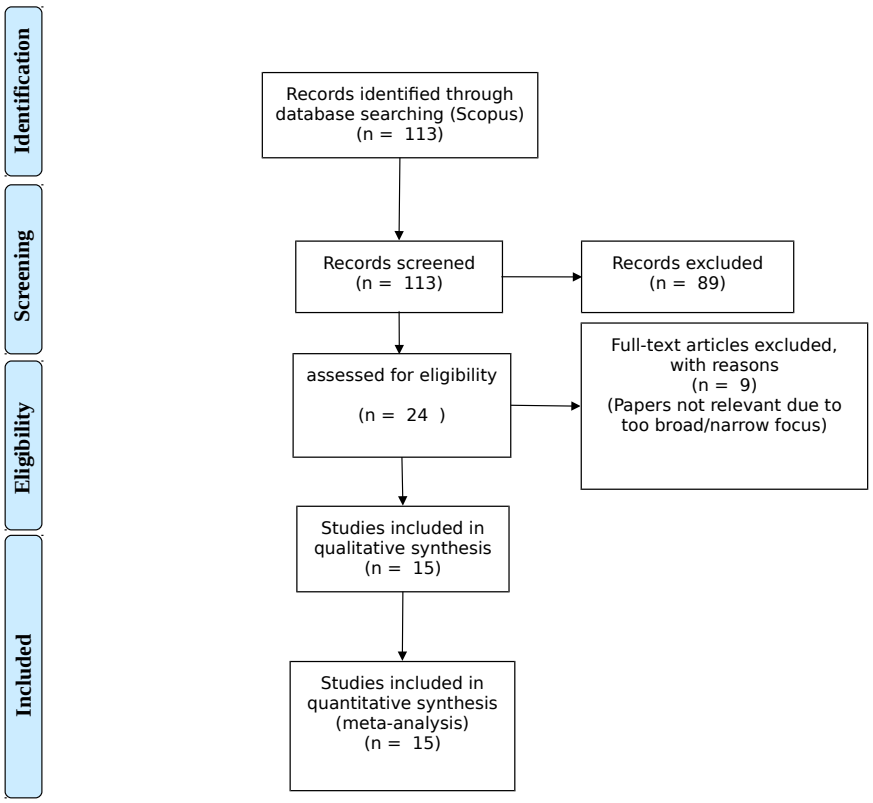


Figure 2.1: A flow chart of the systematic review, based on the process described in [2]

The papers included in the quantitative synthesis are described below. Key findings for each paper are also displayed in table 2.1 on page 18.

M. W. Wong et al. [3] presents a prototpe application which provides OCR ingredient scan and barcode ingredient scan which provides information on

trigger foods based on an intolerance database. The prototypes user interface is presented in figure 2.2.

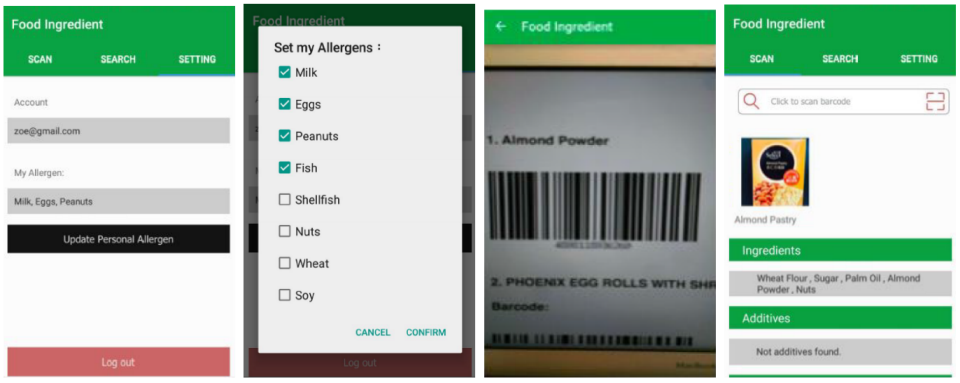


Figure 2.2: M. W. Wong et al. [3] user interface, Figure 2b-e

Pros:

- Has OCR ingredient and barcode scan.

Cons:

- Is not a complete platform for people with bowel dysfunctions.
- Does not contain log or log analysis.
- Has no link between earlier experience and current consumption.
- Does not connect peers.
- Has no FODMAP overview.

Albert Parra Pozo et al. [4] propose and create a prototype system utilizing optical character recognition to translate foreign menu items/ingredients and cross-check the ingredients against a database containing nutritional information and allergens/intolerances. The interface of the prototype is displayed in figure 2.3 on the following page.

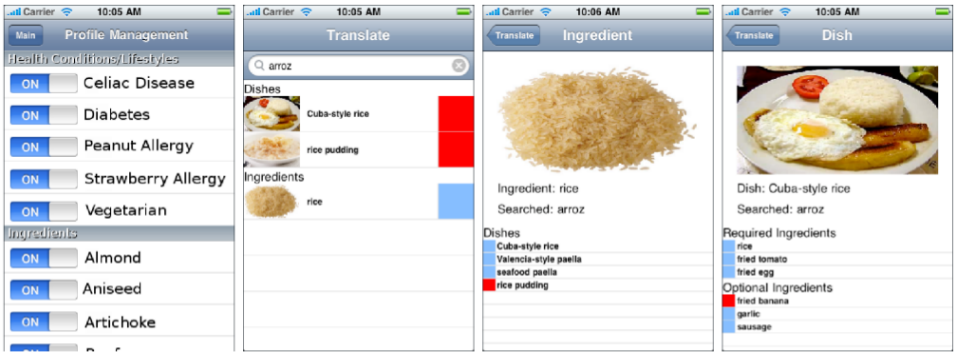


Figure 2.3: Albert Parra Pozo et al.[4] user interface, Figure 5a-d

Pros:

- OCR ingredient scanner usable for many languages.

Cons:

- Is not a complete platform for people with bowel dysfunctions.
- Does not contain log or log analysis.
- Does not connect peers.
- Has no FODMAP overview.
- Has no barcode scanner.

K. Henricksen and S. Viller [5] present a paper covering diet diaries for families with children who have food-allergies of intolerances. In the paper, they presented a simple food log app and conducted a test concerning how often the app was used compared to a paper journal. The app was used less than the paper journal. The paper proposed increasing the likelihood of logging through gamification, reminders, and simplifying the logging process through saving earlier entries for quicker adding of entries.

Z. Mujagic et al. [6] presents a paper which covers the accuracy of logging between logging at the end of the day (recall method) vs. logging at multiple random moments during the day (experience sampling method). Logging through the recall method provided higher numbers on discomfort than logging through the Experience Sampling Method.

J. Ahn et al. [7] suggests and prototypes an augmented reality mobile-app displaying information whether a product in a store aisle is healthy/unhealthy and contain food allergens. Figure 2.4 displays the apps interface.

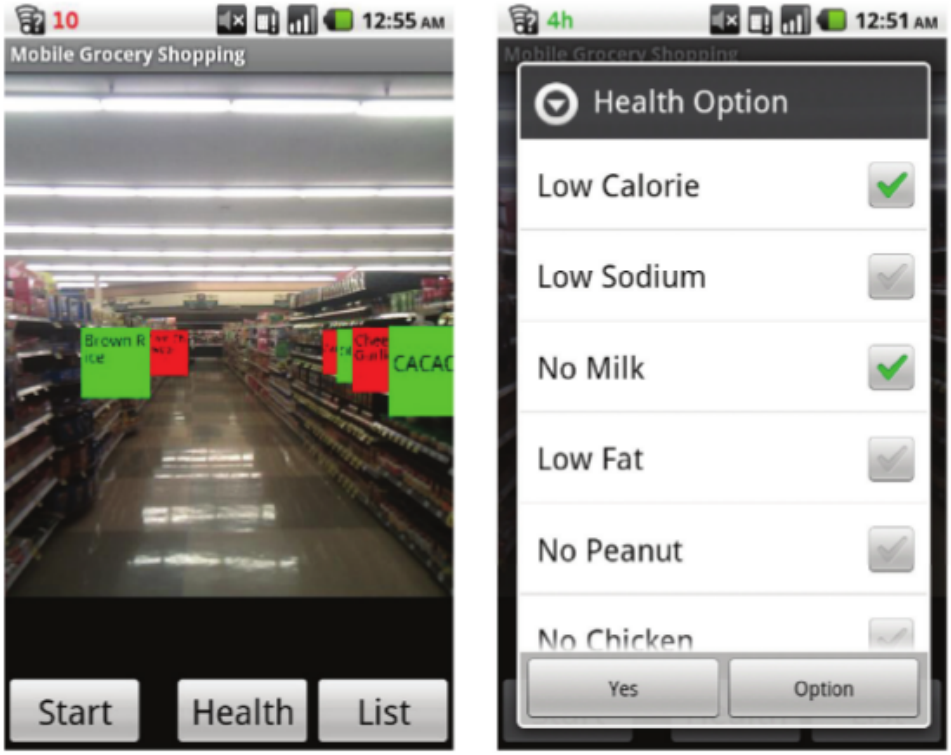


Figure 2.4: J. Ahn et al. [7] user interface, Figure 8ab

Pros:

- Finds products through pointing the camera.
- Checks the products for trigger foods.

Cons:

- Must map each store for product placement.
- Is not a complete platform for people with bowel dysfunctions.
- Does not contain log or log analysis.
- Does not connect peers.

- Has no FODMAP overview.
- Has no barcode scanner.

S. Konrad et al. [8] propose a machine learning based diet-log app which can predict the health of a person based on logged meals. The app is designed to give personalized information of which food a user should stay clear of. Figure 2.5 displays the apps interface.

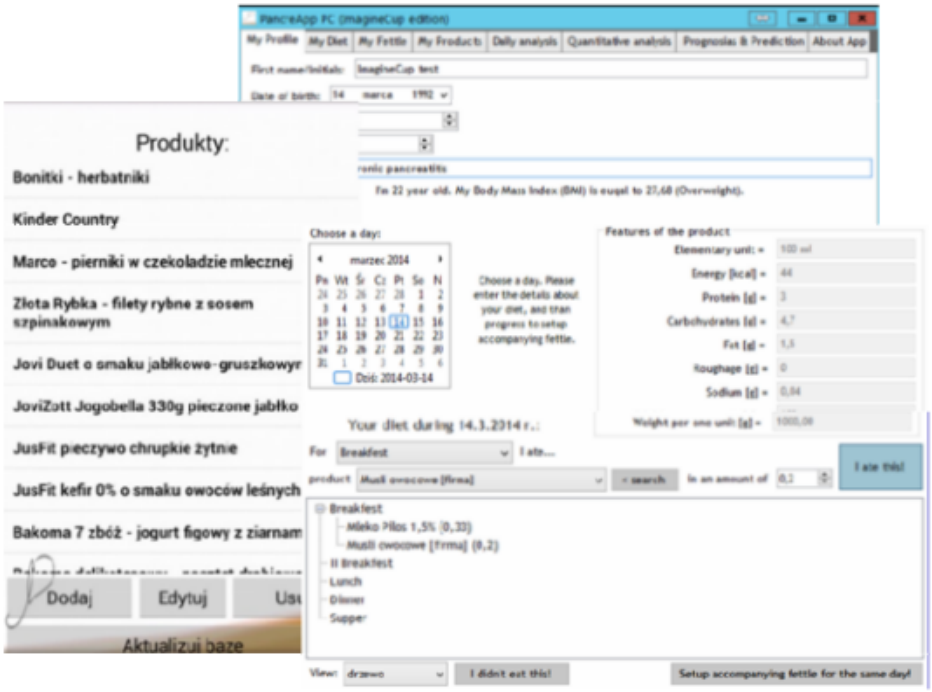


Figure 2.5: S. Konrad et al. [8] user interface, Figure 3

Pros:

- Has advanced log and log analysis.
- Predicts effects of food the user wants to consume.

Cons:

- Is a pure logging app and is missing needed features.

R. Karkar et al. [9] explains a framework which simplifies the process of experimenting with trigger foods. The framework tells the person, based on his

goal, what to eat or drink (or not) until the framework has figured out whether this food/drink cause triggers based on symptom feedback. The applications interface is presented in figure 2.6.

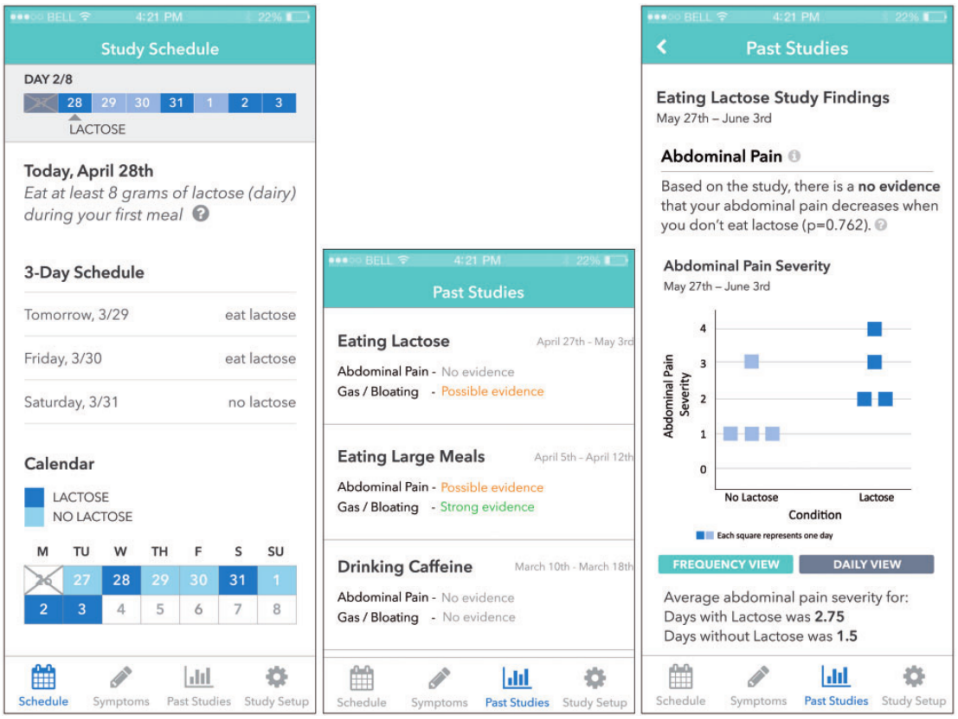


Figure 2.6: R. Karkar et al. [9] user interface, Figure 4

Pros:

- Simplifies experimenting with potential trigger foods.

Cons:

- Is not a complete platform for people with bowel dysfunctions.
- Does not contain log or log analysis.
- Does not connect peers.
- Has no FODMAP overview.
- Has no barcode scanner.

W. K. Van Deen et al. [10] propose a set of questions and scoring system for

monitoring of the health of a patient who has ulcerative colitis or Crohn's disease. The questions and scoring system yielded accurate results for both UC and Crohn's but need tailoring for the characteristics of each disease.

D. V. Ankersen, P. Weimers, and J. Burisch [11] review existing tools for IBS/IBD patients and which features these have compared to requested features from sufferers. Reintroduction stage for FODMAPs and direct contact with medical personnel are often missing from the apps, which leaves room for improvement.

D. Con et al. [12] cover information gathering from IBD patients concerning the willingness to use e-health solutions for self-management. The majority of patients were willing to use such solutions.

P. Bossuyt et al. [13] takes a critical look at the challenges in using e-health for IBD patients, and points to four areas that should be investigated further before big implementations are started. More clinical trials to figure out effectiveness, multi-model monitoring tools, understanding patients resistance, and a wider digital framework connecting different e-health tools. The paper concludes that the field is not yet ready for widespread implementation.

M. Kelso and L. A. Feagins [14] have reviewed available apps for IBD patients. Their paper concludes that medical personnel needs to be at the forefront of the development of such apps, and that effectiveness studies are needed. It also points out that future studies are needed to create validated tools to better patient compliance and decrease the cost of care.

B. C. Helsel et at. [15] reviews the effectiveness of telemedicine and health technology in the management of digestive diseases. Their paper concludes that telemedicine and mobile health technology may be effective to improve the quality of life and management of the disease for the users. Studies reviewed showed promising results.

W. Szeto et al. [16] conducted a study which included 109 adolescent IBD patients with a mean age of 18. 17% looked up information about IBD "always" or "often" on a daily basis. 47% turned to medical websites for information, 16% connected with other IBD patients. Preferred method of communication with a health provider was by e-mail. 2% used mobile apps for monitoring of symptoms. 9% used apps for medication reminders. There was professed interest in the use of such apps.

M. de Jong et al. [17] propose and develop an IBD app for everyday use for all IBD patients. The app provides monthly monitoring(contains questions regarding disease activity, medication use, extraintestinal manifestations,

medication adherence, treatment satisfaction, side effects, work productivity, nutritional status, fatigue, physical exercise, stress, life-events, anxiety and depression, social support and self-management skills.), personal care plan based on monitoring to better self-management, e-learning modules and communication(administration page for health care provider which gives overview over patients and potential red flags based on monitoring, as well as direct messaging). Lastly, the app includes an outpatient visit module which provides a questionnaire concerning variables necessary for the consultation, making it as effective as possible. Questions included are about disease activity, extraintestinal manifestation, smoking, work productivity, intimacy and sexuality, anxiety and depression, medication adherence, social support, and fatigue. The application showed high compliance score with 100% of the users filling in the monthly monitoring questionnaire. The patients scored the app 7.8 out of 10, while the providers scored 8 out of 10. Figure 2.7 displays the apps user interface.

Figure 2.7: M. de Jong et al. [17] user interface, Figure 3

Pros:

- Provides extensive logging/monitoring for IBD patients.
- Provides IBD information.
- Provides direct connection with health provider.
- Provides personal care plan.

Cons:

- Monitoring is too extensive for IBS/general intolerances.
- Provides no simple help for controlling intake by for example OCR or barcode scanning.

Table 2.1: Systematic review

Paper	***Findings***
A Mobile Adviser of Healthy Eating by Reading Ingredient Labels	Prototype of ingredient scanner and barcode scanner which returns nutritient and intolerance/allergy information
A Hand-Held Multimedia Translation and Interpretation System with Application to Diet Management	Protoype of OCR app which translates text/ingredients and returns nutritional and intolerance/allergy information
Design of Software to Support Families with Food-Allergic and Food-Intolerant Children	Usage of simple log app was used less than paper journal for families with intolerant children. Proposed gamification, reminders and simplifying the log to increase use
The Experience Sampling Method - a new digital tool for momentary symptom assessment in IBS: an exploratory study	Logging at multiple random moments during the day is more accurate than logging at the end of the day
Supporting Healthy Grocery Shopping via Mobile Augmented Reality	Prototype of augmented reality app for finding healthy products within the users diet through the use of the camera
PancreApp: An Innovative Approach to Computational Individualization of Nutritional Therapy in Chronic Gastrointestinal Disorders	Machine learning based diet-log app which predicts users health based on logged meals
A framework for self-experimentation in personalized health	Framework which simplifies experimenting with trigger foods

Development and Validation of an Inflammatory Bowel Diseases Monitoring Index for Use With Mobile Health Technologies	Creates set of questions and scoring system for monitoring health of UC and Chrohn's patients
Whats 'App-ening': the help of new technologies in nutrition in digestive diseases	Reintroduction stage for FODMAPs and direct contact with health provider is often missing from apps
eHealth for inflammatory bowel disease self-management – the patient perspective	Major majority of IBD patients are willing to use e-health solutions
E-health in inflammatory bowel diseases: More challenges than opportunities?	For IBD e-health solutions, more investigation is needed concerning effectiveness, multi-model monitoring tools, patient resistance and digital framework connecting e-health tools. Field not yet ready for widespread implementation
Can Smartphones Help Deliver Smarter Care for Patients With Inflammatory Bowel Disease?	Medical personnel must be at forefront of app development. Effectiveness studies are needed. Validated tools to better compliance and decrease care cost needed
Telemedicine and Mobile Health Technology Are Effective in the Management of Digestive Diseases: A Systematic Review	Telemedicine and mobile technology may be effective in improving quality of life for people with digestive diseases
Use of Social Media for Health-Related Tasks by Adolescents With Inflammatory Bowel Disease: A Step in the Pathway of Transition	Questionaire 109 IBD patients, mean age 18. 17% looked up IBD info "always" or "often" every day. 47% used medical websites, 16% connected with other patients. E-mail was preferred method of communication. 2% used logging apps, 9% used medication reminder apps. Professed interest in such apps
Development and Feasibility Study of a Telemedicine Tool for All Patients with IBD: MyIBDcoach	App which provides monthly monitoring reports, personal care plan, e-learning, communication with health provider. 100% of users filled out the monthly monitoring questionnaire.

