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A web-based tool to calculate the health profile during the innovation process of new food products

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OSLOMET

Preface

Software development is a passion for me. I always try to enrich my skills by learning new technologies during my spare time. As a food lover, I always have extra curiosity about different food products. I feel fortunate to get both of my interests together. Technology helps people to make their life easier. This calculator will help the food clusters to do the nutrition calculations easily. This thesis lets me explore the health profile calculation in the new food product innovation process. I believe that my work will impact the new food innovation process.

Without my supervisors and their immense support, Way Kiat Bong, Ida Synnøve Grini, and Vibeke Telle-Hansen, this journey would not be smooth and fun. Countless thanks to Way Kiat Bong for believing in me; I was lucky to have you as one of my supervisors. He helped me finish my thesis by giving extra support and guidance and pushed me to do well academically. Also, many thanks to my other fellow group member, Karin Doan, and all the participants that participated in the development process and were willing to spend their valuable time testing and adding their opinions to the web-based calculator. Lastly, I like to thank my parents for supporting me and loving me. Special thanks to my son for being my motivation and inspiration. Thank you all for your support.

Oslo, May 14th, 2022

Faisal Ahmed

Abstract

Food is a basic need in our daily life, and this is why we need to consume healthy foods. Fremtidsmat is a Norwegian food cluster for food and beverage producers, research institutes, and knowledge companies to develop healthy food and beverages. To make the food product innovation process healthier, the web-based calculator helps to check the nutrition values if meeting "Nøkkelhullet" guidelines.

These guidelines aim to facilitate the development of healthy food and beverages in member companies that do not have employees with nutrition competence and increase the process's efficiency. To do so, the Nøkkelhullet guidelines translated into a user-friendly web-based calculator. The aim is to explore how a user-friendly web calculator contributes to making healthier food products. Also, how to make this tool user-friendly and accessible to as many members of Fremtidsmat as possible.

The web-based calculator used the User-Centered Design (UCD) approach. The UCD approach helps to understand the user requirements during the development process. The web-based calculator is built using the React.js front-end framework. Several dependencies are used like node.js, npm, Bootstrap, Font Awesome, and Material UI. Different dependencies are used to achieve various functionalities of the tool. The WAVE accessibility checker tool is used for solving accessibility issues.

The development process is done in four iterations. Before and after each iteration, user testing and user feedback are conducted to understand the user requirements and make changes accordingly. This process helps to make the tool user-friendly and accessible. User-friendliness, accessibility, and responsiveness of the calculator will help the users of Fremtidsmat to use this tool more often. The tool also provides the users with a digital platform, so they do not need to check the guidelines manually. However, there are some limitations in the development because of limited time restrictions. Only three food types are functional to check Nøkkelhullet guidelines.

By developing this user-friendly and accessible web-based calculator where the functionality is linked to the Nøkkelhullet guidelines, the concept of healthier food production will be improved among the companies. In the future, the tool can include all the food types for Nøkkelhullet and European Food Safety Authority guidelines.

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Chapter 1: Introduction

The population is increasing rapidly worldwide, and food consumers are also growing, making different countries concerned about food sustainability and the reserve for future generations (Smith et al., 2000). United Nations (UN) statistics show that the population will increase to 8.5 billion in 2030 (United Nations, n.d.). Developed countries are working in different ways to find a suitable and healthy solution for food production processes so that people can have what they need by making less waste. For example, New Zealand introduces a database for food composition to assess the nutrition intake of its population (Sivakumaran et al., 2018). The United Kingdom also created a website called "nutritools" to improve nutritional epidemiology research (Hooson et al., 2019).

Fremtidsmat (www.fremtidsmat.no) is a Norwegian-based food cluster that helps different small to big food producers to produce healthy and balanced food for the people (Forside – Fremtidsmat, n.d.). They are continuously working with various researchers and food manufacturers to develop a sustainable and healthy food production process so that people will eat healthily and remain healthy. The purpose of Fremtidsmat is to give guidance to make more nutritious food that is healthier for the health. For this reason, Fremtidsmat wants to have a web-based calculator to check food nutrition values.

This calculator will show the results in terms of "Nøkkelhullet" guidelines after getting the data from a user (Lovdata, 2015). It reduces the effort to go through all the guidelines and manually check the requirements. To help the clusters of all sizes, the procedures can be created digitally to make it easier for all the food production clusters to achieve the needed food nutrition values to start producing a new product or an existing product more efficiently. There are a few different guidelines for food nutrition. Due to limited time and resources in this short thesis, we only focus on "Nøkkelhullet" guidelines. The web-based calculator is going to make the food nutrition checking process digital.

This web-based calculator is a tool for the clusters in their food innovation process, designed in a user-friendly and accessible way so that one will get the desired result within a few steps. The tool is like a simple form where the user needs to put different nutrition values and press a button to check if meeting Nøkkelhullet. It is difficult for the food production industry to follow up with everything because of different types of resource limitations. To be more detailed, easy to find the nutrition guidelines for a specified

category of products for all clusters, which reduces the gap in producing healthy and tasty foods. The calculator will be a tool for the food innovation process to get the exact nutrient values that will be easy to access and time-efficient. As the data provided in the tool is collected from the Norwegian dietary recommendations "Nøkkelhullet" for now and the guidelines set by the European Food Safety Authority (EFSA), it is safe to follow and proven. We aim to explore how a user-friendly web calculator contributes to making healthier food products. Also, how to make this tool user-friendly and accessible to as many members of Fremtidsmat as possible.

Another concern is to have a user-friendly website. There is a lack of understanding of the need to make a website accessible in terms of its diverse group of users, following some internationally set of guidelines to increase accessibility. This website has followed the guidelines of Website Content Accessibility Guidelines (WCAG) to make it accessible and user friendly for all the users, including different kinds of challenged people where they can easily navigate using their assistive devices so that the tool will be helpful for most of the people without any limitations (Initiative, 2021a). One example is the color contrast of the website considered according to the WCAG.

1.1 Ethical Considerations

This short thesis is about developing a prototype to calculate the new health profiles during the recent food innovation process according to the Nøkkelhullet guidelines for Fremtidsmat, so some ethical considerations need to be followed and maintained. I used confidential food data and copyright to Fremtidsmat and its other cluster to develop the prototype. So, before starting the thesis work, I have signed the transfer declaration, which states the copyrights and confidentialities that need to be followed. OsloMet owns the patents, data, and any development related to this thesis. According to the agreement, as an author, I shall not have the right to disclose any confidentiality with any other party and no right to sell but has the right to publish my work in a conference or journal by getting acknowledgment from OsloMet. Besides all these, OsloMet has the right to transfer the developed prototype to a third party, and they have the right to develop further and use the patents introduced in this thesis. As in this thesis, the focus was only on developing the prototype, so there were few ethical issues. According to the transfer declaration contract, if any uncertainty arises, it will be solved through negotiation with both parties. I can also

help OsloMet in the future if they need help to modify, develop, or reuse this developed prototype.

Chapter 2: Literature Review

2.1 Nutrition-related digital tools

Some existing tools with a few similarities, like the web-based calculator, are aimed for different purposes. Food is a daily necessity for everyday life, and there are many issues from production to consumption that researchers are continuously trying to solve. Some digital tools related to food and nutrition have been found. The purpose of these tools and usages are discussed briefly in this section. Researching existing solutions is to find out if any similar current solution is already done and how the answers add value.

A review by Hooson et al. (2019) has been done to find out the authentic UK dietary assessment tools and put the information of the study into a website www.nutritools.org to help the other researchers to find out the solutions to their research work easily from one platform. In this review, they had conducted some review works but not only limited to that, to have more accuracy, but they also checked with other resources. This tool has a close relation with our web-based calculator because both are trying to guide their users with nutrition assessments, and also both are web-based tools.
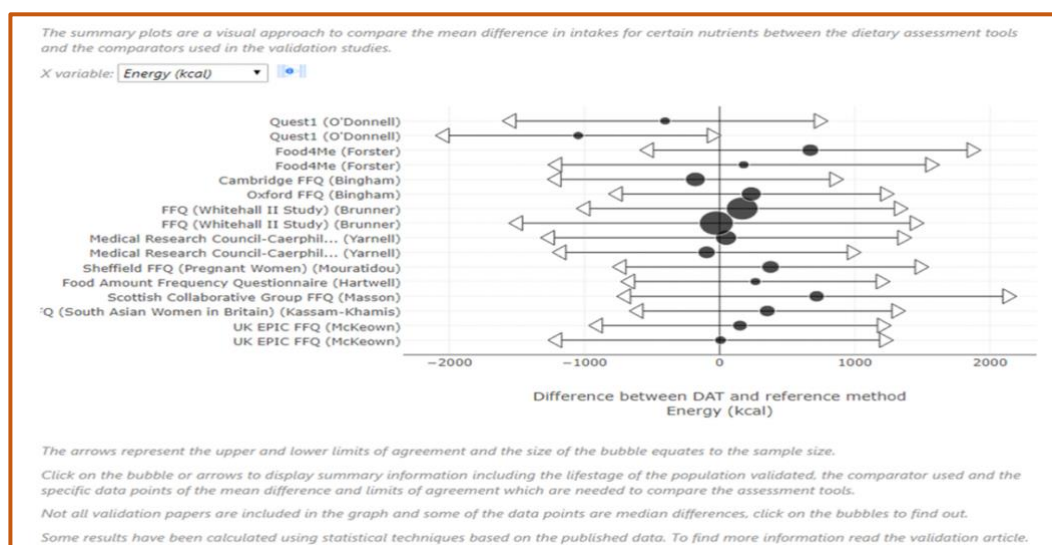
Figure 2.1 A sample screenshot of the nutritools website's summary plot (Hooson et al.,2019)

Figure 2.1 is taken from the website "nutritools" created to help the researchers find out their needed dietary assessment tool, where the authors of this journal validated 63 Dietary Assessment Tools (DATs) on their website. The website's usage is straightforward and organized according to the authors who described the functionalities of the tool's usage. There are sub-sections of the website to describe different features like guidelines to

use the tool. This is a nutrition tool where the user-focused group is researchers of dietary or nutrition for foods. The authors found that it was difficult for the health researchers to choose a specific validated dietary to provide people to consume healthy food guidelines. The identified validated dietary assessment tool is for adults, the elderly, and children, including infants. The website consists of 63 authentic UK DATs with various age groups with referred nutrients to help the researchers find the most suitable DAT according to the specific age group.