2.3.2 App review

Google play store and Apple store were searched for apps concerning FODMAP and IBS. The app review consists of the top resulting apps, in addition to an app found while searching for apps doing optical character recognition for allergies. The apps reviewed and their key features are displayed in table 2.2.

Table 2.2: App review

App	*Producer*	*Features*
FODMAP	Monash	FODMAP overview, personalization, log, FODMAP reintroduction, recipes
low FODMAP av Molyssa	Molyssa	FODMAP overview(Norwegian), product overview(norwegian), recipes, information, shopping list
FODMAP	FM	FODMAP overview, barcode scanner (FODMAP info), personalization, log
Noba	Iterate AS	FODMAP overview(Norwegian), product overview(norwegian), barcode scanner (FODMAP info), add products and estimate FODMAPs manually
Low FODMAP diet A-Z Food list for IBS sufferers	Temeraire 1978 Ltd	FODMAP overview, personalization
Fodmap Helper	Appstronaut Studios	FODMAP overview, log, log analysis, share food experience with community (Analyzed foods), FODMAP reintroduction
Low FODMAP Diet	Axcore	FODMAP information
Low Fodmap meal recipes	Andromo	FODMAP information
The low-Fodmap's Diet plan	Not found	FODMAP information
Belly Balance	Belly Balance	FODMAP overview, barcode scanner(FODMAP info), log, log analysis
Low-Fodmap diet plan for beginner's guide	AngelicMiho	FODMAP information
Food Intolerance	Baliza GmbH	Trigger food overview, personalization

Fodmap Friendly	FODMAP Friendly	FODMAP overview, product overview
FODMAP Food Guide	In Ident	FODMAP product overview
FODMAP deutsche liste	Not found	FODMAP overview
FODMAP SWAPP	Kerith Duncanson	Suggests FODMAP friendly foods to replace wanted food
Low Fodmap Diet	GSMFlasher	FODMAP information
My low Fodmap Life	Not found	FODMAP recipes
Low Fodmap Diet	RBJmobile app	FODMAP information
FODMAP all in one	FODMAP All in One Team	FODMAP overview, personalization, add tested ingredients to private list
Low Fodmap Diet	Rnamobile	FODMAP information
500 Low-Fodmap recipes	Trellisys.net	FODMAP recipes
Low-Fodmap diet	Sean Colombo	FODMAP overview
FODMAP	Bspham	FODMAP overview, product overview, barcode scanner (FODMAP info)
My Food Intolerance List	cr3ative.info, Steffen Mauser	FODMAP overview, personalization, add tested ingredients to private list
FODMAP finder	Peter Schofield	Overview over FODMAP information
Low Fodmap diet guide for beginners	Soufien Game	FODMAP information
IBS Diet Match with low-Fodmap diet	Informdiets Ltd	FODMAP information, recipes
Mr symptoms Food Diary & Symptom Tracker	SkyGazer Labs Ltd	Log, log analysis
Low-fodmap recipes	Membermedia	FODMAP recipes
Casa De Sante	MBODY360	FODMAP recipes, shopping list, log
FODMAPer	Joopkins	FODMAP overview
Food and symptoms diary lite	nmi-Portal / panthera.cc	Log
Allergy Checker - Food Allergy Tracker Allergy App	Sportistic	Scan text for trigger foods, personalization

The most downloaded apps are FODMAP by Monash 100 000+, FODMAP Helper 50 000+, Low FODMAP diet A-Z Food list for IBS sufferers 50 000+, My Food Intolerance List 100 000+, and Mr symptoms Food Diary and Symptom Tracker 100 000+.

FODMAP by Monash

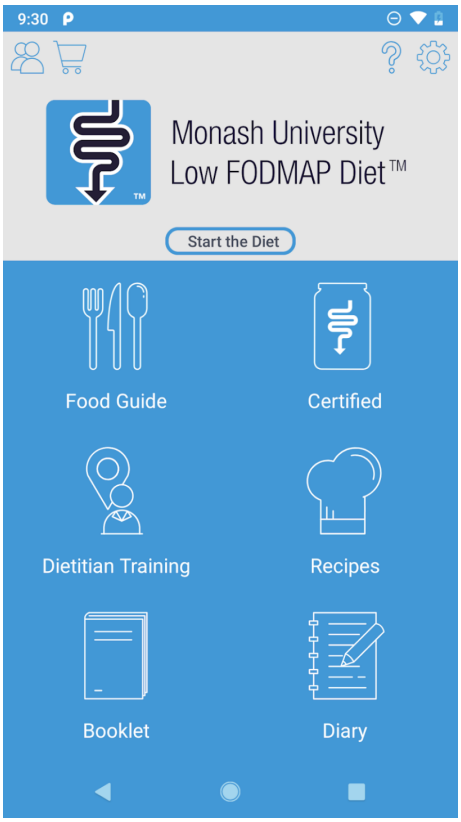
The FODMAP app by Monash is the most established FODMAP app in the market. Since Monash University is the world leader on FODMAPS, the app provides the newest FODMAP information available. It also provides personalization of FODMAP intolerances, a log, recipes, and a feature for FODMAP reintroduction. Screenshots from the app are displayed in figure 2.8 on the facing page.

Pros:

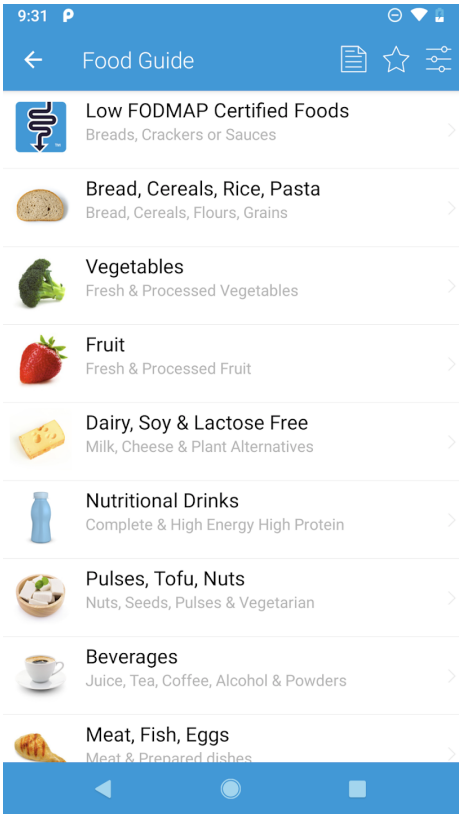
- Most recent information.
- Personalization, log, recipes, reintroduction stage.

Cons:

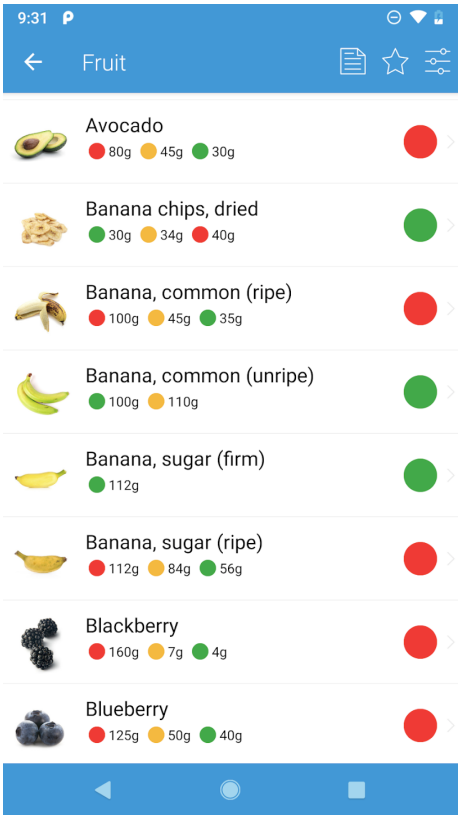
- Has no OCR feature, all lookups must be done manually.
- Has no barcode scanning.
- Does not display earlier logged experience when looking up food (does allow for notes on food).
- Has no in-app solution for contacting peers (Has links to social media).



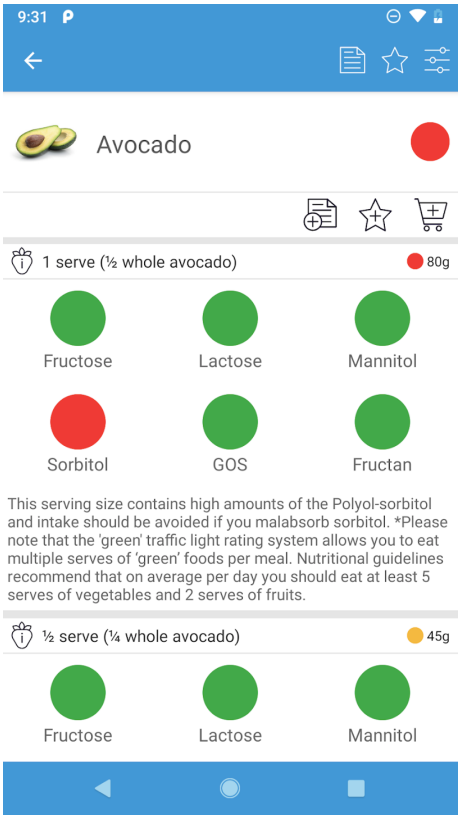
(a) Monash 1



(b) Monash 2



(c) Monash 3



(d) Monash 3

Figure 2.8: Screenshots from the app FODMAP by Monash

FODMAP helper

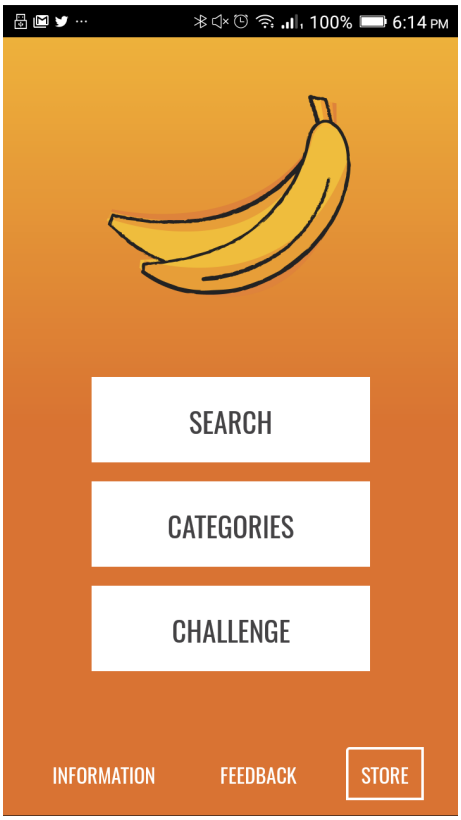
FODMAP helper by Appstronaut Studios has 50 000+ downloads on Google play store and has features such as FODMAP overview, log, log analysis, share food experience with the community (Analyzed foods) and FODMAP reintroduction. Screenshots from the app are displayed in figure 2.9 on the next page.

Pros:

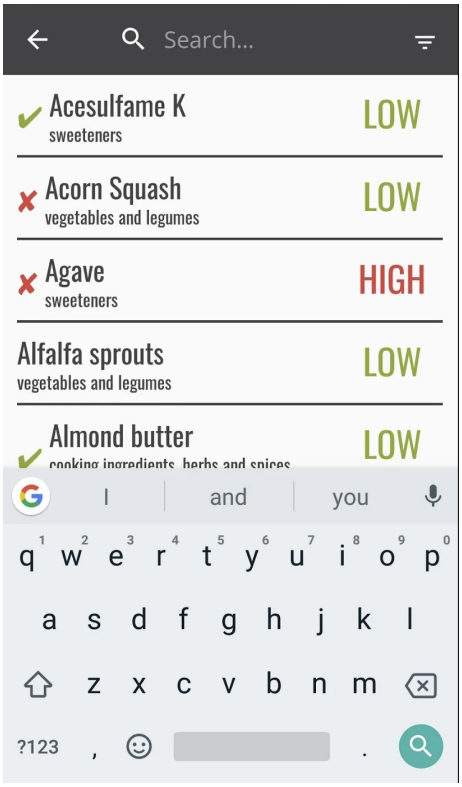
- Conducts log analysis.
- Can share experience with the community concerning analyzed foods.
- Has FODMAP reintroduction stage.

Cons:

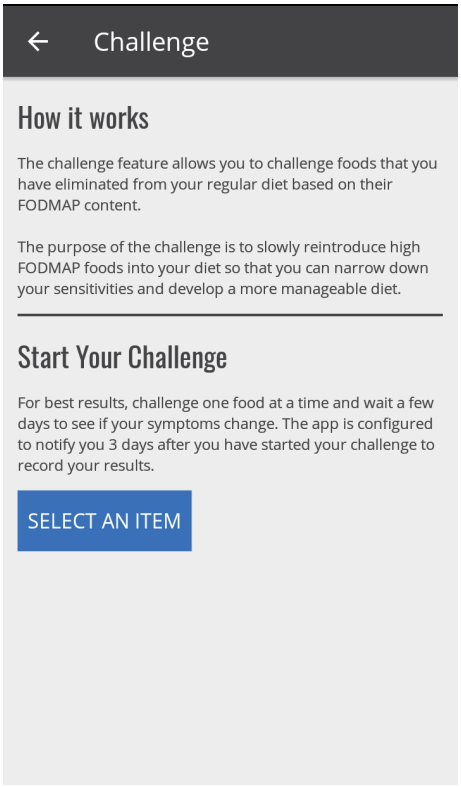
- Has no OCR feature, all lookups must be done manually.
- Has no barcode scanning.
- Has no functionality for contacting peers.



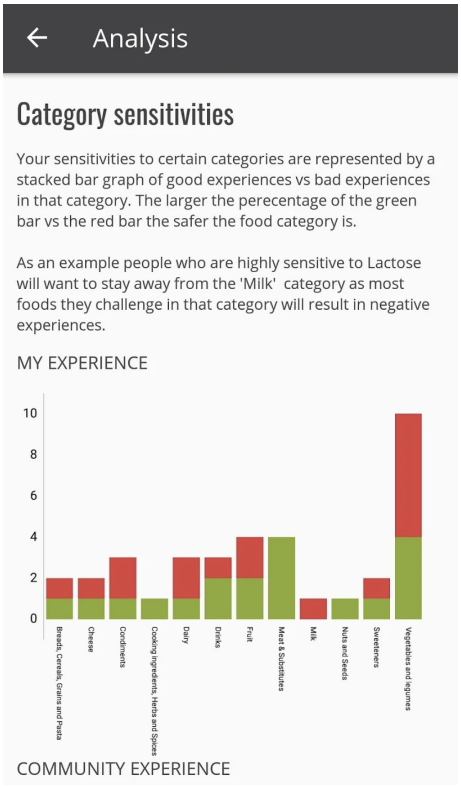
(a) FODMAP helper 1



(b) FODMAP helper 2



(c) FODMAP helper 3



(d) FODMAP helper 4

Figure 2.9: Screenshots from the app FODMAP helper

Low FODMAP diet A-Z Food list for IBS sufferers

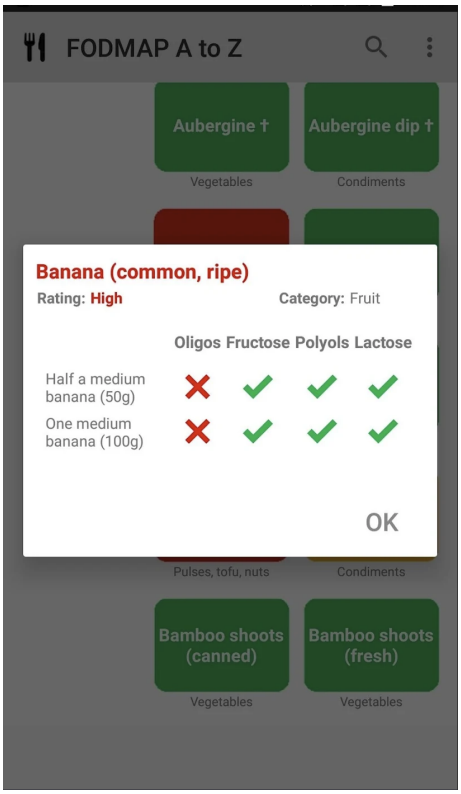
The app Low FODMAP diet A-Z Food list for IBS sufferers has 50 000+ google play store downloads and contains a FODMAP overview and added personalization. Screenshots from the app are presented in figure 2.10 on the facing page.

Pros:

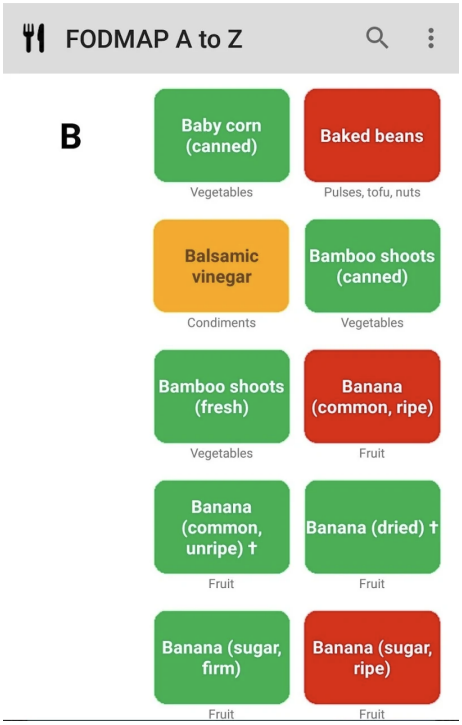
- Personalization.

Cons:

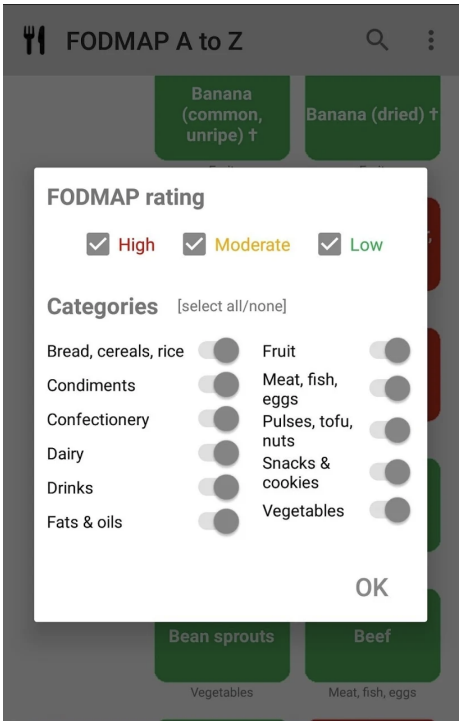
- Has no OCR feature, all lookups must be done manually.
- Has no barcode scanning.
- Has no functionality for contacting peers.
- Has no log.



(a) Low FODMAP diet A-Z 1



(b) Low FODMAP diet A-Z 2



(c) Low FODMAP diet A-Z 3

Figure 2.10: Screenshots from the app Low FODMAP diet A-Z Food list for IBS sufferers

My Food Intolerance List

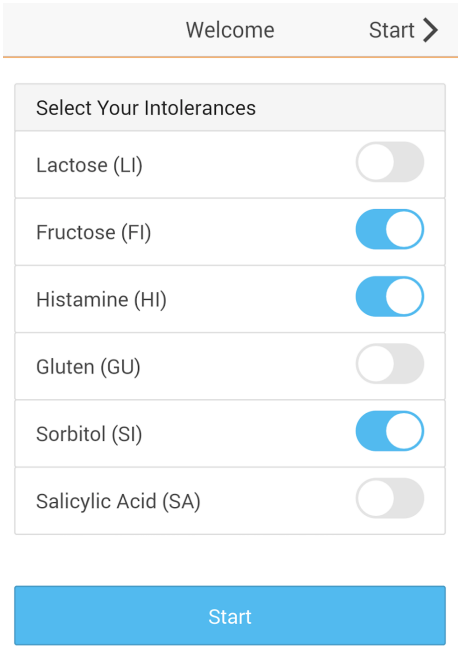
My Food Intolerance List by cr3ative.info, Steffen Mauser offers a FODMAP overview, personalization, and the ability to add tested ingredients to a private list. The app has 100 000+ downloads on Google play store. Screenshots from the app are presented in figure 2.11 on the next page.

Pros:

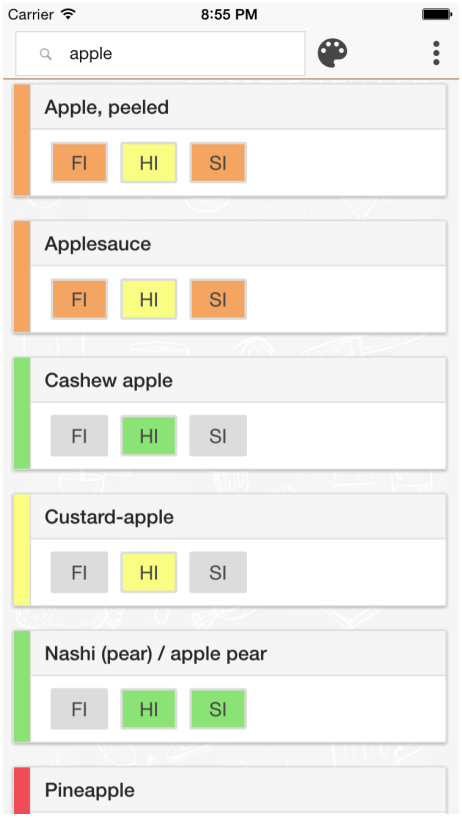
- Personalization.

Cons:

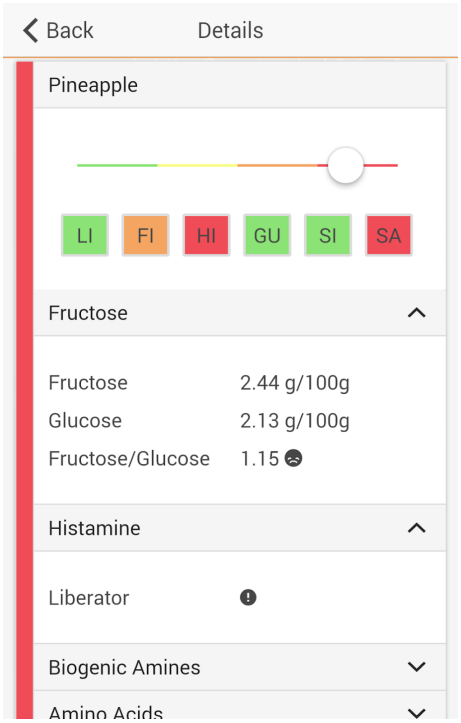
- Has no OCR feature, all lookups must be done manually.
- Has no barcode scanning.
- Has no functionality for contacting peers.
- Has no log.



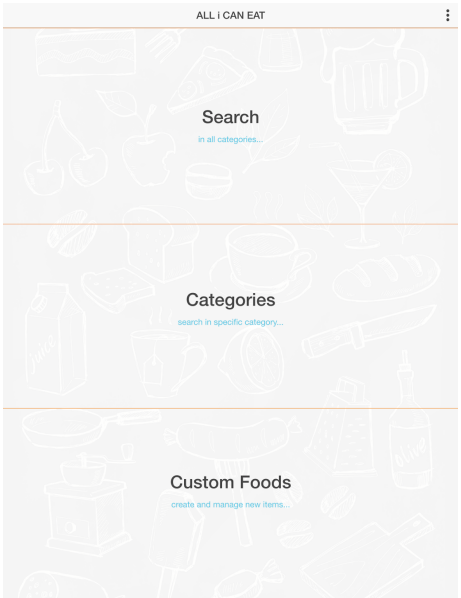
(a) My Food Intolerance List 1



(b) My Food Intolerance List 2



(c) My Food Intolerance List 3



(d) My Food Intolerance List 4

Figure 2.11: Screenshots from the app My Food Intolerance List

Mr symptoms Food Diary and Symptom Tracker

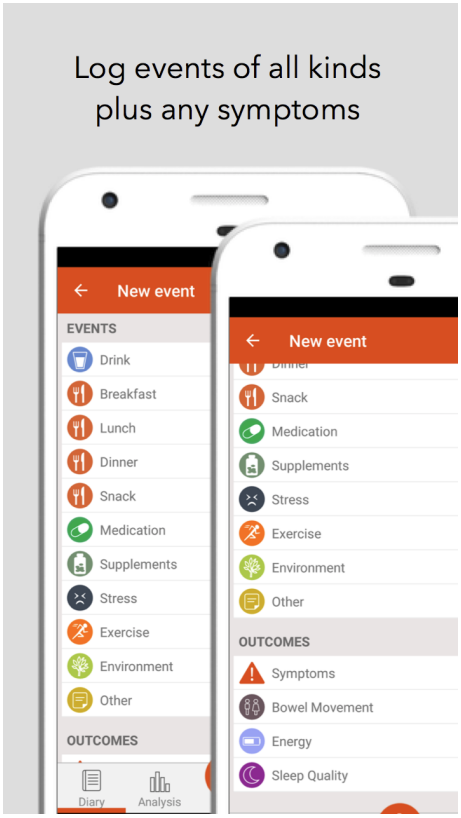
Mr symptoms Food Diary and Symptom Tracker by SkyGazer Labs Ltd has over 100 000 downloads on the Google play store and sets the standard for log and log analysis. Screenshots from the app are displayed in figure 2.12 on the facing page.

Pros:

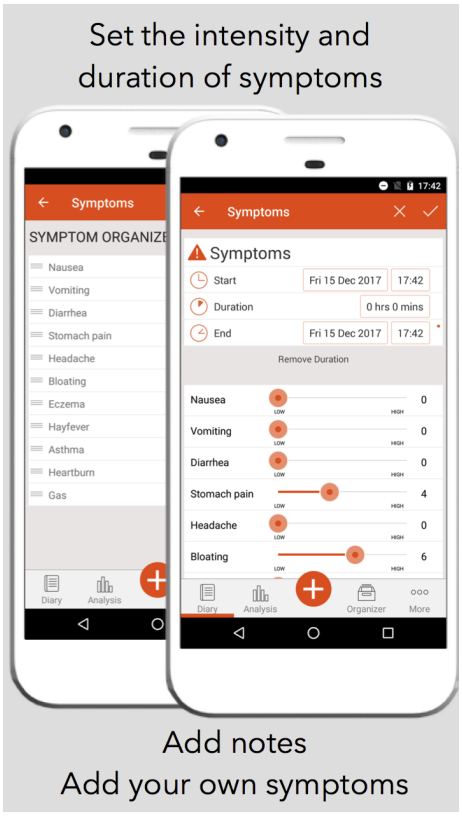
- Has advanced log and log analysis.

Cons:

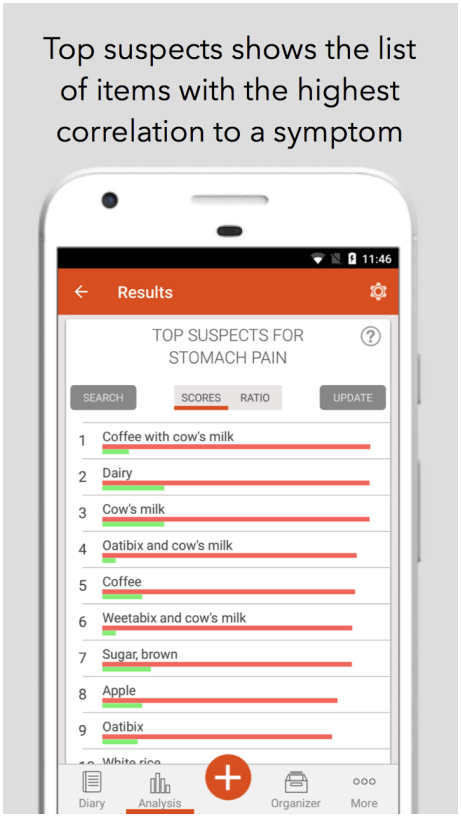
- Is a pure logging app and is missing needed features.



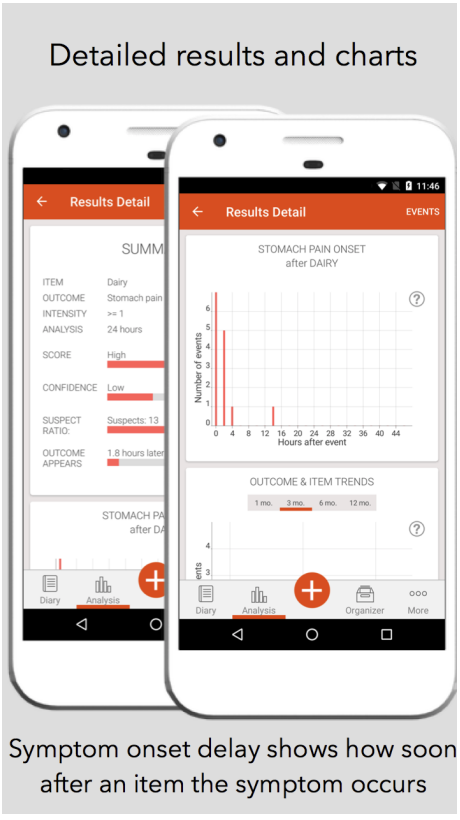
(a) Mr symptoms 1



(b) Mr symptoms 2



(c) Mr symptoms 3



(d) Mr symptoms 4

Figure 2.12: Screenshots from the app Mr symptoms Food Diary Symptom Tracker

2.3.3 Review summary

Although papers are describing and presenting prototypes of apps and there are apps on the market for people with bowel dysfunctions and food allergies, they are not available and/or in widespread use in Norway and provide only parts of the complete functionality needed to address the target groups challenges. What has become apparent through the systematic review is the need for complex and comprehensive logging as well as a direct connection with a health provider for people with inflammatory bowel diseased such as Chrons or Ulcerative Colitis.

3

Method

The purpose of the project is to research, design, and develop a mobile app for people with intolerances, bowel dysfunctions, or allergies. The app should simplify the every-day life of the users through simplifying the food intake, logging, and communication between people with these challenges. To fulfill the purpose of the project, the methods described in this chapter has been used.

3.1 Setting

3.1.1 User scenarios

The user scenario method gives valuable insight into which groups of people can have use of the application through practical examples. Creating examples of use clarifies what functionality and requirements are needed for the application to fill the users' needs. User scenarios for the project can be found in section 4.1.

3.2 Participants

The app developed from this project is primarily intended to be used by people with digestive dysfunctions such as IBS, intolerance's and/or food allergies. People who follow complex medical diets will find the app most useful. Although people with inflammatory bowel diseases such as Chron's or Ulcerative Colitis will have use of the app if they follow specific diets, they have more needs in terms of direct contact with health care providers and more complex logging as covered in multiple studies [10], [17]. Anyone shopping/cooking/planning meals for individuals with these challenges will also have use of the app for greatly simplifying the process of checking whether a meal is within the persons' diet. Individuals with allergies will primarily have use of the scanning feature for identifying trigger foods and the barcode scanner.

3.3 Procedure

3.3.1 State of the art review

Reviewing state of the art is necessary when doing projects which should contribute to the market, field of study, or society as a whole. When creating mobile apps, it's necessary to look into relevant apps in the market, as well as apps described in scientific papers. The review builds a base on which the project should be built on top of. The conducted reviews apps features, lack of features, and their design and usability were mapped and used to create a design for an app filling the needs in the market.

3.3.2 Pilot test

Once the app was mostly ready for a user test, the app was given out for testing by colleagues. They discovered inconsistencies in language, minor bugs and gave some general quality of life suggestions. Their suggestions were taken into consideration and implemented before the app was distributed for a user test.

3.3.3 User test

Landsforeningen mot fordøyelsessykdommer (LMF) were contacted at an early stage explaining the project and requesting aid in communicating with the user group. At an early stage, LMF posted a Facebook post explaining the project and the features of the app (displayed in figure 3.1 on page 36). In the

post, the date for a user test was specified, and an expectation of answering an in-app questionnaire was expressed. Ca.100 people expressed an interest in testing the app through the Facebook post or e-mail. When the app was ready for the test, and the specified date came, the app was uploaded to Dropbox for download by the test group. Ca 10% of the test group downloaded and installed the app (based on accounts registered in the app). It was clear that sideloading an app through a Dropbox download was too complicated/too much effort for the majority of the test group. The app was therefore uploaded to Google play store in an open beta test (figure 3.3 on page 38). This allowed users to install the app just like any other Google play store app, considerably lowering the complexity and effort to install the app. Simpler install combined with a new Facebook post from LMF informing about the availability of the app (figure 3.2 on page 37), caused the number of installs to increased significantly to the point of 65 users (not including co-students, friends, and family). For the app to be uploadable to the Google play store, the app needed a home page, as displayed in figure 3.4 on page 39.