Another related tool to our work is "SensoMaker". Pinheiro et al. (2013) have introduced a free software named "SensoMaker" with a user-friendly interface to ensure a good food product acceptance. The user-friendly interface makes this tool similar to the web-based calculator. Our web-based calculator focuses on providing the nutrition guidelines for the processed food innovation process, and this tool also checks the produced food quality. SensoMaker's data collection can be done using multiple techniques: category scale, linear scale, temporal dominance of sensations (TDS), and time-intensity (TI). After receiving the data, it completes examined the data using any of the techniques mentioned earlier and delivered the results in various ways, for instance, conventional internal and external preference mapping, three-way internal and external preference mapping, principal component analysis, hierarchical cluster analysis, TDS and TI curves, in addition to Tukey and Dunnett's tests depending on the user's preference.
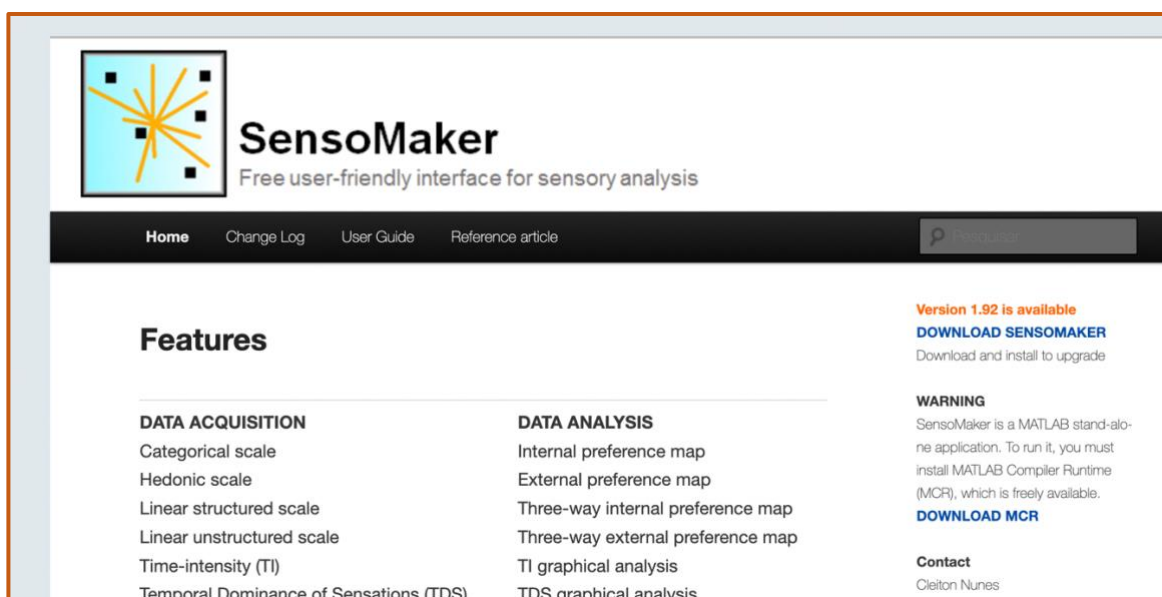

Figure 2.2 A screenshot of the SensoMaker software website

According to the authors, this software can play a vital role in food development or upgrade by considering the customer's desire and matching it with the detailed guidelines to make a sustainable healthy food product. This tool checks different features of the foods to find out the quality of the development of the products. The tool is a stand-alone MATLAB application, but there is no need to install the MATLAB software to run it. Only MATLAB Component Runtime is required to install. SensoMaker software is available free on the website of the Universidade Federal de Lavras (http://ufla.br/sensomaker). This tool also provides additional features like arranging files, converting the files into datasets, graph representation, and allowing the user to export into different formats. Finally, the SensoMaker software is helpful to measure the sensory of the foods to develop a good quality product with a user-friendly interface and is free to download.

"Food Flash" is a website solution. They were specially designed to help nutrition students with photography as an international learning tool (Secinaro et al., 2010). This website aimed to create a scope for nutrition students to know more about the different food cultures and international nutrition with the help of photography. Being a web-based food nutrition solution, it is also partly related to our tool. It introduces a visual learning style where the focus is on getting knowledge through pictures or videos with an expiation where the website makes it easier to access from anywhere in the world.

The target group of this website was the students who are participating as exchange students or international students. Pictures or videos for food culture were focused on four countries: France, Germany, Italy, and Switzerland. Each photo taken by the students was combined with an explanation of the food. Those pictures included all the foods eaten by those students while they were on their travel, like restaurants, bakeries, cafes, sandwich shops, pizza shops, pasta shops, grocery store markets, and fast-food shops. The still images were bound together into a slideshow using Photobucket with the name and description for each picture. The bucket also had different additional options like food category, location, type of the food shop, the quantity of each service, etc. The website gives more accessibility and helps the students worldwide share their own or other's food cultures. The pictures take away the barriers of languages but are understandable for all the nutrition facts.

Ramos et al. (2015) introduced a user-friendly web-based tool named "SENSE tool" to measure the impact on the environment during the food production process. This is a

European-based project which focuses on environmental effects during food production and different food products specially designed for small and medium-sized enterprises and tested in various food production sectors like salmon, beef and dairy, and fruit juice. The tool's output depends on the input of the data, like how many resources have been used and how much emission it creates, including the food or drink products supply chain. This tool is also based on a website and has a user-friendly interface that makes some similarities to our tool. The output data can be used at least for six purposes according to the author's environmental impact assessment of the product, evaluation of the ecological impact development over the years, a business-to-business communication strategy, etc.
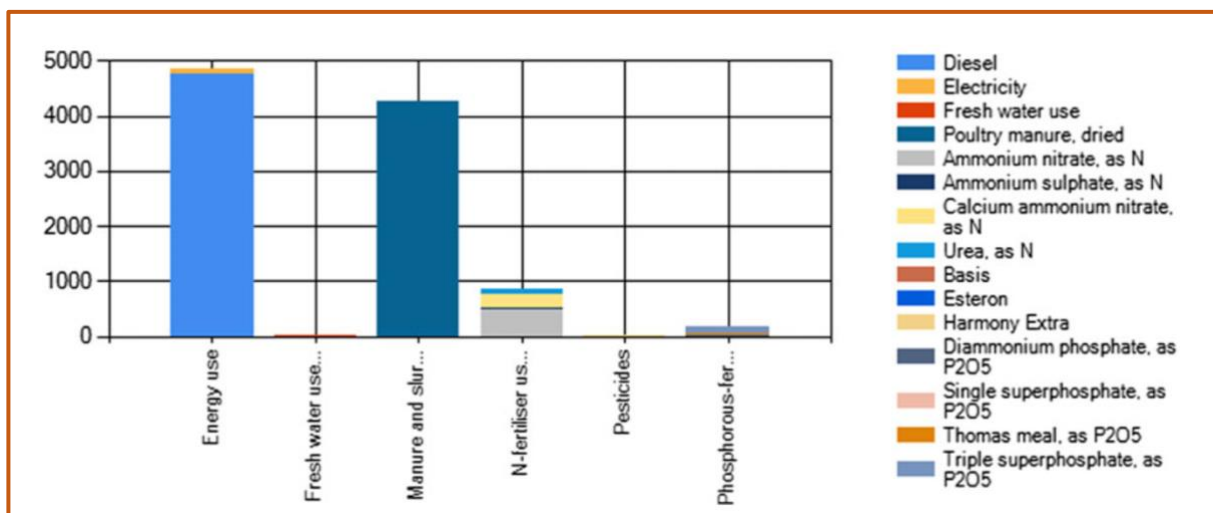

Figure 2.3 A screenshot of the SENSE tool sample output (Ramos et al.,2015)

The experimental data in Figure 2.3 is a screenshot of the SENSE tool results of the different components impacting the environment during the farm stage of the dairy production chain, where the x-axis contains various features and the y-axis shows the numbers for each element. The right side describes what each color stands for and which product. There is no need to download this tool because it is available on the internet, so it becomes easier to access from anywhere. The tech stack for this tool is Visual Basic.Net on Visual Studio 2010, SQL Server 2008 R2 is used for data storage and designing, and they have used Photoshop CS6 and Gimp 2.8. The tool also provides the results in different formats and appearances.
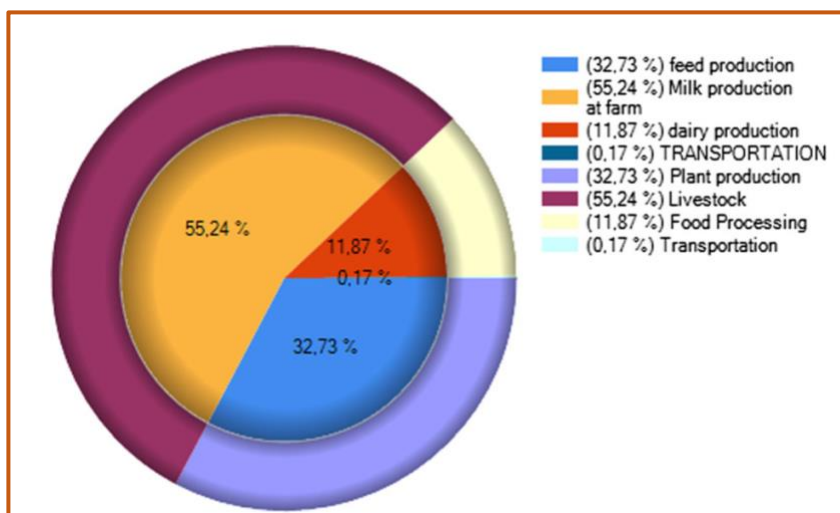
Figure 2.4 A screenshot of the SENSE tool results in a pie chart version (Ramos et al.,2015)

The pie chart in Figure 2.4 is a screenshot of another version of the output in the pie chart from the SENSE tool. This tool was used by 23 different companies like meat and dairy, fruit juice, and salmon. The users were provided guidelines and trained on how to use the tool. The main positiveness of this tool is user-friendly, benchmarking, sustainability assessment, carbon footprint calculation, and so on.

The final relevant tool is a database of food composition in New Zealand by Sivakumaran et al. (2018) to help the researchers, nutritionists, and medical practitioners quickly have an overall idea about the country's food consumption habits and what nutrition they intake mostly. The database is connected to a website to have easy accessibility and always updates to have the correct information on it. According to the paper, more than 2500 food items in 22 different groups are currently freely available on the website: www.foodcomposition.co.nz. The relevance between this tool and our one is a web-based solution focusing on food nutrition.

Figure 2.5 Screenshot of the home page of New Zealand food composition developed by the authors

As shown in Figure 2.5, the screenshot of the home page of the New Zealand food composition website consists of more than 2700 food databases. This database is based on the food habit and nutrition intake habits of the people of New Zealand. This database model is developed in three parts with three different purposes where one is the database itself, which is a relational SQL database system, the other one is Food Information Management System which is a Java-based web application for data entry and editing, and another one is a PHP-based web application for the users to archive the information from the database for user needs.
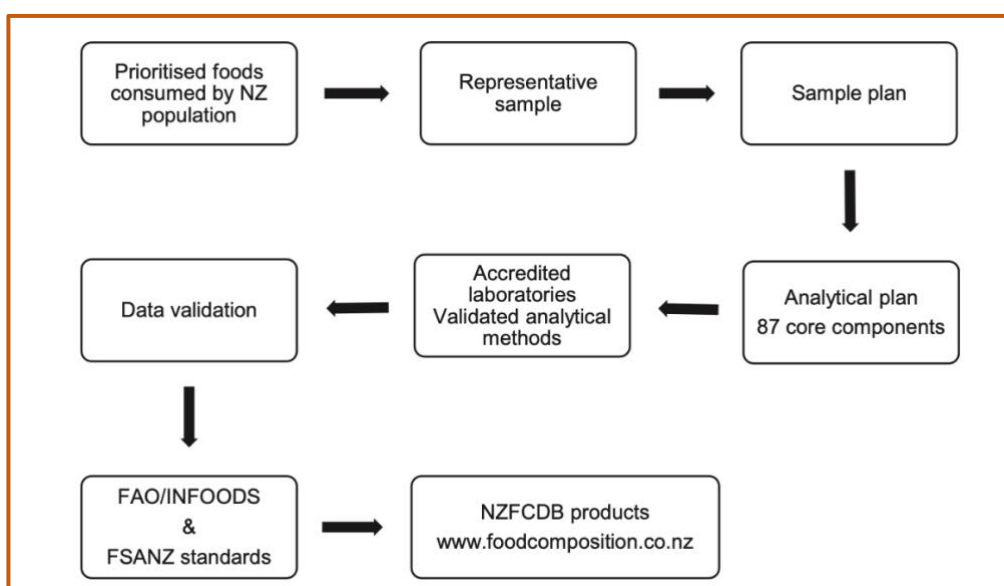

Figure 2.6 Work flowchart of New Zealand Food Composition Database (NZFCDB) (Sivakumaran et al.,2018)

The flowchart from Figure 2.6 is the flowchart for the work process of the NZFCDB, which shows how the adding of different food works. The abbreviations used on the flowchart are FAO/INFOODS – Food and Agricultural Organization of the United Nations/International Networks of Food Data Systems, FSANZ – Food Standards Australia New Zealand, and NZFCDB – New Zealand Food Composition Database. Finally, this paper aims to help nutritionists, dietaries, researchers, and nutrition students find the food composition in New Zealand and the primary food habits and nutrition intake patterns.

2.2 Accessible Website

The concept of an accessible website means a useful and meaningful website for its diverse group of users (Initiative, 2021a). Accessibility increases the usability of a platform by making it simple, informative, and easy to visualize. It is also easy to understand the purpose of an accessible website. One of the main focuses of the web-based calculator for the food innovation process is to make it accessible. For making a website accessible, there are some sets of guidelines from Website Content Accessibility Guidelines (WCAG) which is developed by the Web Accessibility Initiative (WAI) following the World Wide Web Consortium (W3C) process where WAI is a part of the W3C (Initiative, 2021). The concept of accessibility is not that popular among many developers, especially in developing countries, because of a lack of knowledge and educational guidance, so it is difficult to make them understand the importance of an inclusive website and how it can help a different group of people. The guidelines are also divided into three different levels to make it easier to understand which one is more important. The levels are A, AA, and AAA, where A is the following minimal guideline when developing a website (Initiative, 2020). These guidelines are universal, and they will help build the web platforms in the same manner so that it will be easier for a diverse group of users.
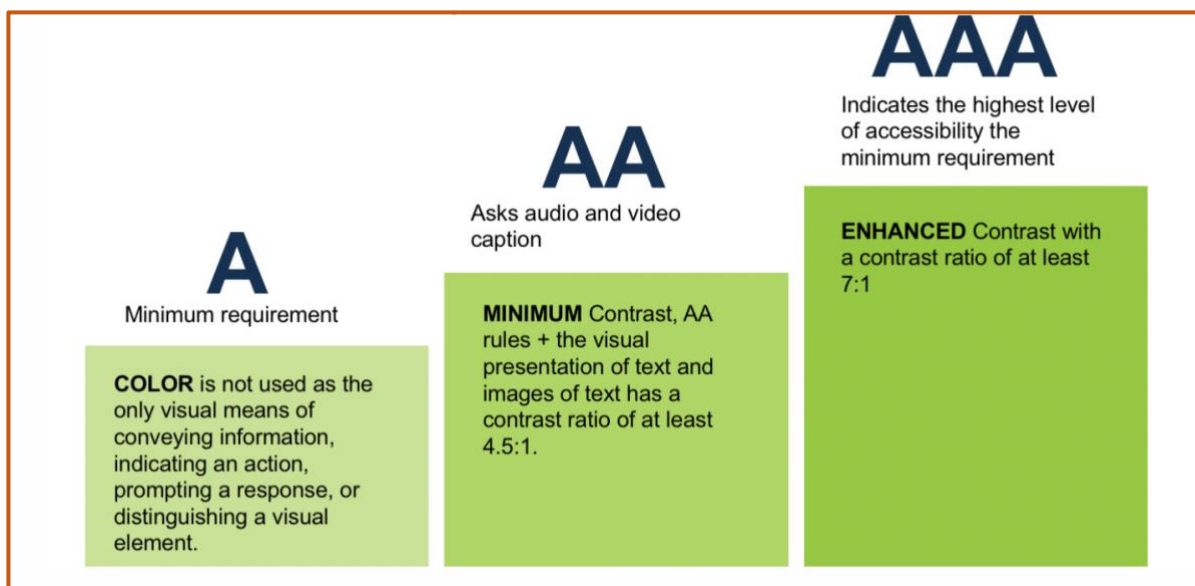
Figure 2.7 Three different levels of WCAG guidelines (Website Compliance: Taking the Fear Out of GDPR & Accessibility, 2018)

There is a diverse group of users using technologies in their everyday lives. Different people have a different levels of knowledge and understanding of technologies. For example, a non-technical person has less competency than a technical person; on the other hand, an additional technical person has different expertise in different technologies. To help the diverse group of people, the WCAG is introduced to help people use the technologies even with various assistive devices. One article researched the websites operated by adults with learning complaints. They examined 19 different websites using google search and tried to find out how much accessible each website is (Waight & Oldreive, 2015). The finding shows that each website needs literacy skills which means a lack of knowledge to make an accessible website. Different websites were using different kinds of fonts, no proper color contrast, lack of text alternatives, and many other minor issues had been identified.