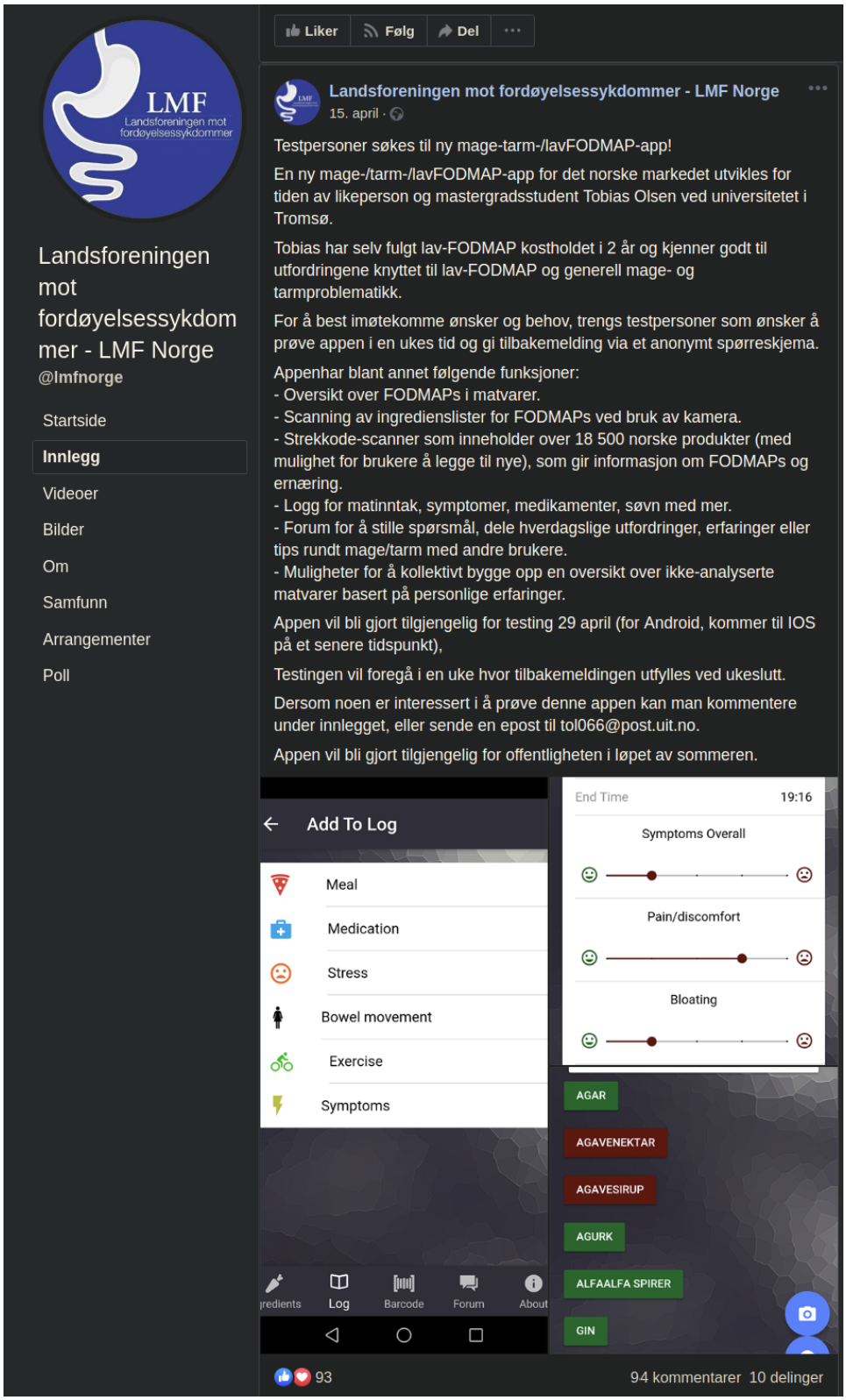


Figure 3.1: LMF first post

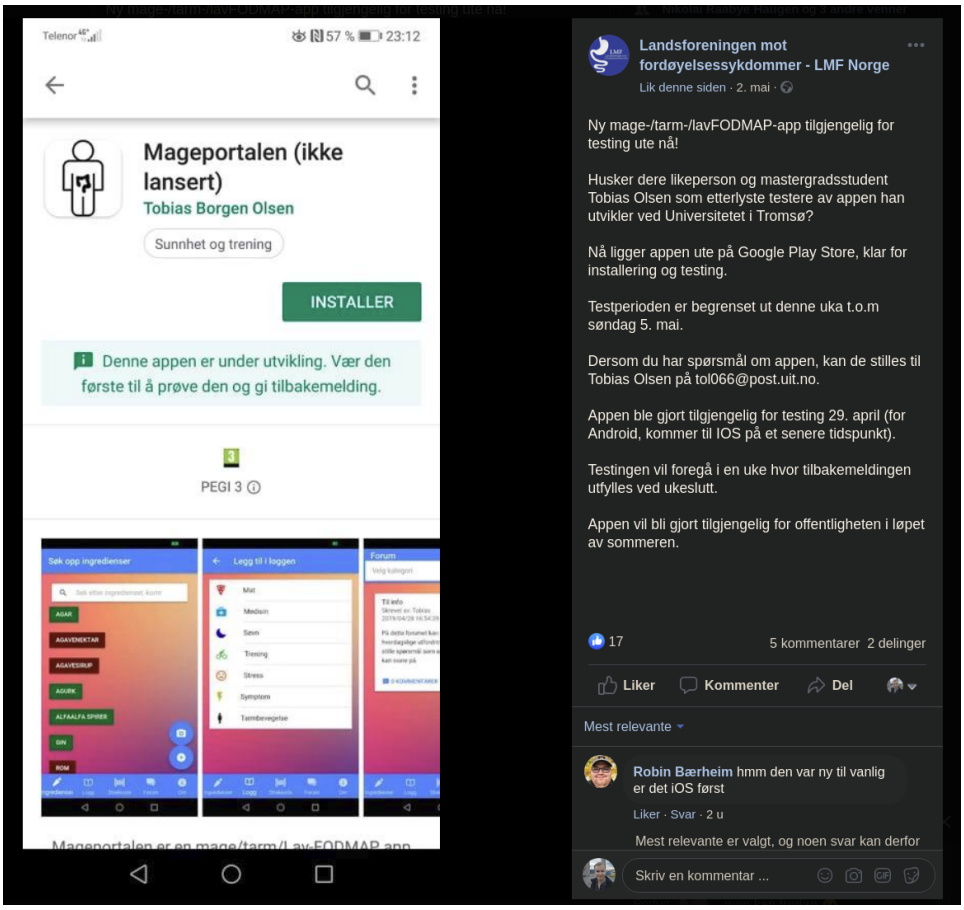


Figure 3.2: LMF second post

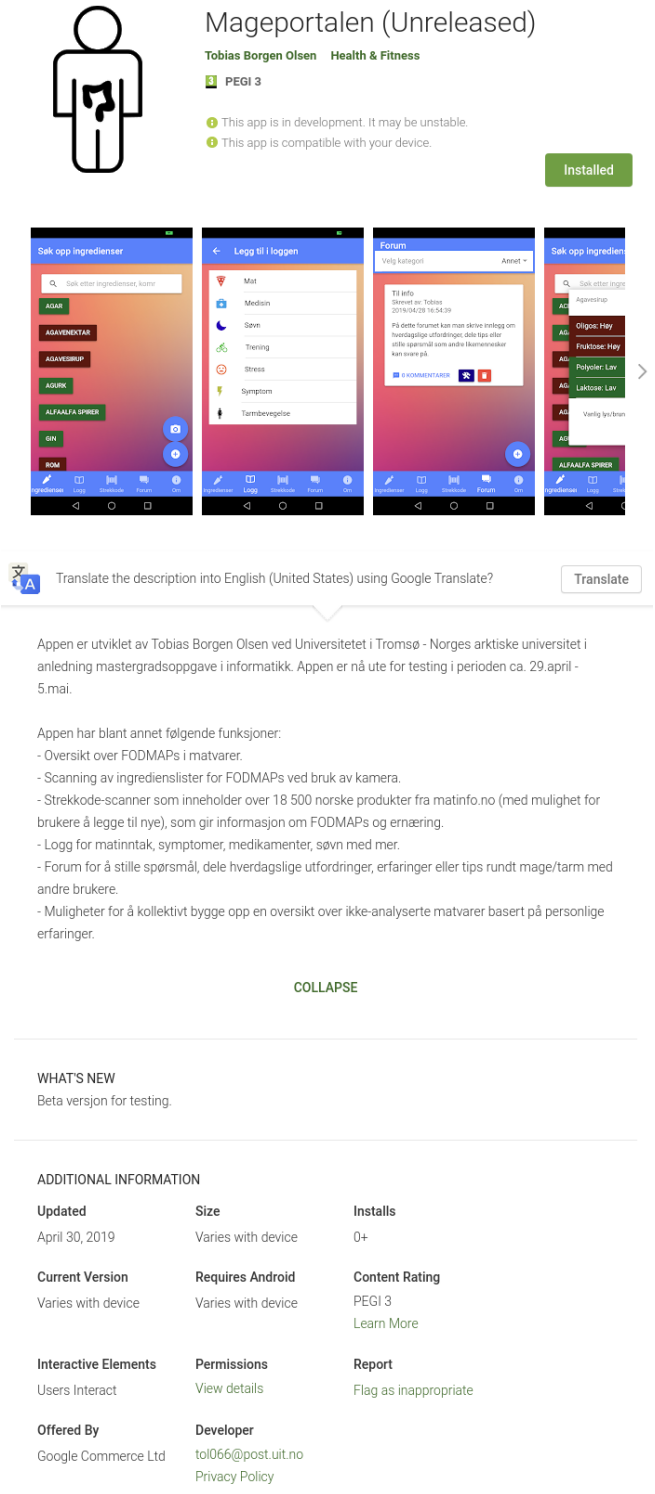


Figure 3.3: Google play store

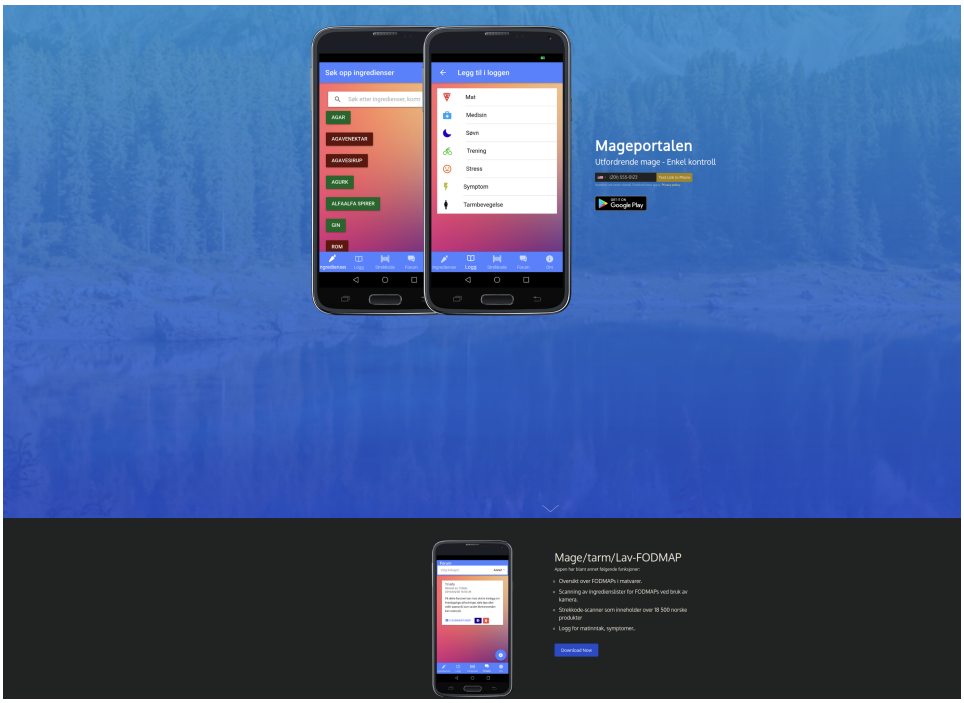


Figure 3.4: Home page

The app contained a survey answerable from within the app. The survey is a service provided by the University of Oslo [1] presented in the app through an in-app browser. The survey consisted of the system usability scale in addition to a few app-specific questions. User feedback was also collected from the in-app forum where the users gave requests for features and tweaks during the test phase.

Some feedback on the project itself was given on the Facebook post presenting the project:

Woman: "I would like to try the app when it's published. I have Chron's, but my doctor also thinks I have IBS. Would like to try the low-FODMAP diet, but I think it's a little complicated and a lot of work, so if an app is made available which simplifies the process it would have been great. I'm rooting for the project. Good luck!"

Woman: "Would like to test the app. Tired of laying in the fetus position in the bathroom x times a week..."

1. `https://nettskjema.no/`

Woman: "Would like to test the app. I have active Chron's, and no medication has worked so far."

Woman: "Would like to test. I've had IBS for 17 years. I am following the low FODMAP diet, which works well for me."

Woman: "I would like to test the app. I have Chron's and have no effect from medications. I am currently using low FODMAP and stress relief as a treatment. Would like an app to keep me on track with the diet.

Woman: "I would like to test the app! I've had IBS for over 20 years."

The feedback received shows a clear need for the app in the market and for the target group.

3.4 Analysis of findings

The questionnaire distributed to the test participants contained the system usability scale, which is a standard for usability, as well as some application-specific questions. In addition to the questionnaire, feedback on the project itself and the application was received over Facebook and the in-app forum. The additional feedback was handled without the use of any specific tools.

3.4.1 System usability scale

The system usability score of the application was calculated as follows. Each SUS question has a contribution score from 0-4. For questions 1,3,5,7 and 9, its contribution score is the scale position minus 1. For questions 2,3,6,8 and 10, the contribution score is 5 minus the scale position. The sum of the scores is multiplied by 2.5 to obtain the total system usability score [1]. The Norwegian version of the SUS was created by the author and has as such not been validated for correctness or accuracy compared to the original English version, and may as such not be accurate [18]. The SUS score of the implemented application is presented in section 7.7.

3.5 Criticism of methods

Due to time constraints, some areas have room for improvement. The systematic review and the app review could have been more thorough. There is a

vast number of apps which might be relevant to some degree for the project, but testing all of them is a time-consuming process. Therefore only the top apps have been tested. The user-test phase of the project could have been extended or ran in multiple iterations. If after each test, the app was improved based on feedback, the resulting app would better suit the needs of the target group.

4

Requirement specification

The requirements for the app was based on the conducted app review of competing apps available in the Norwegian market combined with the conducted systematic review of relevant papers, as well as personal experience dealing with intolerances. Individuals with bowel disorders and intolerances have also played a role in setting the requirements for the app. An individual with IBS and following the low-FODMAP diet wanted a simple overview and control system for checking FODMAPs in ingredients and products.

4.1 User scenarios

Let's take a look at a couple of use cases for the application. The apps primary target is persons with digestive dysfunctions such as IBS. An example scenario for this group is displayed in figure 4.1 on the next page. In the morning the person wakes up and does an overall evaluation of his shape, and logs any symptoms, bowel movement, and sleep. The user eats breakfast and logs the meal. After an hour, the app prompts the user for logging of symptoms. If the user has any, he logs them. At lunch, it's the same procedure. When the time is right for shopping groceries, he writes a list of what groceries are needed. If he has any recipes he wants to use, he scans the recipe for trigger food and modifies the recipe if needed. He takes the app with him to the store, looks up any unfamiliar products with the barcode scanner, takes a picture of the ingredient declaration, or searches the food in question manually. Once the

food has been made, and he's eaten, he logs the meal. Once again, he logs any symptoms after an hour. In the evening, he browses the apps forum for tips and tricks and asks questions about IBS.

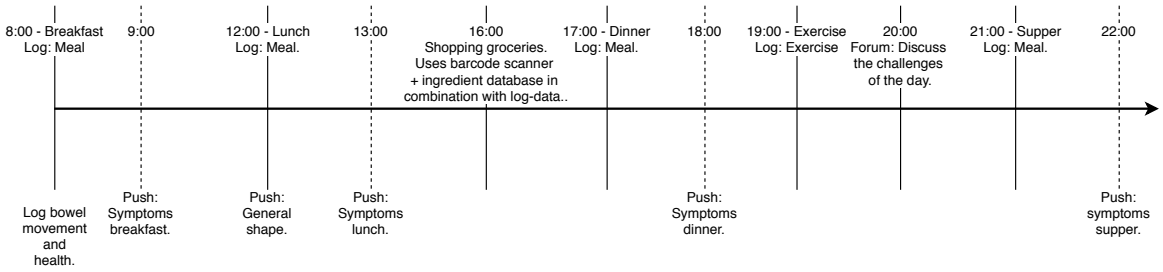


Figure 4.1: Time line of example of use

For friends, family, and anyone cooking or shopping groceries for a person with intolerances, the app has a more limited use than for the primary target group. An example would be a family member planning a dinner for a person following the low-FODMAP diet. The family member writes a shopping list of ingredients needed for a meal and scans the list with the app. The app gives feedback on which ingredients are within or outside the diet. He or she then proceeds with finding alternatives for the ingredients which are not low-FODMAP and repeats the scanning, alternatively checks the ingredient in question manually, until all ingredients are okay. If he/she plans on using any products from the store, he/she use the barcode scanner while shopping to figure out which product (if any) are okay.

For a caterer, the app can be used when developing a menu with courses within a specific medical diet or intolerance. The process is the same as the previous scenario where the list of ingredients for a menu item is scanned when creating the menu, refining the list until no trigger foods are present.

4.2 Requirements

Using the Volere requirement specification [19], the following table was created. The table has the following abbreviations: type 1: Product purpose, 5: Naming conventions and definition, 8: Product scope, 9: Functional and data requirement, 11: Usability requirement. Customer satisfaction and customer dissatisfaction are in the rightmost columns.

Requirements

Req #	Type *	Description	Rationale	Source	Fit Criterion	Sat *	Dissat *
1	1	Simplify following a medical diet	Following complex medical diets is difficult and time consuming	Author	The process of following a complex medical diet shall be simpler with the app than without	5	3
2	5	Shall use norwegian language and products	There are no apps with the needed functionality for the norwegian market	Author	The apps language and products shall be all norwegian	5	3
3	8	Shall use a norwegian food product database	The app shall be suitable for norwegian users	Author	The app has info from a norwegian food product database	5	3
4	9	Food analyzed for FODMAPs/ intolerances shall be searchable by text	Core feature which simplifies following a diet	Author	The food shown to the user shall be the food searched for	3	4
5	11	The app shall be able to scan images for trigger foods	Significantly simplifies following complex diets and lowers the effort needed to use the app	Author	When scanning images of ingredients the app shall produce a result with information on the ingredients and their matching intolerances if it's in the database	5	2
6	9	Looking up products available in norwegian grocery stores shall return relevant FODMAP, intolerance, allergy and nutritional information	Allowing products to be looked up is easier than searching each ingredient	Author	When looking up products it shall display relevant FODMAP, intolerance, allergy and nutritional information	3	2
7	11	Products shall be able to be looked up through barcode scanning	Scanning the barcode is simpler than searching for a product	Author	When utilizing the app a barcode scan option shall be available, and the result from the scan shall give relevant FODMAP, intolerance, allergy and nutritional information on the product if it exist in the database	5	2
8	11	Users shall be able to add products to the product database	Having an expandable database includes the users in the app and increases the chance of finding products	Author	There shall be a option for the user to add products to the database. The product added shall be searchable by other users	2	1
9	11	Adding products for users shall be simple	Motivates adding products	Author	The process of adding products shall be seen as simple and not time consuming from the users perspective	2	1
10	11	Products added by users shall instantly and automatically be classified for intolerances	Giving the users the ability to instantly receive product information motivates adding products and provides the users with information when needed	Author	Instantly after adding a product the product shall be searchable and provide information	3	1

:

11	9	Voting system on whether food item not analyzed for FODMAPs gives symptoms	Expands the users collective knowledge on FODMAPs	Author	A user shall be able to vote on if an food item gives symptoms	2	1
12	9	The app shall contain a log system for logging food intake, symptoms, stress, exercise, bowel movements and other relevant factors	Essential feature for keeping track of intake and events and their resulting symptoms	Author	The app shall contain a log system for logging food intake, symptoms, stress, exercise, bowel movements and other relevant factors. The events logged shall be the events displayed in the log	3	2
13	11	The logging interface shall be simple	Simple interfaces makes it less of an effort to utilize the log	Target group	The users shall not consider the logging as too time consumable	3	2
14	11	The app shall remind the user to utilize the log	Makes logging more likely, and improves accuracy compared to logging once a day	Author	The app shall be able to present users with push notifications	1	1
15	11	The log shall be complex enough to gather needed information	Provides the user with important information	Target group	The app shall allow the user to input information covering the events and symptoms	3	3
16	11	The log shall provide analysis for which events trigger which symptoms	Provides simple and clear information on which food and events gives which symptoms	Author	Analysis of the log concerning which events cause which symptoms shall be conducted and presented to the user in a understandable fashion	4	2
17	11	The user shall be able to personalize the app to fit their intolerances	Makes the app suitable for more people, and makes the app feel more tailored	Author	Which trigger foods searched for and searchable in the app shall be changed based on the users customization	3	2
18	9	The app shall provide a communication platform for users to communicate with each other	Lets the users feel part of a community, and allows users to reach and help each other	Author	A user shall be able to read/write posts in the platform and thereby reach other users	2	1

:

Let's discuss some of the requirements.

4.2.1 Requirement 4-5

Having the ability to search for foods analyzed for FODMAPs/known trigger foods for the intolerance in question, is the core and often only feature of many FODMAP apps. Half of the apps in the app review has this feature. This strongly supports the importance of such a feature. While having a searchable overview is fine, being able to scan images for trigger foods greatly simplifies the process and differentiates the app from most others on the market.

4.2.2 Requirement 6-10

Although checking a single ingredient or many at a time for trigger foods through scanning images provides possibilities to check all ingredients in a product, being able to scan only a barcode and get the same information in addition to nutritional information makes the app more user-friendly.

4.2.3 Requirement 12-16

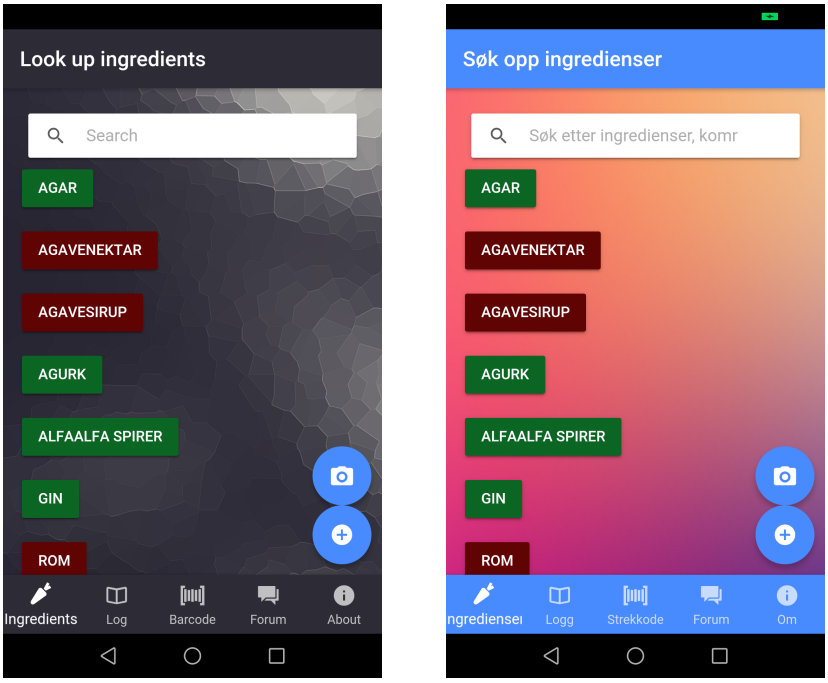
For discovering relations between consumption, events, and symptoms logging is the most effective tool. Apps such as FODMAP by Monash, FODMAP helper, and Belly Balance supports this feature's importance in FODMAP applications, while apps such as Mr. Symptoms Food Diary and Symptom Tracker sets a standard for design and interface. The benefits of utilizing mobile devices to log at sporadic or strategical intervals during the day instead of using the recall method is supported by the findings of Z. Mujagic et al. [6].

5

Design

5.1 Color scheme

The color scheme for the app has, as displayed in figure 5.1 on the following page, changed from black and grey tones to shades of orange and purple with blue menu and buttons. While grey represents the feeling of uncertainty, the new color scheme is connected with warmth, calm and happier emotions [20], which is beneficial for the target group since the target group has a higher chance of having anxiety and depression.



(a) Old scheme **(b)** Current scheme

Figure 5.1: Old vs new color scheme

5.2 Ease of use

The application is created with ease of use in mind. Minimizing the number of clicks needed for each operation increase the likelihood of regular use.

5.3 Users

When it comes to users in a system containing sensitive information, it is important to create and store users in such a way that no security or privacy violations are encountered. Most applications store email and password, but email can often easily identify the user. Using username only can reduce the possibility of identification drastically. The username can also lead to identification, but only if the user creates an identifiable user name. Once the user is logged in, he remains logged in as long as his user token has not expired, in which case he must log in again.