To make understand the importance of the accessible websites, the proper education for accessibility is essential, and teach the developers about the WCAG, which contains all the guidelines to make it easy to understand the implementation of the different success criteria to create a website accessible like perceivable, operable, and understandable (Web Content Accessibility Guidelines (WCAG) 2.1, 2018). In an article by Frick (2020), the four primary principles of WCAG are described very well, along with some examples to make it more understandable. A website needs to be perceivable because it

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helps users understand its features and purpose. Detailed information and a proper showcase of components create a website perceivable. Navigation and elements should be with different inputs like a keyboard to make the website operable. Understandable means the language and color contrasts are clean on the website. Finally, the website needs to be responsive to work fine across different devices, browsers, and platforms, which makes it robust (Frick, 2020).

A study has been conducted to show the significance of the usability of accessible websites and non-accessible websites even if a person has no challenges. It also includes different ages of people, and the result shows that the accessible websites are flexible and easy to use terms of any age, even without any disorders (Schmutz et al., 2017). This study also includes different devices like tab and computers. Still, in all cases, the accessible websites performed well and user friendly for other groups of diverse users of different technologies.

Above all, the discussions and studies clearly show the importance of accessibility and how it creates value for its diverse users. Accessibility comes to help the people and society make a bridge so that everyone can strengthen their ability to cope with the technologies and meet the community's needs.

2.3 User-centered Design (UCD)

A design that includes the users directly while developing the application to get their feedback and make changes to make it more user-friendly and easy to use is known as UCD (What Is User Centered Design?, n.d.). The web-based calculator followed the UCD process because different clusters gave feedback while designing the tool. UCD is a popular approach to designing software or application. Still, it is also challenging for the designers to understand the user's needs where different people have a different perception of usage.
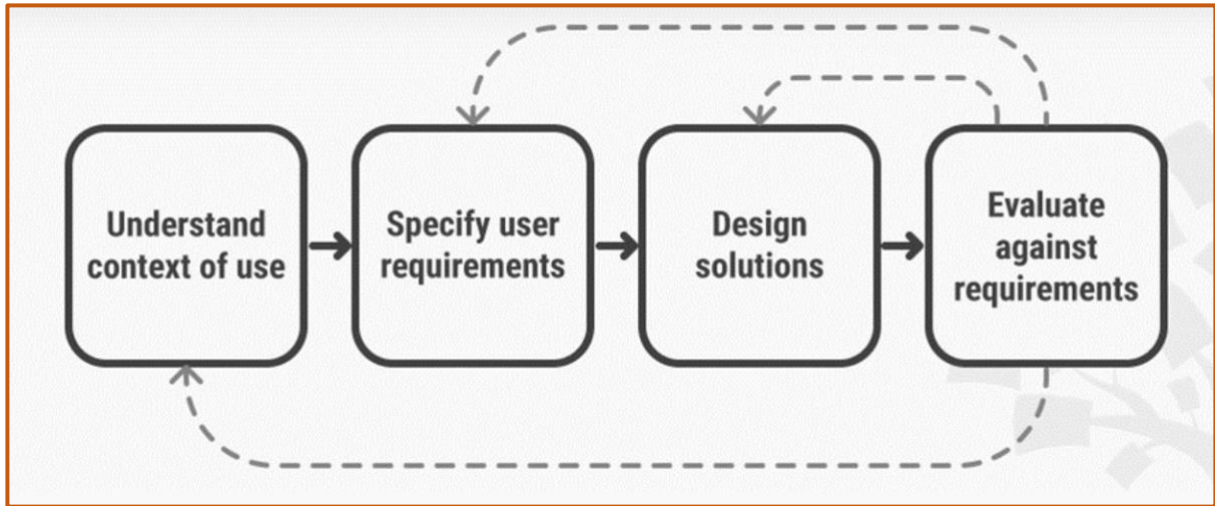
Figure 2.8 UCD process (What Is User Centered Design?, n.d.)

Below in Figure 2.8 is a diagram that shows the workflow that needs to be considered during a UCD approach because it is essential to understand the user's needs to create a finished product. Designers need to keep in mind the budget, timeline, customer requirements, and availability of technologies, including user, needs, because a successful finished product is more beneficial than a non-finished product. It is challenging to manage all these factors while making a good product. One needs to take into consideration those different factors. According to Nunes & Pratt (2012), the usage of UCD started long ago, in the 1940s, and still, now it is a popular approach for designing products.
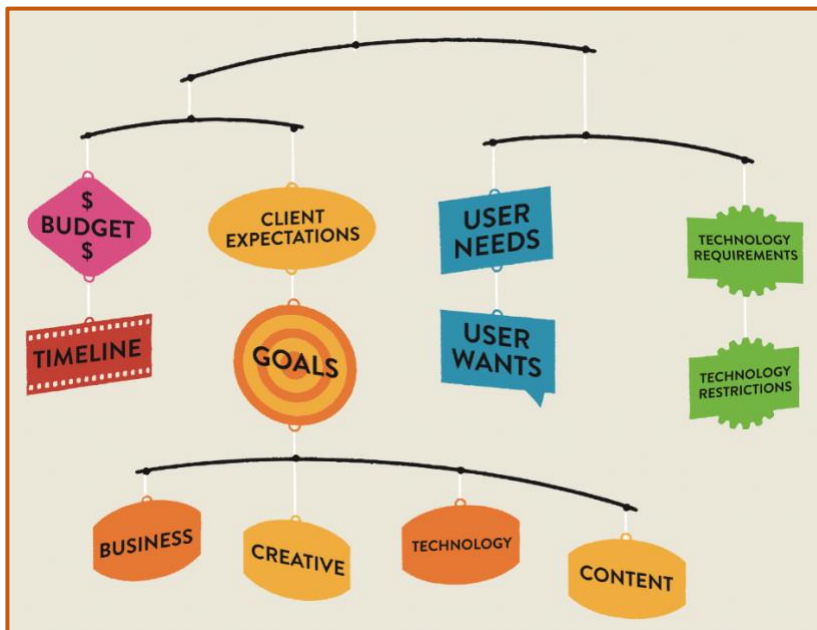

Figure 2.9 Different factors in a UCD approach (Nunes & Pratt, 2012)

Before taking a UCD approach for product design, it is crucial to identify the targeted user group. In the book by Doroftei et al. (2017), chapter 2 explains the Integrated Computer Application for Recognizing User Service (ICARUS) project and how this project was designed and implemented using UCD. The first and most important task is to identify and gather the requirements of the targeted user group. In this approach, it is common to put the users in the center of the design part and add or remove functionalities according to the user's needs. As users are always connected to the designing process, the final developed product is user-friendly and accessible. Even though all can't interact with the potential users during the development process continuously, other factors also need to be considered, like the client's requirements, budget, delivery time, etc. The chapter also describes how to conduct a better user interaction by breaking down the tasks into smaller pieces. It also makes it easier for the users to determine the exact needs for each functionality (Doroftei et al., 2017).

UCD is a popular approach to designing a website or software. In Indonesia, a public health service website was redesigned using the UCD approach to make the website more user-friendly and increase accessibility (Puspitasari et al., 2018). According to Puspitasari et al. (2018), after the website's redesign, the usage increased significantly after the whole development process and user requirements and user testing. Another website that aims to provide knowledge about the "batik" fashion uses the UCD approach (Richard & Kaburuan, 2020). According to the authors, batik is an uprising fashion because of its uniqueness and artistic value.

Still, people have limited knowledge about "batik," so this website will help them know more about its history. The UCD approach helped the developers make the website more valuable and accessible as the user always gave input in the development process. In the development process, Richard and Kaburuan (2020) found that the website is more appealing and user-friendly because it identified the user needs and did user testing. Research from Yuwei Xiong and Ansheng Wang (2010) said that the final target of software development is to match the requirements of the user's as much as possible. UCD is a way to identify the user needs more accurately. Therefore, this thesis uses the UCD approach to closely understand users' expectations to make the web-based tool user-friendly and increase accessibility. To be more detailed about the importance of the UCD approach,

according to research by Miah (2004) showed how UCD could influence the designing of a multicultural educational web interface and improves accessibility as well. Effective and efficient websites are essential if the website user is multicultural because different cultures have different choices, norms, and faiths. The UCD approach helps understand the various users of different cultures and their requirements (Miah, 2004). This is how the user's presence with another diverse group regarding their technical knowledge and age helps create an ideal website with usability and accessibility.

Chapter 3: Methodology

It was a big project, so we divided it into two parts among two members. Both members were doing our short thesis, and there were time limitations. My fellow team member worked with the designing and user testing, and I developed the web-based tool. We collaborated to deliver the product as per user requirements. The UCD approach followed the development. Another fellow member mainly focused on user testing and collecting their feedback during the development process. My role was to understand user requirements and implement them accordingly.