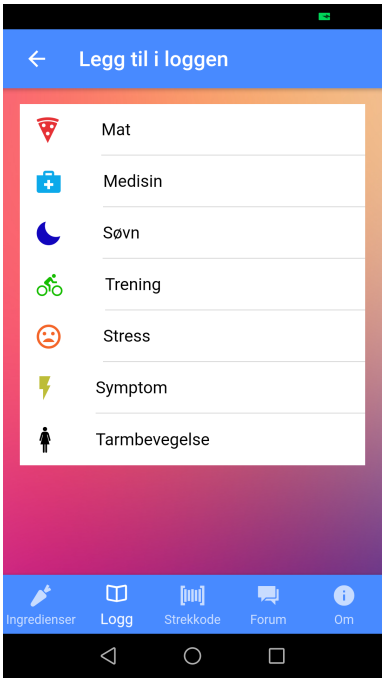
5.4 Log

5.4.1 What to log

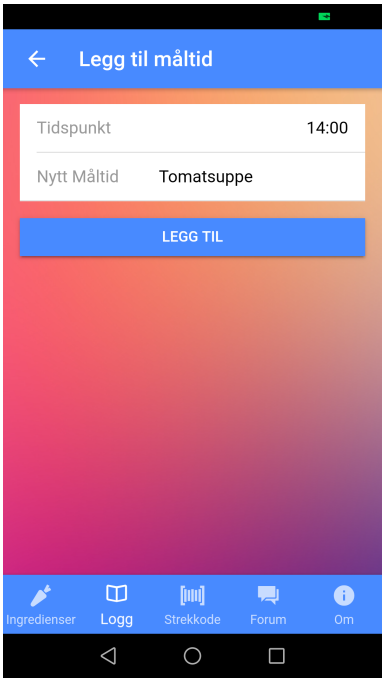
The app allows, as displayed in figure 5.2a, logging of meals, medicine, exercise, sleep, stress, symptoms, and bowel movements. What to log is based on the app review and knowledge of IBS. Meals, medicine, and in reality everything ingested, greatly affects the symptoms and bowel movement of the user. In addition, elements such as exercise and sleep affect bowel functions. Stress is a well-known factor of bowel distress, even for perfectly healthy people. For a person with a bowel dysfunction, stress can be even more detrimental, and lowering stress have shown to be equally important as dieting for keeping the symptoms at bay [21].

5.4.2 Minimizing logging effort

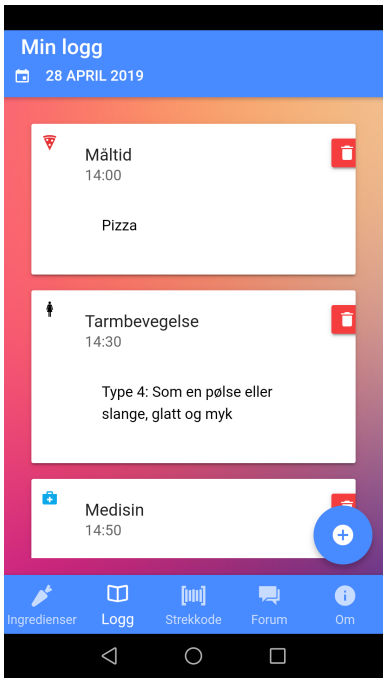
Minimizing clicks is a high priority in the logging feature. The log is not a functionality that instantaneously gives the user needed information such as the ingredient overview or barcode scanner, but it could be helpful in the long term for the users to keep a log. To better the users' compliance for logging, the logging should therefore not be unnecessarily time-consuming. To make logging as simple as possible, the details of a log entry must be kept just complex enough to get the needed information. All log entries need a timestamp. Logging food needs food consumed, medication needs the name of the medication, exercise needs exercise type. Stress, sleep, and symptoms are slider-based for simplicity, as shown in figure 5.2d. The bowel movement entry utilize the Bristol scale, which is used by apps in the review, and requires a single multiple-choice value.



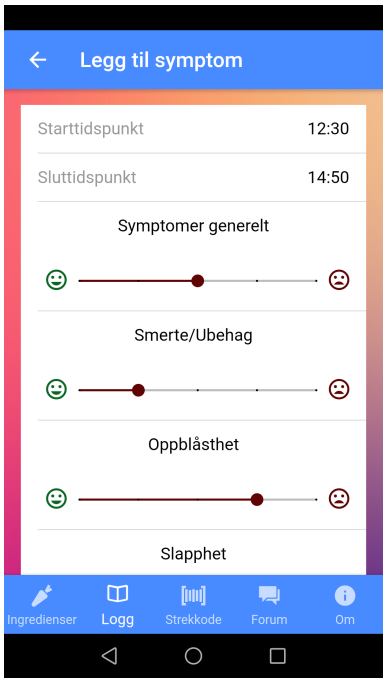
(a) Log categories



(b) Adding meal



(c) Log overview



(d) Adding symptoms

Figure 5.2: Log categories, overview and adding entries

5.4.3 Log notifications

For a person with intolerances, symptoms are heavily related to food intake. If the wrong food is ingested, symptoms can occur. To simplify the process of remembering to log, and to simplify the logging itself, a timer set for one hour is started whenever a meal is logged. When the timer runs out, the app sends a notification to the user asking the user to log symptoms (if any), which is displayed in figure 5.3. Pressing the notification leads the user directly into the view for logging symptoms, thereby minimizing the number of actions needed.

When to log is a decision which affects the accuracy of the log. Studies have shown that logging at strategic or random intervals throughout the day provides a more accurate log result than using the recall method at the end of the day. The study showed that when using the recall method, the symptoms were often logged at peak values, thereby yielding a higher result than logging at random intervals [6]. To further motivate this behavior, push notifications can be sent at strategic or random moments during the day.

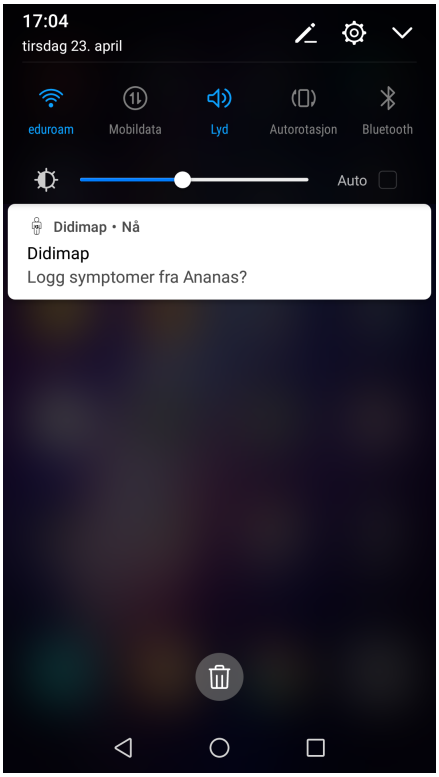


Figure 5.3: Log notification

5.5 Forum

The forum, displayed in figure 5.4, is a place for the users to share experience and ask questions to people with similar challenges as themselves.

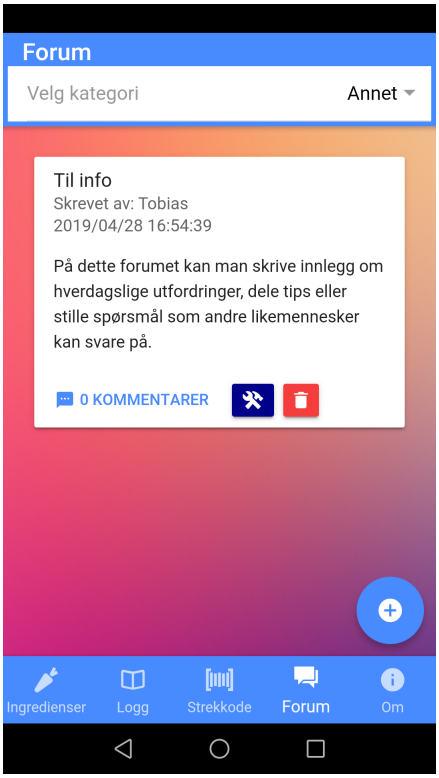


Figure 5.4: Forum

5.5.1 Forum categories

In the forum, the users can discuss within the categories tips, questions, recipes, feedback to the developer, and "bad day". The "bad day" category is meant to be a place for expressing frustration, bad experiences and so on. A category "other" is also included for posts outside the defined categories.

5.5.2 Notifications

For the forum to feel as expected, receiving notifications when someone replies to your post should be present. This makes the app feel more finished and responsive and make the forum more tempting and desirable to use.

5.6 FODMAP/trigger food overview

As displayed in figure 5.1, the application has a FODMAP/trigger food overview which, in the current FODMAP implementation, displays all food analyzed for FODMAPS in a searchable list. To simply identify whether a food contain low/moderate/high amounts of FODMAPs a traffic light coloring system is used. This coloring system is widely used in similar apps covered in the app review, and is easily understandable. Low FODMAP foods are marked with green, moderate FODMAP foods are marked with orange, and high FODMAP foods are red. In addition, the implementation mark some foods with the color blue to indicate that this food has multiple variants with different FODMAP values. Banana for example, has low FODMAP value if the banana is unripe, but a high FODMAP value if it's ripe. To get additional information concerning which FODMAP type the food has and other available information, the user simply clicks the food, as displayed in figure 5.6b. If the user does not find information concerning a specific food in the overview, and decides to eat the food, he can add the food and give information whether he gained any symptoms from the consumption. This information will be available to all users, and everyone who has tried the food can give their vote whether they gained symptoms from the consumption or not. Although this information is displayed in the overview, they are clearly differentiated from official analyzed foods by having only the borders of the box colored, which is illustrated in figure A.5 on page 98 in the appendix.

5.6.1 Scanning ingredients

Checking ingredients for trigger foods has always been manual labor. When the intolerances become complex enough, you don't know which ingredients you shouldn't consume. The process then becomes checking each ingredient that you are not familiar with against some source like Google or an app. If you are looking up a large list of ingredients, it can be time-consuming looking up one ingredient at a time. To aid in this process, the app uses an optical character recognition feature. When a user wants to check ingredients, he can simply capture an image of the ingredients as displayed in figure 5.5. The image is sent to the OCR engine through the server. Once the result is returned to the server and cross-checked against the intolerance database, the intolerance information on the ingredients is returned to the user in an easily understandable format (figure 5.6).

Having the ability to use the OCR feature when traveling is valuable, as covered by Albert Parra Pozo et al. [4]. This can be done by sending the resulting text from the OCR engine to a translator engine such as Google translate. The result from the translation is passed on through the system as it should have been in

Norwegian all along.

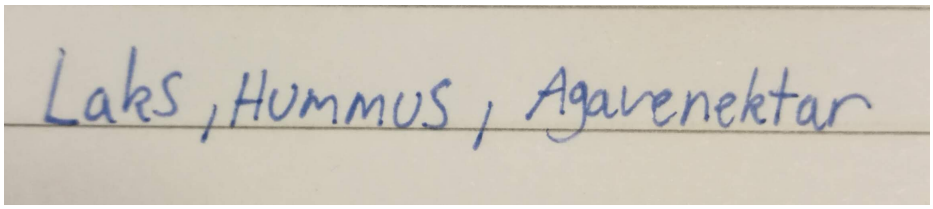
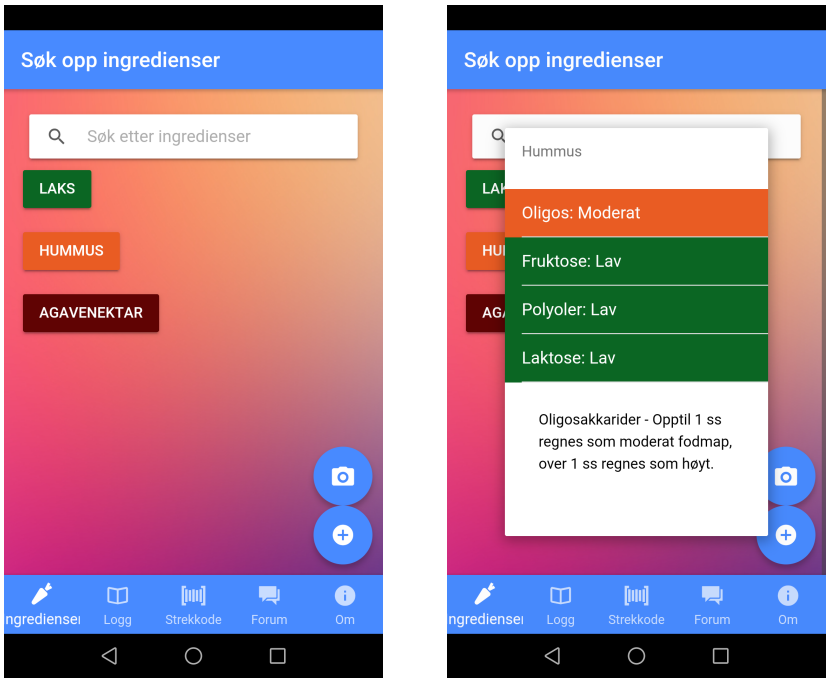


Figure 5.5: Input text



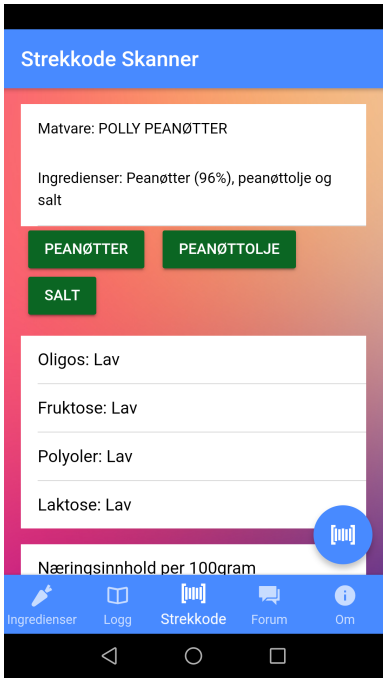
(a) Resulting ingredients **(b)** Ingredient information

Figure 5.6: Scan ingredient procedure

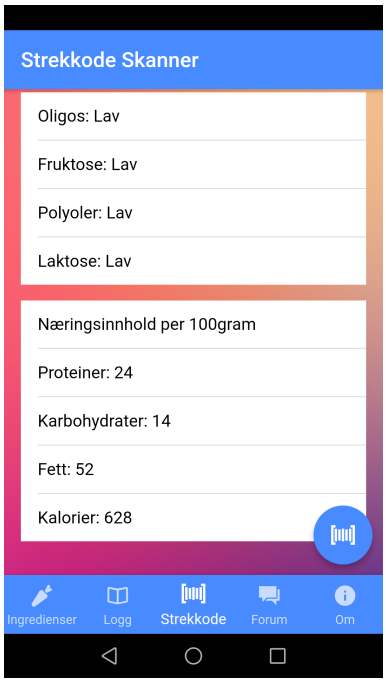
5.6.2 Barcode scanner

The barcode simplifies the process even further for food products found in the grocery store. Scanning a products barcode (figure 5.7a) yields the same result on a per ingredient basis as the ingredient scanner, but in addition gives nutritional information and classifies the product as a whole based on the ingredients as displayed in figure 5.7b-c. If a user doesn't get a match on the scan, he can add the product to the database himself, scan it again, and receive the desired information. Adding products is further described in section A.13 in the appendix.

(a) Input image



(b) Result



(c) Result continuation

Figure 5.7: Barcode scan procedure

6

Implementation

The implementation and its functions are based around an underlying database containing a list of food representing the users' intolerances. If the list is changed or expanded, the app can cater to any intolerance's or allergies making this a general solution.

The system architecture is displayed in figure 6.1 on the following page. The mobile app holds the log and relays requests to the server. The server holds databases on users, food, and products, and communicates with the OCR provider as well as the product info provider.

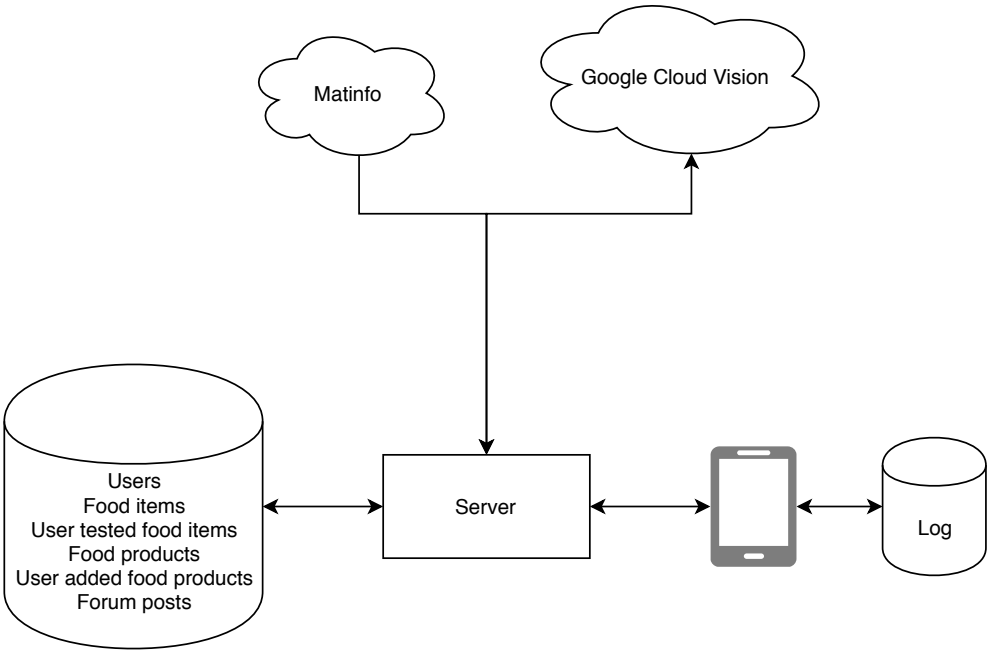


Figure 6.1: System architecture

6.1 Server

For the back-end, Rails 5.2 [1] has been used because of earlier experience and integration with needed functionality. Postgres has been used for the database. The server has 4 modules, which include users controller, intolerance controller, barcode scanner, and forum.

The data on food products which can be found in Norwegian grocery stores are collected through the API of Matinfo.no [2]. The Matinfo API is simple and consists of two essential calls. The first call takes input a date and returns all product IDs that have changed since the given date. The other call takes as input an ID and returns all info about the product with the given ID. Matinfo is not built for direct requests from clients, meaning all data should be stored locally and updated from Matinfo periodically. To populate the local database, all of Matinfos products have been collected by issuing a call retrieving all product IDs from the start of time, then sending a request for each ID retrieved. Since no documentation was available concerning possible variables and values in a product, a parser had to be made incrementally, collecting new fields each

1. `https://rubyonrails.org/`
2. `https://matinfo.no/`

time a new field was encountered. This was quite a time-consuming process. Each product was saved in the database with all values deemed relevant at the time and for future work.

The user controller handles user registration, login, and sessions. Users are handled by the "Devise" gem modified for using JSON web tokens. Devise is a complete model view controller package and by default not well suited for authentication over HTTP, but using JWT solves the issue. The user module accepts requests for user creation and creates a JWT for the user. When the user logs in, he receives the JWT which he sends to the server to authenticate his actions. JWT is on this point only utilized for authentication in the forum, but can be utilized for all functionality if need be.