3.1 Development

3.1.1 User-Interface

A complete website is divided into two frameworks: front-end and back-end. The front-end frameworks are also known as client-side frameworks, including the user interface, search engine optimization, performance, etc. Several front-end frameworks are available now, like React, Vue, Angular, etc. Most frameworks use HTML, CSS, JavaScript, and jQuery languages (Patel, 2022). This web-based tool is built using React.js (reactjs.org) as a front-end framework created by Meta Platforms, Inc. (Meta Platforms, Inc., n.d.). According to Statista (2021), React.js is a modern JavaScript library. In this short thesis, the only focus was on the tool's front-end part with some mock data because of the time limitations.
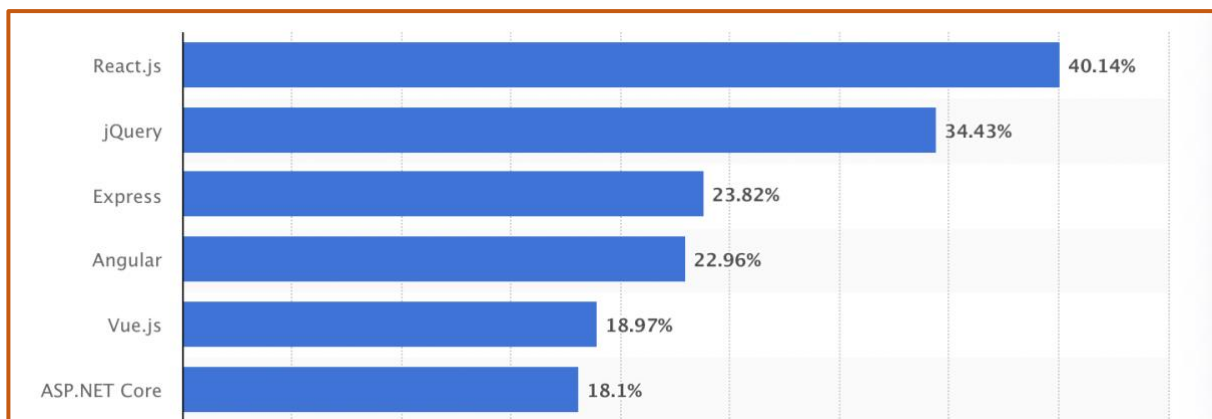

Figure 3.1 Popularity chart of the website frameworks (Statista, 2021)

There are some reasons to choose React.js to develop the website because we aim to build an accessible and user-friendly website that is easy to use. As shown in Figure 3.1, according to Statista (2021), the statistics show that React.js is a primarily used JavaScript

library or front-end framework. It is mainly used because there are several advantages of using this framework. React.js is a component-based framework which means one can make multiple components of different functionalities so that the website will load only the required elements at a time (Meta Platforms, Inc., n.d.). By doing this, it makes it faster. It also allows writing the Hypertext Markup Language (HTML) code inside the JavaScript code to make logical rendering easier. Another reason is that earlier experience, and knowledge about this library could contribute to developing the prototype for a short thesis within the given short amount of time. This web-based calculator used HTML version 5 and React.js version 17.0.2.

3.1.2 Responsiveness

There are different screen ratios nowadays, and it is essential to automatically adjust the website's visuals according to the screen sizes. A responsive website adapts the contents automatically according to different screen sizes (Beal, 2022). The calculator is developed by using the Bootstrap (getbootstrap.com) version 5.1.3 library for styling along with Cascading Style Sheets (CSS) version 3 to make the web-based tool responsive to different sizes as well (Bootstrap, n.d.). Responsiveness of a website is essential because different screens have different frame ratios, so if the website is not compatible with all sizes of screens, then the website's structure will be broken and displayed differently. This responsiveness feature is a significant advantage so that the website will automatically change its layout according to the size of the screen. Bootstrap is a powerful tool to help organize and make a website responsive by using its boilerplate classes (Bootstrap, n.d.). It has several built-in functionalities like buttons, menus, etc., making the task more accessible and beautiful. In this web-based tool, I have used a few libraries of Bootstrap and modified some of the designs according to the user feedback by using CSS. For example, it changes the background colors, font styles, family, button colors, borders, etc.

3.1.3 Dependencies

Node.js is used to run and test the functionalities of JavaScript in the localhost. It helps to create a React.js project into local storage and runs the project into localhost using a web browser. This project used "npm" to automatically download the required dependent libraries to run the project. Node version 16.14.0 and npm version 8.3.1 are used to build the web-based tool. According to Node.js official website (nodejs.org), it is an asynchronous

event-driven JavaScript runtime that can manage multiple connections automatically (Node.Js, n.d.). Two more external libraries were used to develop the web-based calculator. All the icons added to the tool were from Font Awesome. There was a massive collection of icons, and some of them were free to use. Font Awesome version 6.1.1 was used. To add the hover-over effect, the web-based tool used the Material UI version 5.6.2, with many other features. "Tooltip" was the specific component in the Material UI library for adding the hover-over effect, and this tool only used "Tooltip" in the development process. Visual Studio Code version 1.65.2 (Universal) has been used to write the code, a free IDE developed by Microsoft. The benefits of using this IDE are its free of cost. It has many extensions to help by writing the codes like providing suggestions, explaining different classes, recognizing the other coding languages, and showing errors.

3.1.4 Accessibility

As the calculator is an accessible web-based tool so, to check the accessibility errors, the Web Accessibility Evaluation Tool (WAVE) has been used (wave.webaim.org), which is a web accessibility evaluation tool. This tool is developed by WebAIM and has been providing different web accessibility solutions since 1999. It is a non-profit organization (WebAIM: About WebAIM, n.d.). They aim to give individuals or organizations knowledge, training, and tools to develop accessible technologies.
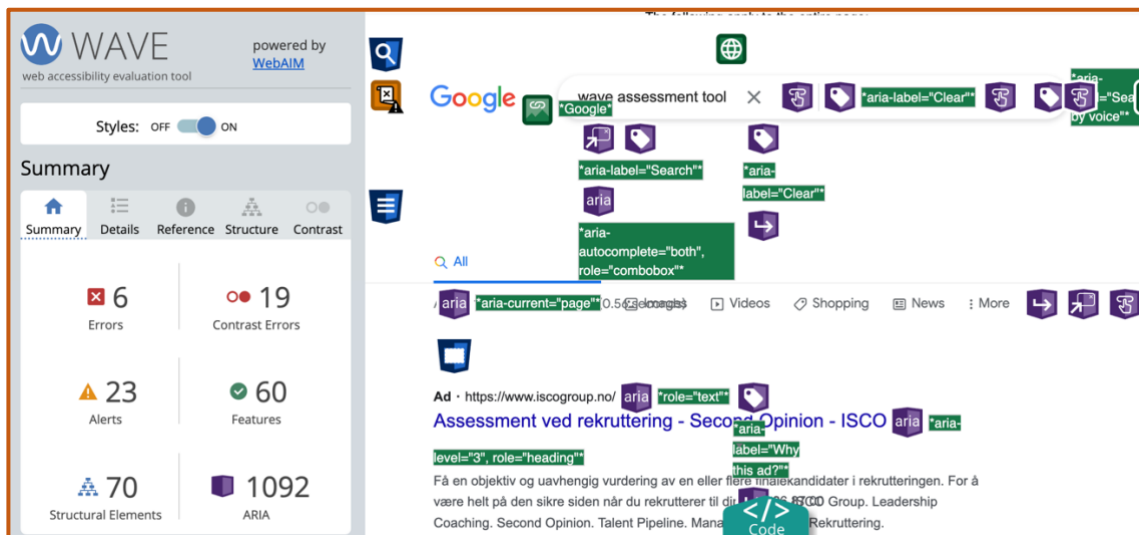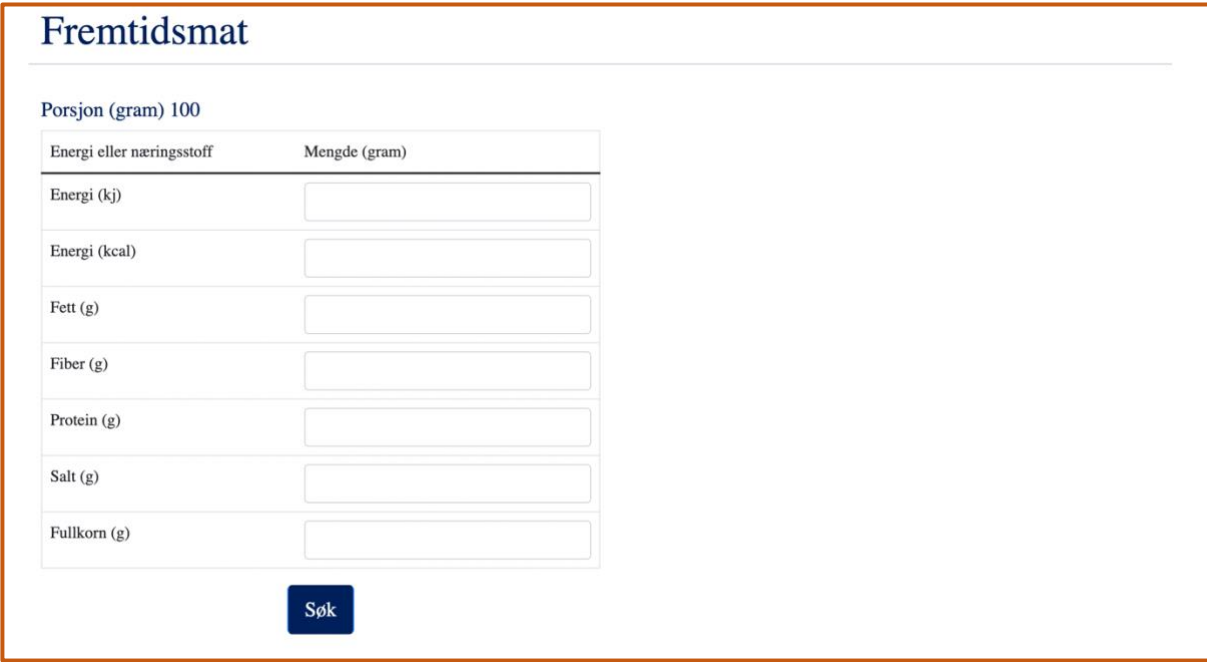