The intolerance controller handles checking ingredients for specific trigger foods or allergens by cross-checking with a database containing food and their corresponding intolerance values/allergens. In the implemented case, the intolerance database contains food and their corresponding FODMAP values (low, moderate, high) in addition to information concerning amounts. Once a request arrives for controlling an ingredient, the module removes irrelevant words such as "conservative" or "thickener", which may be received if doing OCR on an ingredient declaration. The ingredient is checked against the intolerance database through fuzzy search. If an ingredient in the database matches the ingredient in the request with 30% or more, the ingredients database record is returned to the app. The module also receives images meant for the OCR engine. Once an image is received, the server passes it on to Google Cloud Vision for document text detection. The resulting text is first purged for duplicates. Since OCR engines "guess" words, they conduct multiple runs, yielding multiple results. The text is then controlled against the intolerance database, and any data concerning the ingredients is returned to the app. The controller also handles adding ingredients to a database for ingredients tested by users. These ingredients have not been analyzed, and there is as such no FODMAP or intolerance information available. Saved in the database is a counter on how many of a total number of users reporting this ingredient has gained symptoms from its consummation. The user reports should ideally be authorized to prevent multiple reports from the same user on the same ingredient. This would require saving a list on which users have reported which ingredients. Ingredients controlled for trigger foods/allergens are also checked against this database if no hits are found in the intolerance database.

The barcode scanner accepts requests containing global trade item numbers(gtin), checks the gtin against a database of products and returns the product if it exists. The module also receives requests for adding new products from the user. The products ingredients are controlled for trigger foods, and if information exists on all ingredients, the product as a whole is classified in

concern to the medical diet.

The forum controller functions provide CRUD functionality where create, update, and delete is authenticated through the passing of a JWT.

6.2 App

For the app, Ionic 3 [3] has been used. Ionic 3 is a cross-platform framework, meaning the same code can be deployed to IOS, Android, and browser. Ionic 3 has been built on Cordova, which puts a layer of abstraction between the programmer and the native APIs of the platform, which is what allows the cross-compilation. Ionic use angular/typescript and an abstraction of HTML.

The app communicates with the back-end through JSON over the hypertext transfer protocol. At first launch, the user creates an account and logs in. The user credentials are sent to the back-end, and a JWT is received which is stored locally on the device. When the app starts next time, the JWT is fetched from local storage and sent to the server, which returns the user object.

Once the app launches and the user is authenticated, all foods analyzed for FODMAPs are fetched from the server in a single request and displayed in the overview.

6.2.1 Log

All log data is stored locally on the device. For Ionic 3 local storage consist of a single key/value store for holding any local data of all types and formats. For this reason, storing complex data simply, becomes somewhat of a hassle. Grouping one days log entries together makes sense in terms of simplicity when displaying the log for each day. As such, date has been used to identify groups of entries. This although leaves the key matching a single value containing a full days log entries. For storing multiple log entries in a value a custom string format has been created which utilize string operations to insert and remove data. Essentially all the days' entries are one string which divides each entry on the character "|" much like the CSV format. Every single entry starts with a unique ID which consists of an Md5 hash of the current time. The ID is used to identify entries for deletion. Within an entry, the values are divided on other special characters unlikely to be used in the actual log entries. Each entry contains a type and a range of values depending on which log entry

3. `https://ionicframework.com/docs/v3/`

category the entry belongs to. When extracting a day's entries from the log, the log entry with the corresponding day's key is fetched, and the string is split firstly on "|" to separate each entry, then on each special character to isolate wanted values. In retrospect, this is not a great solution. If a user uses any of the special characters in the log post, which is, although unlikely, a possibility, the log would break. This could have been solved in a more solid and simple fashion by building an object for each log entry, use JSON stringify to save the object as a string on storage and extracting into an object through JSON parse when needed. This possibility was although not known to the author at the time of the implementation.

7

Results

7.1 User test

Through user feedback from the test phase the following system usability score was accomplished.

SUS score:

- Question 1: 3,5
- Question 2: 3,375
- Question 3: 3,5
- Question 4: 4
- Question 5: 3
- Question 6: 2,5
- Question 7: 3,375
- Question 8: 3,5
- Question 9: 3,5

- Question 10: 3,75

Calculated score: 85

75% of the responders thought the application greatly simplified following the low-FODMAP diet, 12% thought it made no difference, 12% slightly disagreed. When it comes to whether the logging is too time-consuming, 12.5% strongly disagreed, 25% slightly disagreed, 25% neither agreed nor disagreed and 37.5% slightly agreed. Concerning whether the logging is too simple 25% strongly disagreed, 50% neither agreed nor disagreed, 12.5% slightly agreed, and 12.5% strongly agreed. On whether it's too complicated to add new products to the app, 12.5% strongly disagreed, 25% slightly disagreed, 25% neither agreed nor disagreed, 25% slightly agreed, and 12.5% strongly agreed.

Changes wanted to the log was the possibility to, when logging symptoms, only set starting time and set end time later, and the possibility to add their own symptoms field, alternatively a free text field for notes. Another tester requested free text fields on all log entries for notes and comments. Setting a number on each medication entry to simpler keep track of medication intake was also requested, as well as an interface for marking an entry as lasting the entire day. In the apps forum, a user suggested an additional text field when logging symptoms, for logging diffuse symptoms that are not currently covered in the symptoms logging. Another user would like to be able to write a log entry with an "ongoing" timestamp, to not have to write the log entry first when the symptoms have stopped.

Rapport fra «Tilbakemelding mobil-app mage/tarm/FODMAP»

Innhentede svar pr. 21. mai 2019 10:08

- Leverte svar: **8**
- Påbegynte svar: **0**
- Antall invitasjoner sendt: **0**

Med fritekstsvar

Brukbarhet

Jeg tror jeg ville brukt mobil-applikasjonen jevnlig. *

Svar	Antall	Prosent
Svært uenig	0	0 %
Litt uenig	0	0 %
Verken enig eller uenig	0	0 %
Litt enig	4	50 %
Svært enig	4	50 %

Jeg fant applikasjonen unødvendig komplisert. *

Svar	Antall	Prosent
Svært uenig	5	62,5 %
Litt uenig	1	12,5 %
Verken enig eller uenig	2	25 %
Litt enig	0	0 %
Svært enig	0	0 %

Jeg synes applikasjonen var lett å bruke. *

Svar	Antall	Prosent
Svært uenig	0	0 %
Litt uenig	0	0 %
Verken enig eller uenig	1	12,5 %
Litt enig	2	25 %
Svært enig	5	62,5 %

Jeg tror jeg vil trenge hjelp fra en teknisk person for å bruke applikasjonen. *

Svar	Antall	Prosent
Svært uenig	8	100 %
Litt uenig	0	0 %
Verken enig eller uenig	0	0 %
Litt enig	0	0 %
Svært enig	0	0 %

Jeg synes applikasjonens funksjonaliteter var godt integrert. *

Svar	Antall	Prosent
Svært uenig	0	0 %
Litt uenig	0	0 %
Verken enig eller uenig	2	25 %
Litt enig	4	50 %
Svært enig	2	25 %

Jeg synes applikasjonen var for inkonsekvent. *

Inkonsekvent vil i denne sammenheng bety at appen ikke gjør ting gjennomgående likt. At for eksempel å legge til logg-elementer foregår på ulike måter.

Svar	Antall	Prosent
Svært uenig	1	12,5 %
Litt uenig	2	25 %

Svar	Antall	Prosent
Verken enig eller uenig	5	62,5 %
Litt enig	0	0 %
Svært enig	0	0 %

Jeg innbiller meg at folk flest lærer seg fort å bruke denne applikasjonen. *

Svar	Antall	Prosent
Svært uenig	0	0 %
Litt uenig	0	0 %
Verken enig eller uenig	1	12,5 %
Litt enig	3	37,5 %
Svært enig	4	50 %

Jeg fant applikasjonen svært tungvint å bruke. *

Svar	Antall	Prosent
Svært uenig	5	62,5 %
Litt uenig	2	25 %
Verken enig eller uenig	1	12,5 %
Litt enig	0	0 %
Svært enig	0	0 %

Jeg følte meg svært sikker i bruk av applikasjonen. *

Svar	Antall	Prosent
Svært uenig	0	0 %
Litt uenig	0	0 %
Verken enig eller uenig	1	12,5 %
Litt enig	2	25 %
Svært enig	5	62,5 %

Jeg trengte å lære mye før jeg kunne bruke applikasjonen. *

Svar	Antall	Prosent
Svært uenig	6	75 %
Litt uenig	2	25 %
Verken enig eller uenig	0	0 %
Litt enig	0	0 %
Svært enig	0	0 %

Applikasjonen gjør det betydelig enklere å følge lav-FODMAP kostholdet *

Svar	Antall	Prosent
Svært uenig	0	0 %
Litt uenig	1	12,5 %
Verken enig eller uenig	1	12,5 %
Litt enig	0	0 %
Svært enig	6	75 %

Funksjonalitet: Logg
Loggføringen er for tidskrevende. *

Svar	Antall	Prosent
Svært uenig	1	12,5 %
Litt uenig	2	25 %
Verken enig eller uenig	2	25 %
Litt enig	3	37,5 %
Svært enig	0	0 %

Loggføringen er for simpel. *

Svar	Antall	Prosent

Svar	Antall	Prosent	
Svært uenig	2	25 %	
Litt uenig	0	0 %	
Verken enig eller uenig	4	50 %	
Litt enig	1	12,5 %	
Svært enig	1	12,5 %	

Om noen, hvilke endringer ønsker du ved loggføringen?

For eksempel: Flere kategorier, flere felt innad kategorier...

- mulighet for å legge inn symptomstart uten slutttidspunkt da noen symptomer varer mange timer og det kan være vanskelig huske logge først etter symptomene er borte. Mulighet for å legge inn flere/egne symptomer.
- Mulighet til å enten legge til egne symptom, eller ha et notatfelt hvor man kan skrive annet symptom enn de forhåndsdefinerte. Dette kunne det gjerne vært på de andre punktene under loggen også, sånn som på mat.
- Nummering på medisiner siden mange har flere medisiner samtidig i løpet av dagen
- Egent felt til å skrive kommentarer og egen knapp om det er hele dagen

Funksjonalitet: Strekkode-skanner
Det er for komplisert å legge til nye produkter. *

Svar	Antall	Prosent	
Svært uenig	1	12,5 %	
Litt uenig	2	25 %	
Verken enig eller uenig	2	25 %	
Litt enig	2	25 %	
Svært enig	1	12,5 %	

Se nylige endringer i Nettskjema (v620_0rc1)

8 Discussion

8.1 Generalization

The app was proved functional for a low-FODMAP use case, there is although no reason for why it should not work with any intolerances or food-allergies by adding multiple intolerance/allergy databases and small frontend customizations based on the intolerance/allergy.

8.2 Privacy

8.2.1 Log placement

Although log placement doesn't affect the user experience or feel of the application, it makes a big difference in terms of handling privacy. The log contains sensitive information that must be handled according to international standards. The log can be placed either on a server or locally on the mobile device. Placing the log on a server means one has the responsibility for the data and must set in play actions to protect the privacy of the user. This does although leave room for doing analytics and sharing of the data between users. Putting the log at the device leaves the users themselves responsible for their own data, since only they can access it. From an implementation standpoint, this is a much simpler solution, and it could be argued that this is also the best solution at this point. If the program does not need the data, it should not put the users'

privacy at risk unnecessarily by storing it. This solution does although not allow the server room for analytics of log data. Sharing of data can although be done either through exports directly from the device or through the server on requests from the user. Log exports could be valuable for consultations with dietitians or doctors. Although a direct dump of the log into for example a pdf would hold some value, exporting data analyzed for connections between consumption, events and symptoms would be more valuable.

8.3 Fuzzy search

When an image is scanned through OCR for ingredients, there is no guarantee the scanned ingredient exists in the intolerance database. The ingredient might not exist at all, or the wording could be slightly different. Although an exact match might not exist, it is still valuable for the user to get some information if available. If for example, the image contains the ingredient "apple acid" and it does not exist in the database, the user should get information about apples in general. Although the intolerance/FODMAP values might differ, it will at least give a general pointer. Ingredient lists of products do from time to time include ingredients with a description. "Norwegian Salmon" is such an ingredient. Although "Norwegian salmon" does not exist in the database, salmon does. The OCR engine itself might also interpret the words in the image wrong, leading to spelling errors which would yield no match in the database. To handle these issues, fuzzy database searches are executed when checking the ingredient against the database. The fuzzy search finds any ingredient which matches the searched ingredient within a certain threshold. The threshold is by default 30%. The threshold could be fine-tuned for the search to yield optimal results. False positives will be given if the threshold is too low while false negatives will be given if the threshold is too high. As discussed, giving the user information about similar products is beneficial therefore the threshold must be kept low, although this will at times give the user false positives, meaning the users must manually check that the resulting ingredients are in fact what they are looking for. It is although preferred over not getting any information at all on misspelled ingredients.

8.4 OCR

The optical character recognition features accuracy, can for some users, make or break the app. The optical character recognition engine plays an important role in the usability of the feature. Multiple OCR engines have been tested for the purpose of scanning ingredient labels and handwritten lists. The engines

tested are Tesseract JS, Abby, and Google Cloud Vision.

8.4.1 Tesseract JS

Tesseract JS[1] was the first engine tested for the app. The engine is a pure JavaScript engine which is run directly on the mobile device of the user. This makes the client a little heavier but decreases the server load and the network use compared to sending the image to the server and having the server recognize the text. This solution can help prevent bottlenecks on the server. Tesseract JS is although a weak engine compared to industry standards, and would require heavy pre-processing to be remotely usable for the app, and is therefore not the choice for this project.

8.4.2 Abby

Abby[2] is an OCR cloud service which supports over 200 languages and multiple modes for recognizing data text, handwritten text, receipts, and more. A test was conducted for the use case for the app by uploading an image of an ingredient label with a colored, shiny background. The results from Abby was rather disappointing and judged not suitable for the use case.

8.4.3 Google Cloud Vision

Google Cloud Vision[3] is an OCR cloud service providing recognition for data text, handwritten text, labels, and more. Google was given the same test as Abby and yielded an acceptable result. Google Cloud Vision has also been tested for handwritten text recognition with excellent results. Based on the test results, Google Cloud Vision was chosen as the apps OCR engine. Since the OCR is located in the cloud, the client remains light, and the server is less easily congested. The image to be recognized is sent from the client to the server, which causes some network traffic. The client itself could send the image directly to Google, but the server holds Googles API key. If the API key was located on the client application, it could, in theory, be reached by clients and used for other purposes. Google Cloud Vision is a pay per request service, and as such, giving the user the API key could result in misuse, and high expenses for the developer.

1. https://tesseract.projectnaptha.com/
2. https://cloud.ocrsdk.com
3. https://cloud.google.com/vision/

8.5 Optimization

The app is at this point heavily depending on an internet connection. Before the user can take any actions the app checks if the user is logged in and if the JWT is valid, which itself is a network process, leaving the user locked out of the app until network connectivity is established. All of the app's functionality except for the log need internet for server communication, so even if users offline were allowed to pass the login phase, they would have quite limited functionality available.

Network utilization in the app can be improved. At this stage, all FODMAP/intolerance data is stored solely on the server, meaning the app must request the data each time the app launches. The request response is, to begin with, 150KB, but grows larger as users add additional tested food. To keep the app feeling responsive when adding a tested food, the full 150KB is requested once more to get the newly updated data. While this method leaves the user pleased in terms of user experience, it uses more network traffic. A solution would be to when submitting a tested food, receiving the tested food data in return, for the app to add to its existing list. This would although not update tested food other users have added, which would only have been received on the next app launch. Also this issue could be solved by utilizing the submitted foods timestamps, having the app hold a timestamp on the last update, and receiving all new updates from the last update until the current time when submitting a tested ingredient or changing the apps view to the list. This would likely be the best solution in terms of bettering network utilization while still keeping the app feeling responsive. Further lowering network usage could be achieved by saving the FODMAP/intolerance list locally between sessions, and utilize the discussed timestamp option to keep the list updated. This would also be a step in the direction of making more functionality available while offline.

Functionality such as the OCR ingredient scan, barcode scan, and the forum are at this point entirely dependent on internet connectivity. Product data requested from the barcode scan could, in theory, be stored locally on the device. Each barcode scan use around 2KB of network activity. An image exists for each product, but instead of sending actual images, only a URL to the image is sent, significantly reducing the network traffic from the server. For the app itself, it makes no difference, as the image must be downloaded from the URL, which is located on Matinfo's cloud. The entire current database of 18 500 products would use 2KB x 18 500 = 37 000KB, which roughly equals 37MB. If stored locally it could be updated through timestamps as discussed for the FODMAP/intolerance list.

8.6 Security

As it stands, the app is a test version, and does not take any measures to prevent attacks on the server, or prevent bloating or incorrect data from users. Although this hasn't caused any issues in the test phase, it can be more problematic at a production release stage. To reduce angles of attack, a few measures can be taken. Firstly the possibility to spam-register users can be limited by forcing the user to confirm an email address. The email address would have been deleted from the server as soon as the registration was completed to limit privacy concerns. Preventing bloating or incorrect data from users when adding a tested food or products to the databases is, from a software perspective, a difficult task. Advanced machine learning or artificial intelligence comes to mind and is way out of the scope of the project. This leaves us with manual solutions such as having administrators approve new products and tested foods. To still keep the app feeling responsive for the user adding the product, the new data can show on their device only, until approved by an admin. Another solution could be giving everyone the rights to either report incorrect data or delete data themselves. This solution works for Wikipedia, but giving users these admin right does itself allow for attacks and destruction of data.

Denial of service attacks is another threat the app at this point is not implemented to stop. This would although be reasonably simple to significantly reduce the effect of by forcing all operations against the database to be authorized through the users JWT. This would mean only people with a valid JWT, which should only be registered users, can successfully use the API. The attack would still slow down the server to some degree since the server must check for credentials, but it will be significantly less impactful than, for example requesting the FODMAP/intolerance database repeatedly. The attack can further be prevented by giving an IP which seems to be conducting an attack based on request frequency, a timeout.

8.7 Evaluation

The app provides a complete platform covering the needed functionality for a person with bowel dysfunctions such as IBS or general intolerances, which is at the time not available in the market. The app combines some of the best functionality from the app review and systematic review in addition to introducing new elements such as communication between peers and collaborating with peers to expand FODMAP knowledge. The platform is customizable for any intolerance or food-allergy by changing out the underlying intolerance database. Other available solutions in the market offer fractions of needed functionality, leaving the user stuck with multiple applications to fill some of

their needs. Since the different applications do not communicate, things such as connecting earlier experience from the log with checking for trigger foods can't exist.

In the beginning, the applications target group consisted of IBS, IBD, general intolerances, and food allergies alike, but throughout the project, it has become more apparent that persons with IBD need closer connections with health providers and substantially more complex logging than what is the case for IBS, general intolerances and food allergies. If a person with IBD is in addition following the low FODMAP diet, or in general need help controlling intake, the app can accommodate those needs, but it may not accommodate all the needs of the person.

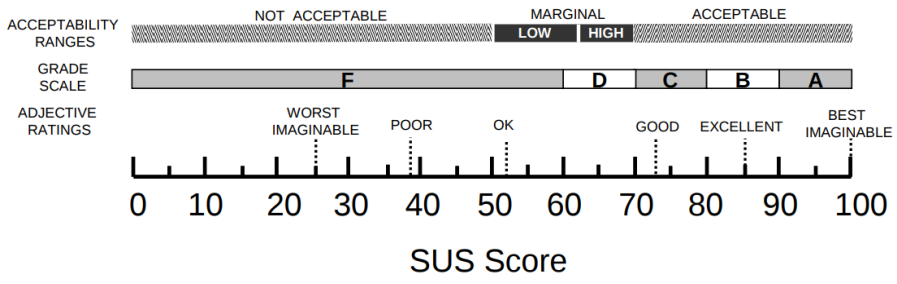


Figure 8.1: SUS score grading, [22]

The app received a SUS score of 85, and as displayed in figure 8.1, is considered an excellent score. The high score indicates that the application was deemed acceptably user friendly by the testers. The general feedback on the app and the project itself was positive. In relation to the applications requirements, all requirements are met on some level besides 16 and 17, which is addressed in the future work section. The usability of the features described in the requirements, although not perfect, has been given some level of confirmation through the user feedback. Based on the feedback there are still some areas of improvement, in particular when it comes to the logging feature.