Figure 3.2 A screenshot of the WAVE tool results

The above screenshot in Figure 3.2 is the WAVE tool accessibility evaluation of "google.com", which finds the different errors according to WCAG guidelines. This helps to identify the mistakes in terms of non-compliance with WCAG. This tool is used to find out

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the errors so that by solving the errors, the web-based calculator can be accessible. However, it is suggested by WAVE to do some manual testing to achieve fully-functional accessibility as the general focus is also on developing the website according to the guidelines of WCAG to make it accessible so that the web-based calculator follows specific standardized guidelines. This will make it user-friendly and easier to use it.

Chapter 4: Results

4.1 First Iteration

In the first iteration, I mostly spent time studying the guidelines of Nøkkelhullet to find out the pattern of the guidelines so that it would be easier to implement the functionality of the calculator according to the guidelines. Also, a single-page web calculator design was created using React. The aim was to show the user input interface for the calculator without implementing any logic. Based on the user interface design for the tool, which the other group member provided, developed the product according to that design. The look of the web-based calculator in the first iteration is shown in Figure 4.1. The guidelines were well documented on the Lovdata website (Forskrift om frivillig merking av næringsmidler med Nøkkelhullet, 2015). The guidelines were separated into different food groups with additional requirements.

Figure 4.1 User interface after the first iteration

The idea was to make the calculator's user interface intuitive and easy to understand. It was a single-page web-based calculator. It was divided into two parts. On the left side was a table to put values of the different nutrition. The importance of nutrition needs to be set according to every 100 grams of measurement of the food. Also, a button was added after the user input table. After pressing the button, the expected outcome should show the result on the right side of the same page. There were two types of results,

one was for meeting the Nøkkelhullet guidelines, and the other was for not meeting the Nøkkelhullet.

4.2 Second Iteration

After the team member conducted the usability testing, the second iteration was developed with additional features. First, the calculator was introduced with a home page with a button to navigate the user to the calculator. Then, a few website designs were updated. A functional logo of Fremtidsmat on the header to guide the user to the home page had been added. A menu button on the top left of the title without any functionality had been added for future development. The general appearance of the home page for the second iteration is shown in Figure 4.2 below.
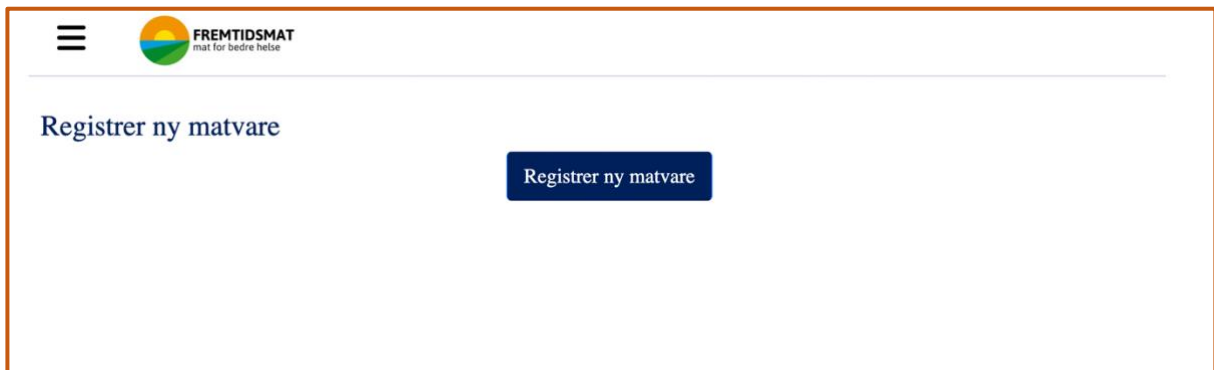
Figure 4.2 Home page on "Second Iteration"

Inside the calculator page of the website, some new features were added with unique stylings and some logic to show results. The calculator page came with an additional navigation back button to take the users to the home page. Inside the calculator page, there were two dropdown menus. One was to select a food group, and the other one was to choose a specific food type from the selected food group. Then it would display the table with different nutrition where a user would provide values to check the Nøkkelhullet. The calculator page was divided into two parts. One was for user input, and the other was for results. The calculator page contained two separate titles to make the divisions more understandable. Figure 4.3 shows the appearance of the changes on the calculator page.

Figure 4.3 Calculator page in the second iteration

The calculator had a working functionality to display the output after getting the inputs from the user. In Figure 4.4, the outcome is shown on the right side of the calculator page inside a keyhole product box. If the user inputs met the guidelines, then the result was revealed in a green box with texts, and if it did not make satisfying, then nothing appeared on the result section. The website was running on the localhost and not deployed yet. The values used in the calculator to check the logic for nutrition inputs were mock data. The database was not added yet. Then, the focus was to develop the logic and patterns properly for easier future development.

Figure 4.4 Output from the calculator in the second iteration

After the end of this second iteration, TINE SA (www.tine.no) participated in the user testing and provided feedback. I, along with my other team member and supervisor, participated in the meeting. During the meeting, we presented the functionalities of the calculator. They asked for some changes to the functionalities and user interface designs. For instance, the result box explains the reasons for not meeting Nøkkelhullet. User feedback was essential for us to design and develop as we were developing the tool using the UCD approach. The third iteration prioritized the user feedback and made changes accordingly.

Figure 4.5 A picture of TINE SA during the meeting

4.3 Third Iteration

Several updates were made to the web-based calculator in the third iteration as per user requirements. Firstly, we finalized three specific food types from three different food groups. Below, Figure 4.6, Figure 4.7, and Figure 4.8 are the three other food type guidelines to meet Nøkkelhullet. Tine SA and Fremtidsmat selected these three food types. Functionalities to check Nøkkelhullet for these three food types, Margarin og smør, Yoghurt, and Lapskaus, were added to the calculator.

Matfett og oljer	
19 Matfett og matfettblandinger. Produktene kan være tilsatt smak.	– fett høyst 80 g/100 g – mettede fettsyrer høyst 33 % av fettinnholdet – salt høyst 1,1 g/100 g

Figure 4.6 "Margarin og smør" food type

12 a) Syrnede melkeprodukter som ikke er beregnet til å drikke, uten tilsatt smak. Tilsvarende laktosefrie produkter omfattes også.	– fett høyst 1,5 g/100 g

Figure 4.7 "Yoghurt" food type

27 Ferdigretter med grønnsaker og eventuelt en proteindel eller en karbohydratdel. Produkter med: – minst 50 g grønnsaker (unntatt poteter), belgvekster (unntatt peanøtter), rotfrukter eller frukt og bær per 100 g produkt, og eventuelt – en proteindel, eller – en karbohydratdel. Hvis retten inneholder en korndel, skal denne oppfylle kravet til fullkorn som er gitt i den relevante næringsmiddelgruppen. Hvis glutenfri pasta inngår, gjelder kravet til kostfiber i gruppe 10.	– mettede fettsyrer høyst 1,5 g/100 g – tilsatte sukkerarter høyst 3 g/100 g – salt høyst 0,8 g/100 g

Figure 4.8 "Lapskaus" food type

A few demo functionalities were added to the web-based tool's home page. A small description was added to the left side of the calculator navigation button. The report aimed to make the button's functionality more understandable to the users. Then a search field was introduced so that the users could search for an existing product by product name and product's food group. Below the search box, a table displayed all current products to the users. After those, two buttons were added to navigate the existing food products "next" and "previous". Figure 4.9 is the home page of the web-based calculator after the third iteration.
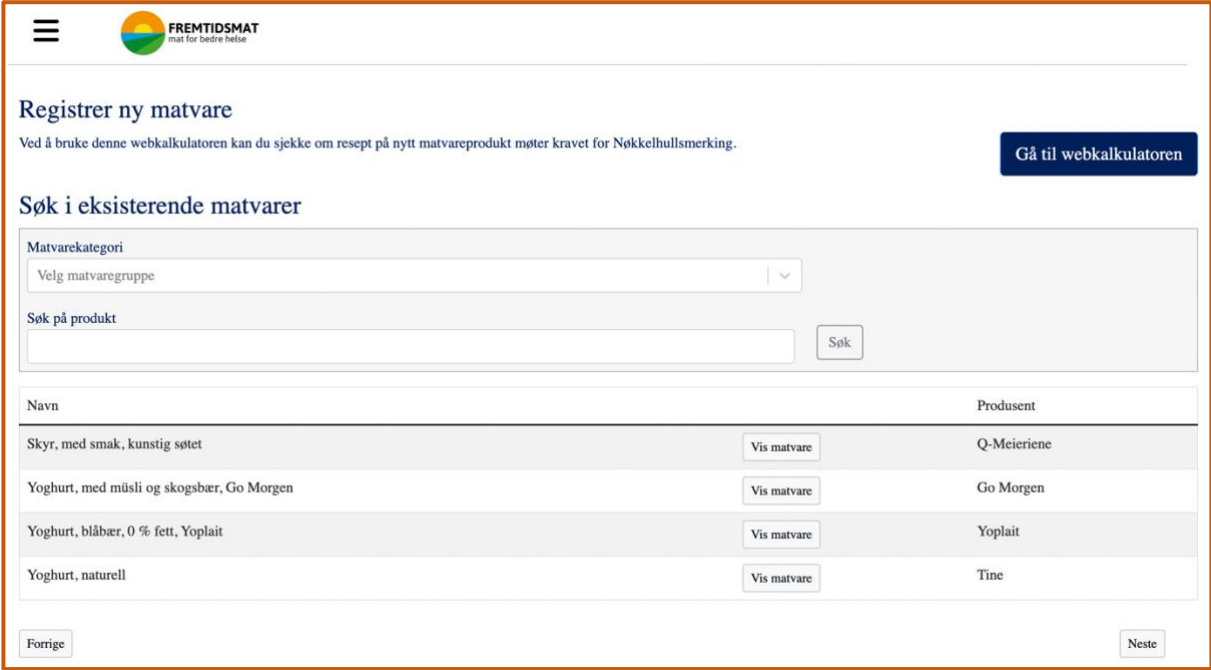

Figure 4.9 The home page after the third iteration

Then, several changes were made to the calculator page. An extra back-arrow was added to navigate the users to the home page. An input field with a heading to write the
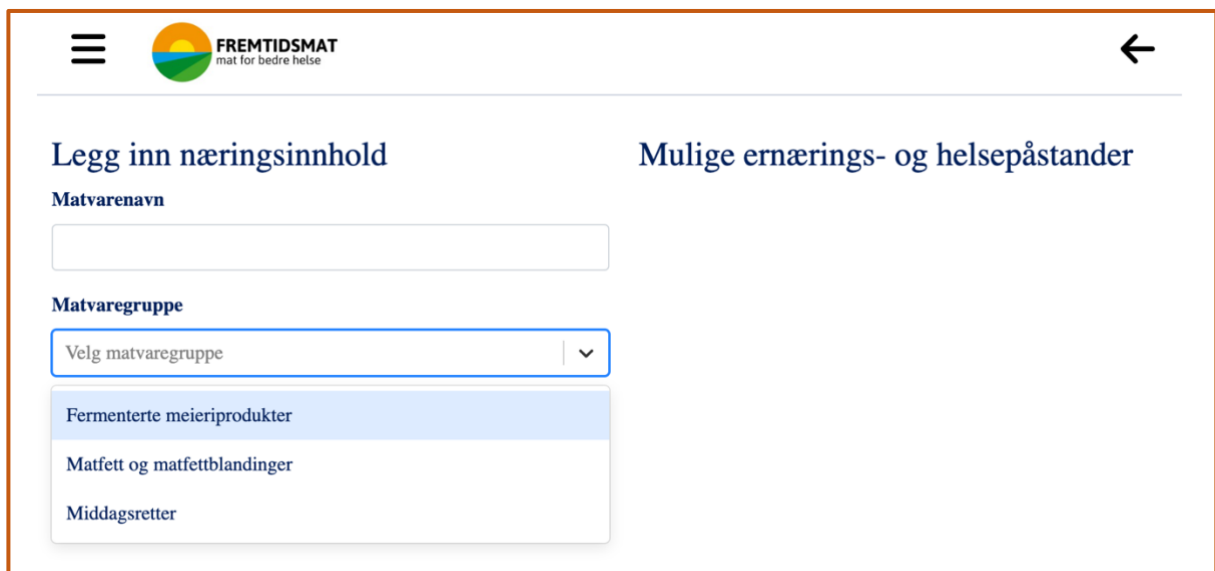
product name was included, but it was not functional, only a demo version. After that, the titles for each dropdown menu were also added. These changes had been added to make the tool more user-friendly. Figure 4.10 is the screenshot of the calculator page after the third iteration.

Figure 4.10 The calculator page after the third iteration.

Below Figure 4.11 and Figure 4.12 are the two different dropdown menus. The first dropdown menu is to select a food group, and the second one is to choose a food type for the selected food group.

Figure 4.11 Dropdown menu to select a food group

Figure 4.12 Dropdown menu to select a food type

After selecting a food group and a food type from the dropdown menus, the user input table appeared with the different nutrition input fields. The nutrition name changes as per the requirements of different food types. Figure 4.13 is the screenshot of the whole calculator page with the user input table.

Figure 4.13 Calculator page with the user input table after the third iteration

During the third iteration, the result appearance of the Nøkkelhullet products was changed. The result included an exclamation icon on the right side of the result box. This icon worked as a button so that by clicking the button, it popped up a text box with a link to check the authenticity of Nøkkelhullet guidelines. Figure 4.14, Figure 4.15, and Figure 4.16 are the screenshots of the three different food types from three other food groups that are Nøkkelhullet products with the user inputs and results.

Figure 4.14 Output of "matfett og matfettblandinger" group's "margarin og smør" food type meeting Nøkkelhullet

Figure 4.15 Output of "fermenterte meieriprodukter" group's "yoghurt" food type meeting Nøkkelhullet

Figure 4.16 Output of "middagsretter" group's "lapskaus" food type meeting Nøkkelhullet

The incorrect result feature was added to the calculator. The wrong result was divided into two segments. One was for empty input fields on required nutrition values, and another was for not meeting the correct values for Nøkkelhullet. Two different error icons were added to the left side of each user input field in the table to distinguish between two various errors. The hover-over effect had been added to provide the correct error information to the user. Figure 4.17, Figure 4.18, and Figure 4.19 are the screenshots of the imported libraries to use the hover-over effect and error icons.

```
import { faCircleExclamation } from '@fortawesome/free-solid-svg-icons';
import { faBan } from '@fortawesome/free-solid-svg-icons';
import { FontAwesomeIcon } from '@fortawesome/react-fontawesome';
import Tooltip from '@mui/material/Tooltip';
```

Figure 4.17 Library imports for hover-over effect and error icons

```
...kke Nøkkelhullet på grunn av mengden fett. Mengden på fett
"><FontAwesomeIcon className="alert-icon" icon={faBan} /></div></Tooltip> : nu
le "Mangler verdi i fett parameter" placement="right" arrow>
"><FontAwesomeIcon className="alert-icon" icon={faCircleExclamation} /></div><
```

Figure 4.18 Adding error icon

```
   scope= row  className= table font >
  <Tooltip title="Produktet innfrir ikke Nøkkelhullet på grunn av mengden fett. Mengden på fett må være la
v className="icon"><FontAwesomeIcon className="alert-icon" icon={faBan} /></div></Tooltip> : null}
ll  <Tooltip title="Mangler verdi i fett parameter" placement="right" arrow>
v className="icon"><FontAwesomeIcon className="alert-icon" icon={faCircleExclamation} /></div></Tooltip>
```

Figure 4.19 Hover-over effect to show specific error messages

The right side of the calculator page displayed a red error box with some texts and an exclamation icon button on the right side of the box. The exclamation button showed another pop-up text box with a link for more information about Nøkkelhullet guidelines. Figure 4.20 is a screenshot of empty user input errors, and Figure 4.21 shows the mistake of not meeting the nutrition values of Output of Nøkkelhullet.

Figure 4.20 Errors for empty user fields

Figure 4.21 Errors for not meeting the Nøkkelhullet specified nutrition values

Besides developing the above features, Bootstrap was added to the web-based tool to make the tool responsive. Bootstrap came with some boilerplate classes. Adding the required classes into the tool made the web-based calculator responsive. Figure 4.22 shows a few implemented classes from Bootstrap on the website. Few classes of Bootstrap had been marked with white boxes.