We expressed the projects research problems in chapter 1. Based on the conducted work, we can now evaluate the results in relation to the problems.

Research problem 1: Which characteristics does a mobile application for simplifying the daily life of people with bowel dysfunctions, intolerances or food allergies need?

Simplicity, privacy, security, and usability are all characteristics needed to in a successful app for the purpose. Simplicity is a prerequisite for frequent

usage of the app, and especially the log. The primary purpose of the app is to simplify having a bowel dysfunction and following a complex medical diet. If the app falls short on simplicity or usability, the app provides little to no value and will doubtfully be used. The application has a high focus on simplicity and usability through minimizing the number of clicks needed for any operation and providing functionality such as OCR scanning for identifying trigger foods in ingredients and barcode scanning of products. These features alone are a significant contribution to the usability and simplicity of the app. Simplicity when logging is another important focus area of such apps which has been attempted solved by simple logging fields and sliders. Privacy is another characteristic important for this group of apps. These apps save sensitive patient data, which must be handled accordingly. The app solves this issue by saving all sensitive data locally on the users mobile device and allowing for creating unidentifiable users. The security characteristic is mainly a server-side issue affecting uptime and essentially boils down to usability.

Research problem 2: Which work has been done in the field, and which apps are available in the market?

There have been conducted studies which have presented similar applications, but they are mainly directed towards inflammatory bowel diseases. While apps for IBD have many similarities with apps for IBS they are not well suited for IBS patients due to the differences in disease behaviour. There are many relevant mobile applications available for people following the low-FODMAP diet, which is often the case of IBS patients, but also includes some IBD patient. These apps provide functionality such as FODMAP lists, FODMAP information, log for meals, events and symptoms and log analysis. A few apps include barcode scanning of products and the use of optical character recognition funcitonality to retrieve trigger food information. A problem with these apps are that although most of the functionality needed for the patients is available, there's no one app that has it all.

Research problem 3: Which functionality is needed to help the target group with their daily challenges?

Through reviewing papers on the subject, relevant mobile apps, and consulting with the target group, needed functionality in a mobile-app has been mapped. Needed functionality discovered consist of FODMAP/intolerance overview, controlling food intake for trigger foods through optical character recognition and barcode scanning, a system for logging relevant factors such as meals, stress, symptoms and bowel movements, log analysis, as well as a communication platform for connecting peers and establishing motivation groups.

Research problem 4: How is the application described and implemented in this thesis received by the target group?

The project designed and implemented a complete platform for people with bowel dysfunctions, intolerances, or food allergies containing functionality needed on a daily basis. The functionality included controlling food intake for trigger foods through optical character recognition and barcode scanning, a system for logging relevant factors, as well as a communication platform for connecting peers. The app received a system usability score of 85/100. 75% of the questionnaire responders thought the application greatly simplified following the low-FODMAP diet.

9

Future work

9.1 Personalizing

9.1.1 Customizing intolerance's

Adding multiple choices for customizing the app for different intolerances and allergies would make the app better suit the needs of each individual.

9.1.2 Private lists and notes

At this point, all user tested ingredients are stored in a database available for all users. A separate list owned by each one user could, in addition, be added. This would better personalize the app for each user. Also, the ability to add notes on ingredients and products could be included. Notes could include information on symptoms gained from consuming the food, or measurements on how much of this food can be consumed by the individual before symptoms are gained.

9.2 Forum

9.2.1 Forum Notifications

Receiving a notification when someone replies to your post is expected from the users' point of view. This is although a significantly more complex problem than log notifications. Log notifications are sent to the device from within the same device. Forum notifications must be controlled at the server side. When a reply to a post is sent to the server, the server must figure out which users need a notification concerning the post. The server must then figure out which devices these users use and send the notification directly to the device. This notification is handled by the mobile device itself and not the app. Therefore a third-party service must be used to reach the mobile devices. Services such as firebase can handle this interaction, but it needs information from the server on which hardware IDs each device has. This must be gathered at user registration.

9.2.2 Involving medical personnel

For many apps, especially those made for diseases such as Chron's and Ulcerative colitis, a direct connection with a health provider is a strongly desired functionality. Although this app is directed mainly at less severe conditions such as IBS or intolerances/food allergies in general, the feature would still add some value. This feature could be solved in a multiple of ways, but perhaps the simplest way would be having a category in the forum for asking questions to medical personnel, and having medical personnel answering these questions. This could introduce privacy issues, and so the questions asked could only be general questions, and not specific to a user. Another solution would be linking the app directly up to the users' clinics, but this would require middleware that should be developed at a regional or national level.

9.2.3 Motivation groups

Having a bowel dysfunction or any other disease can leave you feeling alone. In some cases, the issues can cause significant problems in the daily life of a person, to a degree where the person isolates themselves from society. Some quit their studies or jobs and starts studying or working from home. Having issues with the body can easily lead to psychological challenges such as anxiety and depression. Having someone to talk to with the same problems as you can significantly relieve some of this pressure. Having a forum where everyone can talk to everyone helps in this regard, but there are limits on how tight bonds people can form over such a platform. Enabling smaller motivation groups

would give the users a possibility to talk to other people who themselves are interested in close connections and deeper conversation than what is usually the case in open forums.

9.3 Log

9.3.1 Log analysis

To aid the users in figuring out which factors play into their well being the log could be analyzed. This could be solved through pattern recognition, resulting in a graph showing the user a clear connection between which meals give symptoms, but also how sleep, exercise, stress, and medications affect their health. This would be valuable information that the users can use to adapt their choices for better disease management. For this analysis to be accurate, it would require accurate and comprehensive logging from the user.

9.3.2 Displaying past experience when checking for triggers

A significant factor in the health of a person with a digestive dysfunction is the food. Ideally, the previously logged results from food intake should be presented to the user when the user checks foods for known triggers. This could be done simply through showing the user the last few occasions in the log the food was ingested, leaving it up to the user to read their own log entries concerning the food in question. Another solution could be to use the log analysis to present the likelihood the user has of getting symptoms from the food.

9.3.3 Requested features

Some improvements were requested by the users that participated in the test phase. Updating log entries is a requested feature that could be implemented, and would require little effort since adding and deleting entries exist already. Free text fields in all entries is another requested feature which would be beneficial for users. This would allow writing personal notes and give information which is not sufficiently covered in the current entry fields. Lastly, being able to postpone adding end time to entries would be beneficial, since end time is not known if the user logs an event while it's occurring.

9.4 Data updates

It can be difficult to enjoy an app with outdated and non-relevant data. Data on products and FODMAPs are always evolving, making it a clear benefit to keep up.

9.4.1 FODMAP data

FODMAP data is always developing through research and analysis. Always having the newest data in the application would increase the reliability of the data and in general increase the usability of the app. Implementing this would require cooperation with a FODMAP data provider such as Monash University.

9.4.2 Product data

Product data is collected through an API from Matinfo.no. The product data on Matinfo is changing and expanding daily. When a product change in any way or form its barcode changes. This means when a product, for example, changes its packaging, although the ingredients are the same, trying to scan the barcode of the changed product would result in a miss in the database. This also means that if a product changes its ingredients, scanning the barcode results in a miss, which is the desired behavior. Having the database be updated with the newest product data would remove or, depending on how often and how fast after product change the product data at Matinfo is updated, at least limit these misses as well as adding new products and removing any which no longer are valid. Creating a script updating the product data periodically would handle updates to the product data. The code importing the initial data from Matinfo already solves many of the challenges this script would encounter.

9.5 Supporting multiple languages

The app is created for Norwegians and does as such support Norwegian ingredients and products. The app, at its current state, does although do little for Norwegians when traveling in terms of trigger food control. Eating out while traveling can be a particularly stressful scenario for a person with bowel dysfunctions or food allergies, so solving this issue would be of great value. The implemented app already utilize the Google cloud API, which also indlude the Google translate engine. Translating any text that comes from the OCR engine is therefore quite straight forward. This does not require any

user interface changes, as Google translate can efficiently recognize languages received.

10

Concluding remarks

This project has designed and developed a mobile application providing needed functionality for people with bowel dysfunctions, intolerances, and food allergies. Decisions taken regarding design and functionality has been based on reviews of relevant literature and applications. People following the low-FODMAP diet has also been consulted. The application provides functionality such as optical character recognition to identify potential trigger foods, barcode scanning of food products, which gives nutritional and intolerance information, a log to track meals, events during the day, and symptoms, as well as a communication platform for connecting with peers. Through cooperating with the national federation against bowel diseases, the app has been forwarded to the target group for testing. Through a questionnaire issued to the testers, the application gained a system usability score of 85. Of the questionnaire responders, 75% Thought the application would significantly simplify the process of following the low-FODMAP diet.

The application provides functionality which can simplify often challenging lives. Using the apps intended functionality can better the health of the users by aiding in reducing trigger food intake, finding patterns through log analysis and aiding their mental state through communication with peers and motivation groups. Having the ability to simplify the process of cooking by family and friends takes a psychological burden of the shoulders of people who often have enough having to deal with their dysfunction. Lastly, the app might help others understand the challenges of having complex medical diets, intolerances, or bowel dysfunctions, which might aid in removing the stigma surrounding bowel

problems in general.

References

[1] J. Brooke, "SUS - A quick and dirty usability scale," en, p. 7,

[2] D. Moher, A. Liberati, J. Tetzlaff, D. G. Altman, and The PRISMA Group, "Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement," en, *PLoS Medicine*, vol. 6, no. 7, e1000097, Jul. 2009, ISSN: 1549-1676. DOI: 10.1371/journal.pmed.1000097. [Online]. Available: https://dx.plos.org/10.1371/journal.pmed.1000097 (visited on 05/22/2019).

[3] M. W. Wong, Q. Ye, Y. K. Chan Kylar, W.-M. Pang, and K. C. Kwan, "A Mobile Adviser of Healthy Eating by Reading Ingredient Labels," en, in *Wireless Mobile Communication and Healthcare*, P. Perego, G. Andreoni, and G. Rizzo, Eds., vol. 192, Cham: Springer International Publishing, 2017, pp. 29–37, ISBN: 978-3-319-58876-6 978-3-319-58877-3. DOI: 10.1007/978-3-319-58877-3_4. [Online]. Available: http://link.springer.com/10.1007/978-3-319-58877-3_4 (visited on 05/06/2019).

[4] Albert Parra Pozo, A. W. Haddad, M. Boutin, and E. J. Delp, "A handheld multimedia translation and interpretation system for diet management," en, in *2011 IEEE International Conference on Multimedia and Expo*, Barcelona, Spain: IEEE, Jul. 2011, pp. 1–6, ISBN: 978-1-61284-348-3. DOI: 10.1109/ICME.2011.6012229. [Online]. Available: http://ieeexplore.ieee.org/document/6012229/ (visited on 05/06/2019).

[5] K. Henricksen and S. Viller, "Design of software to support families with food-allergic and food-intolerant children," en, in *Proceedings of the 24th Australian Computer-Human Interaction Conference on - OzCHI '12*, Melbourne, Australia: ACM Press, 2012, pp. 194–203, ISBN: 978-1-4503-1438-1. DOI: 10.1145/2414536.2414571. [Online]. Available: http://dl.acm.org/citation.cfm?doid=2414536.2414571 (visited on 05/06/2019).

[6] Z. Mujagic, C. Leue, L. Vork, R. Lousberg, D. M. A. E. Jonkers, D. Keszthelyi, M. A. Hesselink, T. J. C. van Schagen, J. van Os, A. A. M. Masclee, and J. W. Kruimel, "The Experience Sampling Method - a new digital tool for momentary symptom assessment in IBS: An exploratory study," en, *Neurogastroenterology & Motility*, vol. 27, no. 9, pp. 1295–1302, Sep.

2015, ISSN: 13501925. DOI: 10.1111/nmo.12624. [Online]. Available: http://doi.wiley.com/10.1111/nmo.12624 (visited on 05/06/2019).

[7] J. Ahn, J. Williamson, M. Gartrell, R. Han, Q. Lv, and S. Mishra, "Supporting Healthy Grocery Shopping via Mobile Augmented Reality," en, *ACM Transactions on Multimedia Computing, Communications, and Applications*, vol. 12, no. 1s, pp. 1–24, Oct. 2015, ISSN: 15516857. DOI: 10.1145/2808207. [Online]. Available: http://dl.acm.org/citation.cfm?doid=2837676.2808207 (visited on 05/06/2019).

[8] S. Konrad, S. Alicja, P. Anna, and B. Krzysztof, "PancreApp: An Innovative Approach to Computational Individualization of Nutritional Therapy in Chronic Gastrointestinal Disorders," en, *Studies in Health Technology and Informatics*, pp. 325–328, 2015, ISSN: 0926-9630. DOI: 10.3233/978-1-61499-564-7-325. [Online]. Available: http://www.medra.org/servlet/aliasResolver?alias=iospressISBN&isbn=978-1-61499-563-0&spage=325&doi=10.3233/978-1-61499-564-7-325 (visited on 05/06/2019).

[9] R. Karkar, J. Zia, R. Vilardaga, S. R. Mishra, J. Fogarty, S. A. Munson, and J. A. Kientz, "A framework for self-experimentation in personalized health," en, *Journal of the American Medical Informatics Association*, vol. 23, no. 3, pp. 440–448, May 2016, ISSN: 1067-5027, 1527-974X. DOI: 10.1093/jamia/ocv150. [Online]. Available: https://academic.oup.com/jamia/article-lookup/doi/10.1093/jamia/ocv150 (visited on 05/06/2019).

[10] W. K. Van Deen, A. E. van der Meulen-de Jong, N. K. Parekh, E. Kane, A. Zand, C. A. DiNicola, L. Hall, E. K. Inserra, J. M. Choi, C. Y. Ha, E. Esrailian, M. G. van Oijen, and D. W. Hommes, "Development and Validation of an Inflammatory Bowel Diseases Monitoring Index for Use With Mobile Health Technologies," en, *Clinical Gastroenterology and Hepatology*, vol. 14, no. 12, 1742–1750.e7, Dec. 2016, ISSN: 15423565. DOI: 10.1016/j.cgh.2015.10.035. [Online]. Available: https://linkinghub.elsevier.com/retrieve/pii/S1542356515015463 (visited on 05/06/2019).

[11] D. V. Ankersen, P. Weimers, and J. Burisch, "Whats 'App-ening': The help of new technologies in nutrition in digestive diseases," en, *Current Opinion in Clinical Nutrition and Metabolic Care*, vol. 20, no. 5, pp. 426–431, Sep. 2017, ISSN: 1363-1950. DOI: 10.1097/MCO.0000000000000399. [Online]. Available: http://Insights.ovid.com/crossref?an=00075197-201709000-00020 (visited on 05/06/2019).

[12] D. Con, B. Jackson, K. Gray, and P. De Cruz, "eHealth for inflammatory bowel disease self-management – the patient perspective," en, *Scandinavian Journal of Gastroenterology*, pp. 1–8, Jun. 2017, ISSN: 0036-5521, 1502-7708. DOI: 10.1080/00365521.2017.1333625. [Online]. Available: https://www.tandfonline.com/doi/full/10.1080/00365521.2017.1333625 (visited on 05/06/2019).

[13] P. Bossuyt, L. Pouillon, G. Bonnaud, S. Danese, and L. Peyrin-Biroulet, "E-health in inflammatory bowel diseases: More challenges than opportunities?" en, *Digestive and Liver Disease*, vol. 49, no. 12, pp. 1320–1326, Dec. 2017, ISSN: 15908658. DOI: 10.1016/j.dld.2017.08.026. [Online]. Available: https://linkinghub.elsevier.com/retrieve/pii/S1590865817310344 (visited on 05/06/2019).

[14] M. Kelso and L. A. Feagins, "Can Smartphones Help Deliver Smarter Care for Patients With Inflammatory Bowel Disease?" en, *Inflammatory Bowel Diseases*, vol. 24, no. 7, pp. 1453–1459, Jun. 2018, ISSN: 1078-0998, 1536-4844. DOI: 10.1093/ibd/izy162. [Online]. Available: https://academic.oup.com/ibdjournal/article/24/7/1453/5032595 (visited on 05/06/2019).

[15] B. C. Helsel, J. E. Williams, K. Lawson, J. Liang, and J. Markowitz, "Telemedicine and Mobile Health Technology Are Effective in the Management of Digestive Diseases: A Systematic Review," en, *Digestive Diseases and Sciences*, vol. 63, no. 6, pp. 1392–1408, Jun. 2018, ISSN: 0163-2116, 1573-2568. DOI: 10.1007/s10620-018-5054-z. [Online]. Available: http://link.springer.com/10.1007/s10620-018-5054-z (visited on 05/06/2019).

[16] W. Szeto, A. van der Bent, C. R. Petty, J. Reich, F. Farraye, and L. N. Fishman, "Use of Social Media for Health-Related Tasks by Adolescents With Inflammatory Bowel Disease: A Step in the Pathway of Transition," en, *Inflammatory Bowel Diseases*, vol. 24, no. 6, pp. 1114–1122, May 2018, ISSN: 1078-0998, 1536-4844. DOI: 10.1093/ibd/izy021. [Online]. Available: https://academic.oup.com/ibdjournal/article/24/6/1114/4999354 (visited on 05/06/2019).

[17] M. de Jong, A. van der Meulen-de Jong, M. Romberg-Camps, J. Degens, M. Becx, T. Markus, H. Tomlow, M. Cilissen, N. Ipenburg, M. Verwey, L. Colautti-Duijsens, W. Hameeteman, A. Masclee, D. Jonkers, and M. Pierik, "Development and Feasibility Study of a Telemedicine Tool for All Patients with IBD: MyIBDcoach," en, *Inflammatory Bowel Diseases*, vol. 23, no. 4, pp. 485–493, Apr. 2017, ISSN: 1078-0998. DOI: 10.1097/MIB.0000000000001034. [Online]. Available: https://academic.oup.com/ibdjournal/article/23/4/485-493/4560719 (visited on 05/06/2019).

[18] J. Brooke, "Sus: A retrospective," *Journal of usability studies*, vol. 8, no. 2, pp. 29–40, 2013.

[19] S. Robertson and J. Robertson, *Mastering the requirements process*, eng, ser. ACM Press books. New York, NY: ACM Press, 1999, OCLC: 833551226, ISBN: 978-0-201-36046-2.

[20] W. Wong, *Principles of color design: designing with Electronic Color*, eng, 2nd ed., [Nachdr.] New York, NY: Wiley, 1997, OCLC: 248920848, ISBN: 978-0-471-28708-7.

[21] S. L. Peters, C. K. Yao, H. Philpott, G. W. Yelland, J. G. Muir, and P. R. Gibson, "Randomised clinical trial: The efficacy of gut-directed hypnother-

apy is similar to that of the low FODMAP diet for the treatment of irritable bowel syndrome," en, *Alimentary Pharmacology & Therapeutics*, vol. 44, no. 5, pp. 447–459, Sep. 2016, ISSN: 02692813. DOI: 10.1111/apt.13706. [Online]. Available: http://doi.wiley.com/10.1111/apt.13706 (visited on 05/29/2019).

[22] A. Bangor, "Determining What Individual SUS Scores Mean: Adding an Adjective Rating Scale," en, vol. 4, no. 3, p. 10, 2009.

Appendices

A

User doc

The following app documentation was presented in the app at the first time starting up, and also available at any point from within the app.

A.1 Intro

Denne introduksjonen gir nødvendig informasjon og tar deg gjennom hvordan appen brukes. Du vil bli bedt om å registrere bruker. Dette for å kunne gi deg et brukernavn på appens diskusjonsforum. Dersom du ikke ønsker å bli gjenkjent i forumet, lag et brukernavn som ikke kan knyttes til deg. Applikasjonen er utvilket av Tobias Borgen Olsen ved Universitetet i Tromsø - Norges arktiske universitet. Applikasjonen er utviklet i anledning mastergradsoppgave som omhandler tekniske hjelpemidler for mennesker med intoleranser og/eller mage/tarm problemer.

A.2 FODMAP oversikt

Oversikten gir deg enkel tilgang til analyserte matvarer og deres FODMAP verdier. Listen kan søkes gjennom ved å skrive i søkefeltet (separer ord med komma) eller ved å ta bilde av tekst ved å trykke på kamera ikonet. Kameraet kan være fin å bruke for å sjekke oppskrifter, innholdsdeklarasjoner eller lister skrevet på maskin eller for hånd. Ved å trykke på + ikonet kan man legge til matvarer som ikke har vært analysert.

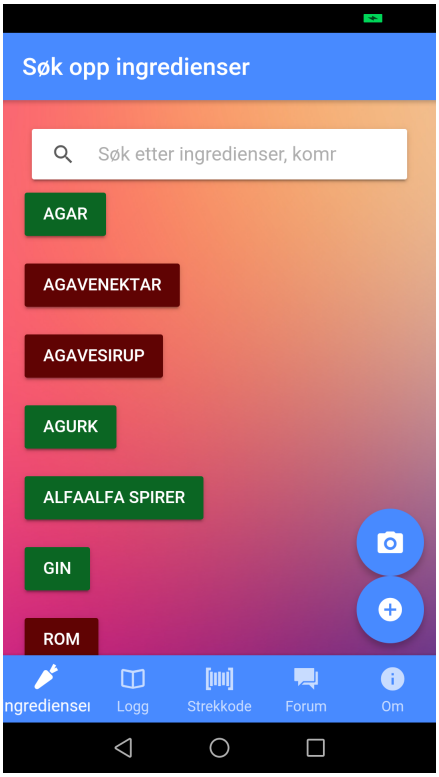


Figure A.1: Introduction

A.3 Hvordan forstå oversikten?

Oversikten følger trafikklys-systemet, grønne matvarer er lav-FODMAP, oransje matvarer er moderat FODMAP og røde matvarer er høy FODMAP. Trykk på ønsket matvare i oversikten for mere informasjon om mengder, kommentarer og FODMAP verdier.

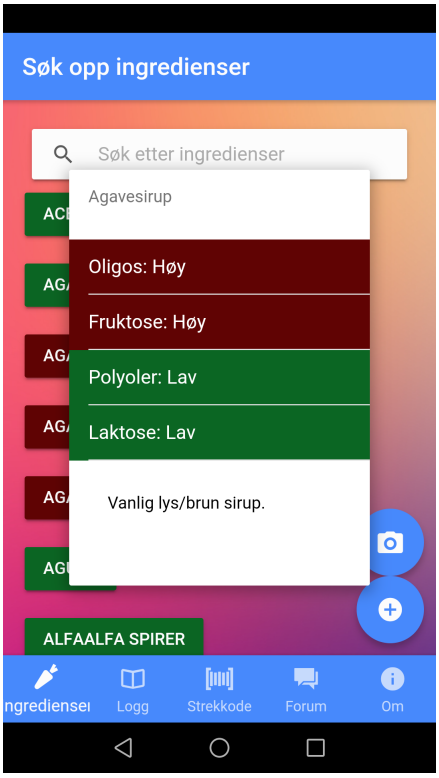


Figure A.2: Overview

A.4 Matvarer med forskjellige varianter

Noen matvarer har forskjellige FODMAP verdier basert på hvilken variant av matvaren det er snakk om. Disse matvarene er merket med blått. Trykk på matvaren for å få ytterligere informasjon.

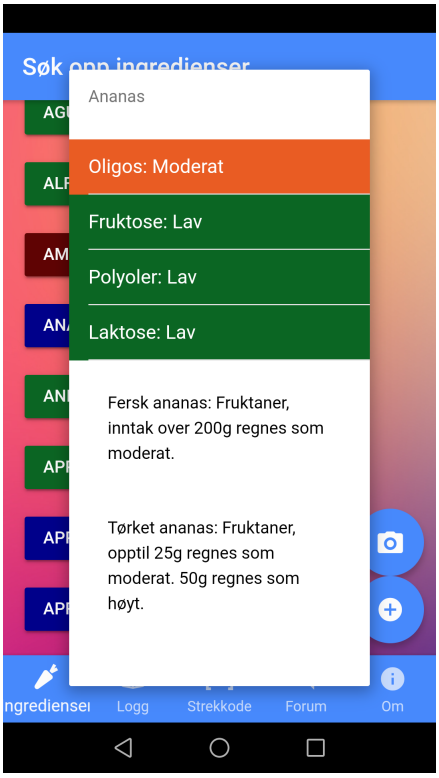


Figure A.3: Multiple variants

A.5 Legg til matvare

Her kan man legge til matvarer som ikke har vært til analyse. Oversikten over ikke analyserte matvarer er tilgjengelig for alle som bruker appen. Oversikten bygges opp ved at alle som har prøvd en spesifikk matvare gir tilbakemelding på om matvaren ga symptomer eller ikke. På denne måten kan vi sammen utforske ny mat.

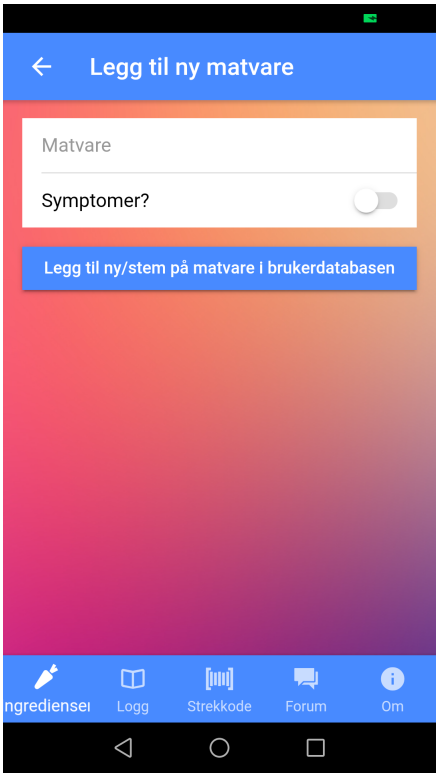


Figure A.4: Adding non-analyzed food

A.6 Hvordan finne ikke analyserte matvarer?

Matvarer som har blitt lagt til av brukere har gjennomsiktige bokser med farget ramme i FODMAP oversikten. Fargen på rammen er basert på hvor stor andel av brukere som har rapportert symptomer på matvaren. For ytterligere informasjon, trykk på matvaren.

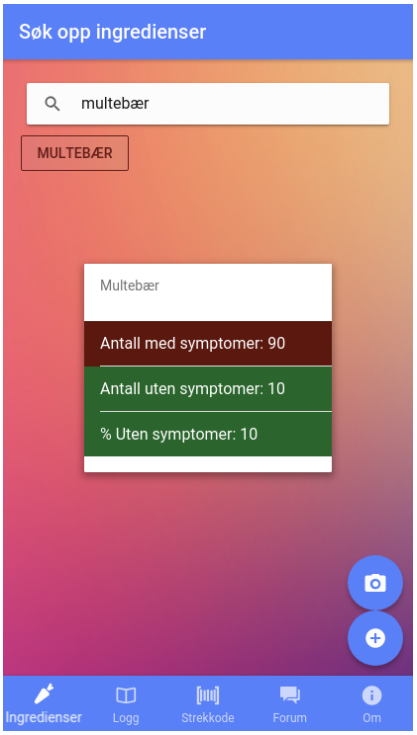


Figure A.5: Finding non-analyzed food

A.7 Hvordan benytte kamera?

Trykk på kameraikonet og ta bilde av listen av matvarer du vil kontrollere. Appen kontrollerer alle ord på bildet, og vil fungere best dersom kun ordene du vil kontrollere er på bildet. Resultatene vil vises i FODMAP oversikten. Sorte ord har ikke fått noe treff i appen. Applikasjonen prøver alltid å finne nøyaktig eller lignende ingrediens av det som står på bildet. Søker du etter en ingrediens som ikke eksisterer i appen vil appen forsøke å gi deg relevante treff. Søker du for eksempel etter eplesyre, og eplesyre ikke er analysert vil appen vise informasjon om eple. Dette betyr at resultatet må sjekkes mot ingrediens-listen manuelt.

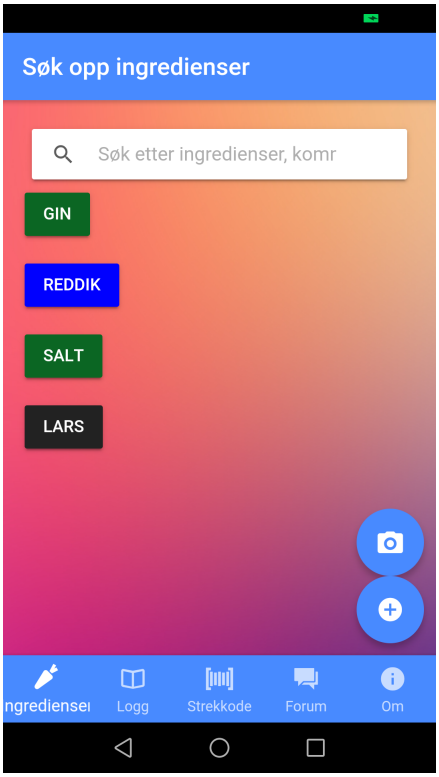


Figure A.6: Utilizing the camera for the OCR feature

A.8 Hvordan fungerer loggen?

Viktig info: Alt du loggfører er lagret lokalt på din telefon. Det betyr at det utelukkende er du som har tilgang til det du loggfører. I loggen vises alle loggførte hendelser. Måltider, medisiner, symptomer og tarmbevegelser er noen av disse. Du kan endre hvilken dag som vises gjennom å dra mot høyre eller venstre, eller å velge spesifikk dato oppe i venstre hjørne. Ved å trykke på + ikonet kan man legge til en ny hendelse.

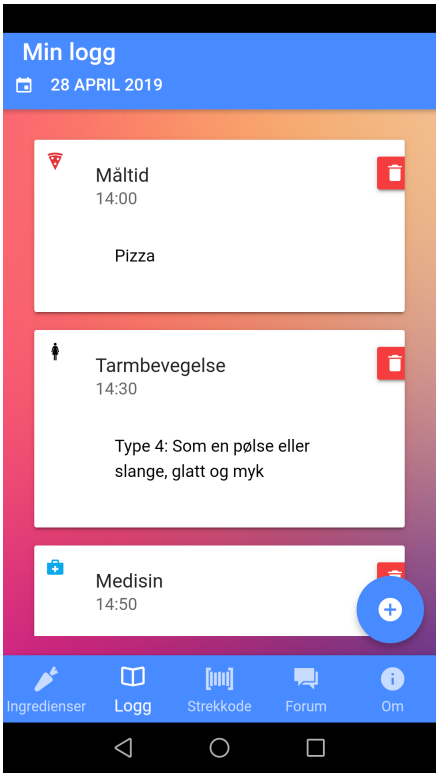


Figure A.7: Log

A.9 Hva kan loggføres?

Mat, medisiner, søvn, trening, stress, symptomer og tarmbevegelser kan loggføres. Klikk på hendelsen du ønsker å loggføre.

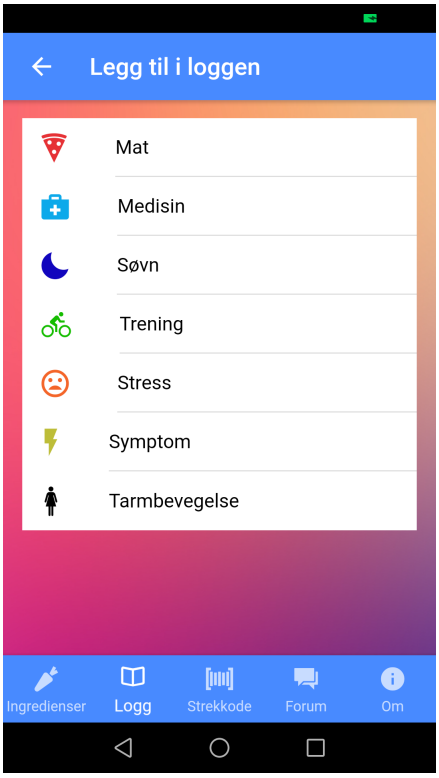


Figure A.8: What can be logged?

A.10 Hvordan loggføre?

Fyll inn feltene, spesifiser klokkeslett og legg til!

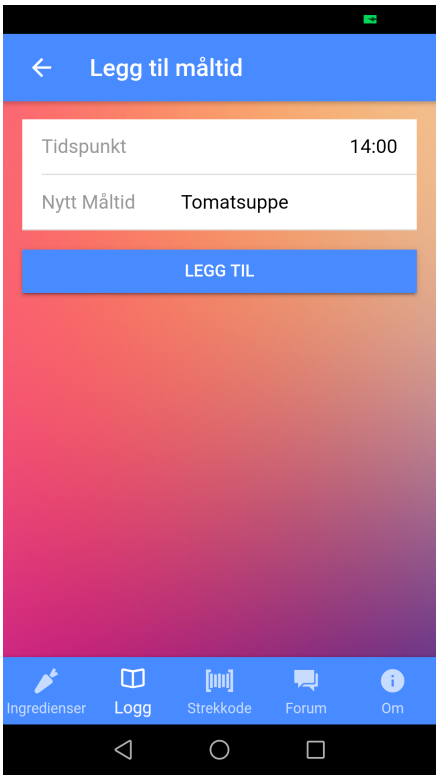


Figure A.9: How to log

A.11 Hvorfor loggføre?

Loggføring vil kunne gi deg nyttig informasjon angående hvilken mat og hendelser som gir deg symptomer. Jo nøyere du loggfører jo mere informasjon har du å jobbe med. For å hjelpe på vei vil det bli gitt varsel 1 time etter et måltid er loggført, for å påminne om å logge eventuelle symptomer.

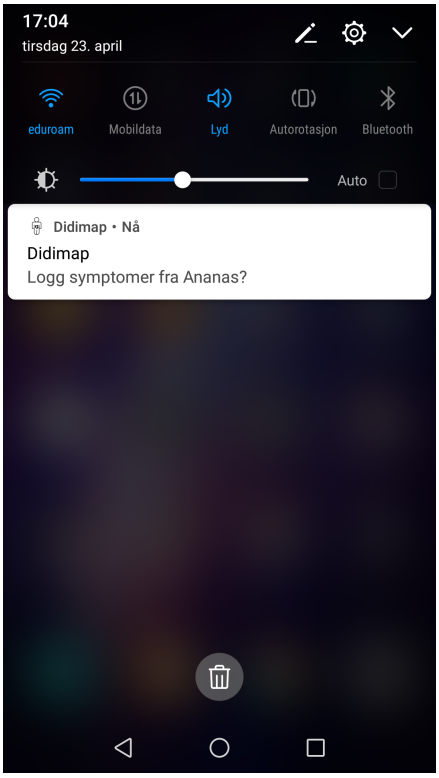


Figure A.10: Why log?

A.12 Hvordan benytte strekkode skanner?

Søk blant over 18 500 matprodukter funnet i norske butikker ved å skanne strekkoden til produktet. Dersom du ikke finner produktet kan du legge det til.

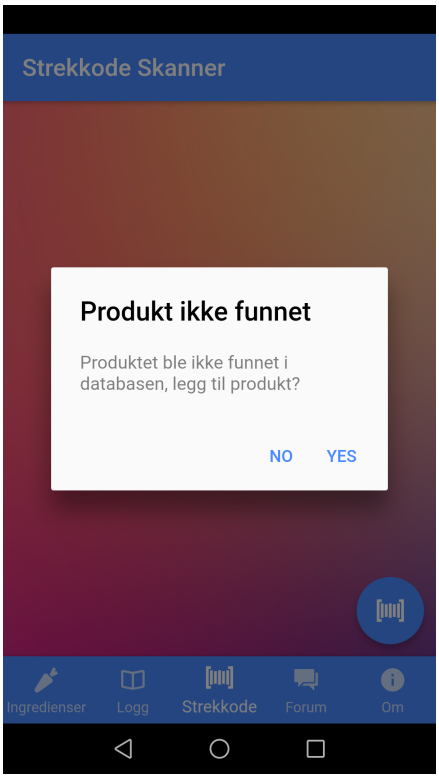


Figure A.11: How to utilize barcode scanner

A.13 Hvordan legge til produkt?

Fyll inn navn på produkt, produsent og ingredienser, ta et bilde og legg til! Produktet er søkbart umiddelbart, søk igjen på produktet for å få frem informasjon om ingrediensene.

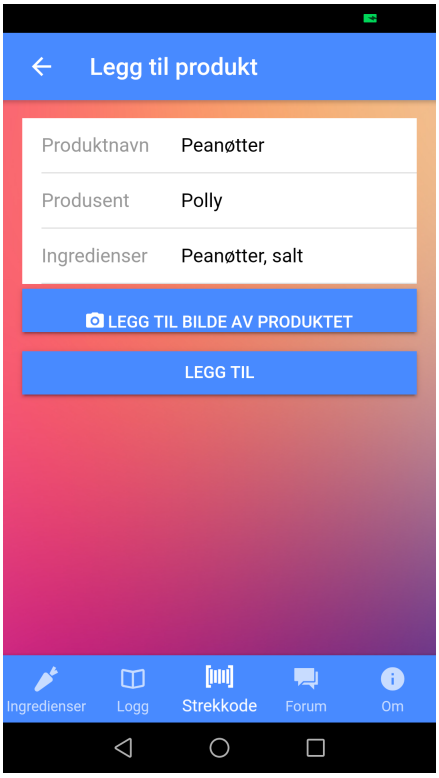


Figure A.12: Adding a product

A.14 Forum

På forumet kan man nå likemennesker ved å skrive innlegg blant annet innenfor kategoriene tips, spørsmål og oppskrifter. Dersom du har en dårlig dag og ønsker å skrive om dine utfordringer så finnes også en kategori for dette. I kategorien kontakt utvikler kan du komme med ønsker om funksjoner og lignende i applikasjonen. Velg kategori og legg ut ditt innlegg.

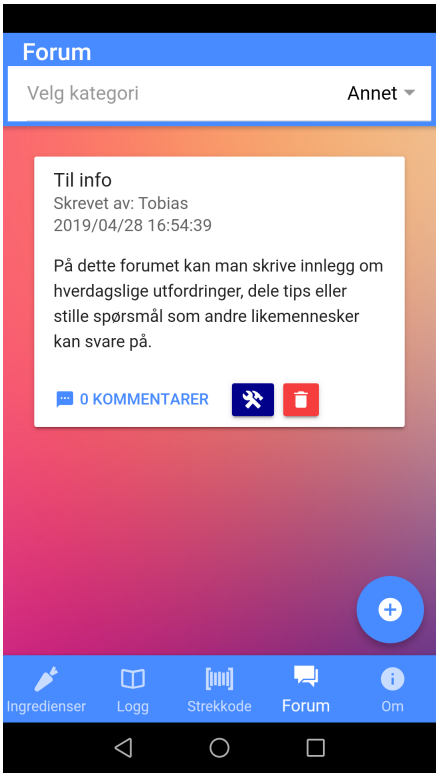


Figure A.13: Forum