Figure 4.22 Bootstrap classes implementation

After implementing all the required Bootstrap classes into the web-based tool, some responsive checks were done using the chrome browser in different screen ratios. Below screenshots of Figure 4.23 and Figure 4.24 are the results of responsiveness checking.
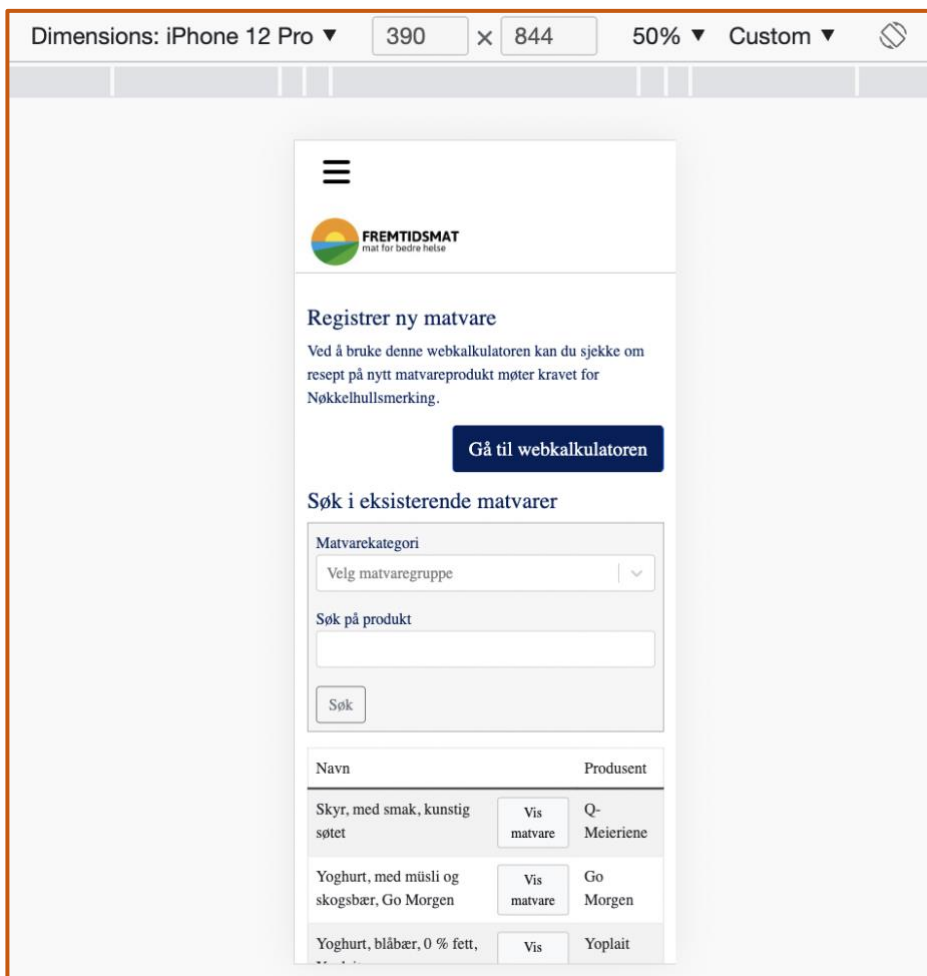
Figure 4.23 Responsiveness checked for home page
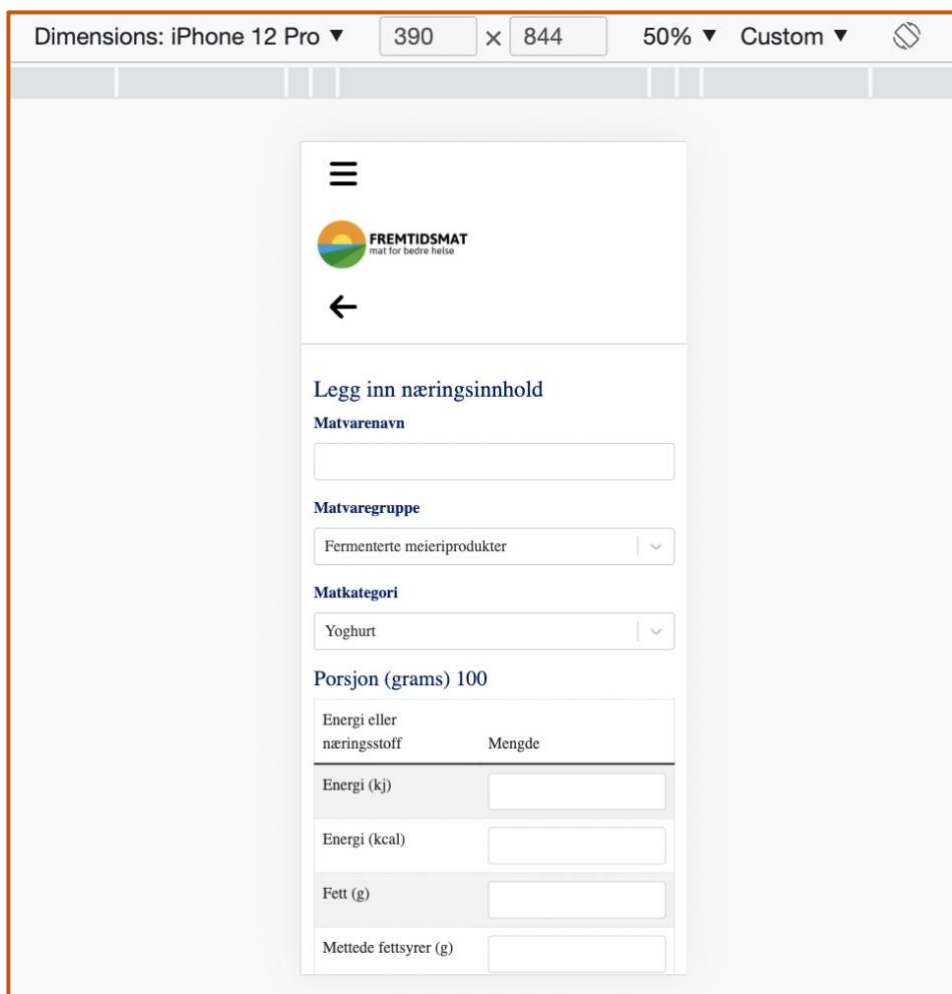
Figure 4.24 Responsiveness checked for calculator page

Finally, WAVE was used to check the accessibility of the web-based calculator. The WAVE extension was added to the browser and ran the extension on both website pages. Figure 4.25 and Figure 4.26 are the screenshots of the WAVE checker before fixing the accessibility issues.

Figure 4.25 WAVE tool checker for accessibility issues of the home page
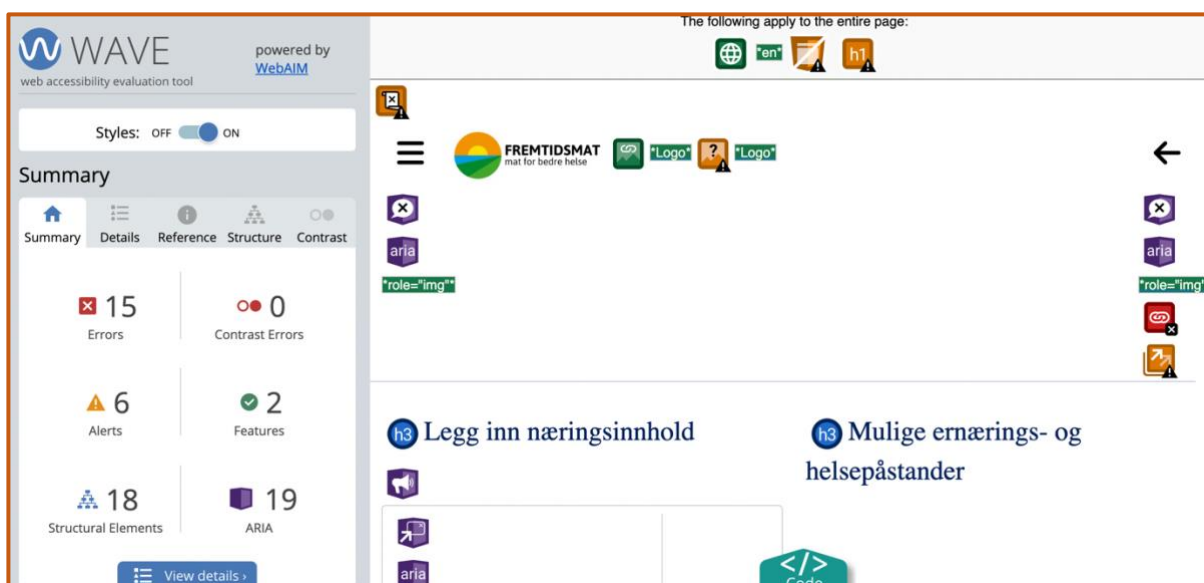
Figure 4.26 WAVE tool checker for accessibility issues of the calculator page

To solve the accessibility issues of the web-based calculator, alternative texts, ARIA labels, "id" names, and "for" names were added to different HTML tags. These features help the screen reader to explain the functionalities accurately. Figure 4.27 and Figure 4.28 show the solutions done inside the coding of the web-based tool.

Figure 4.27 Alternative text added inside the image tag

```
<tr className={mettede ? "alert-box" : null}>
    <th for='mettede' scope="row" className="table-font">{mettede ? <Tooltip title="Mar
        <div className="icon"><FontAwesomeIcon className="alert-icon" icon={faCircleExc
    <td>
        <input id='mettede' aria-labelledby="Mettede" type="number" min="0" step="any"
    </td>
</tr>
```

Figure 4.28 ARIA labels, "id" names, and "for" names have been added

After fixing the issues of accessibility, I again checked the accessibility using the WAVE tool checker to see if the errors had been corrected. Figure 4.29 and Figure 4.30 are the screenshots of the WAVE tool checker after fixing the issues.
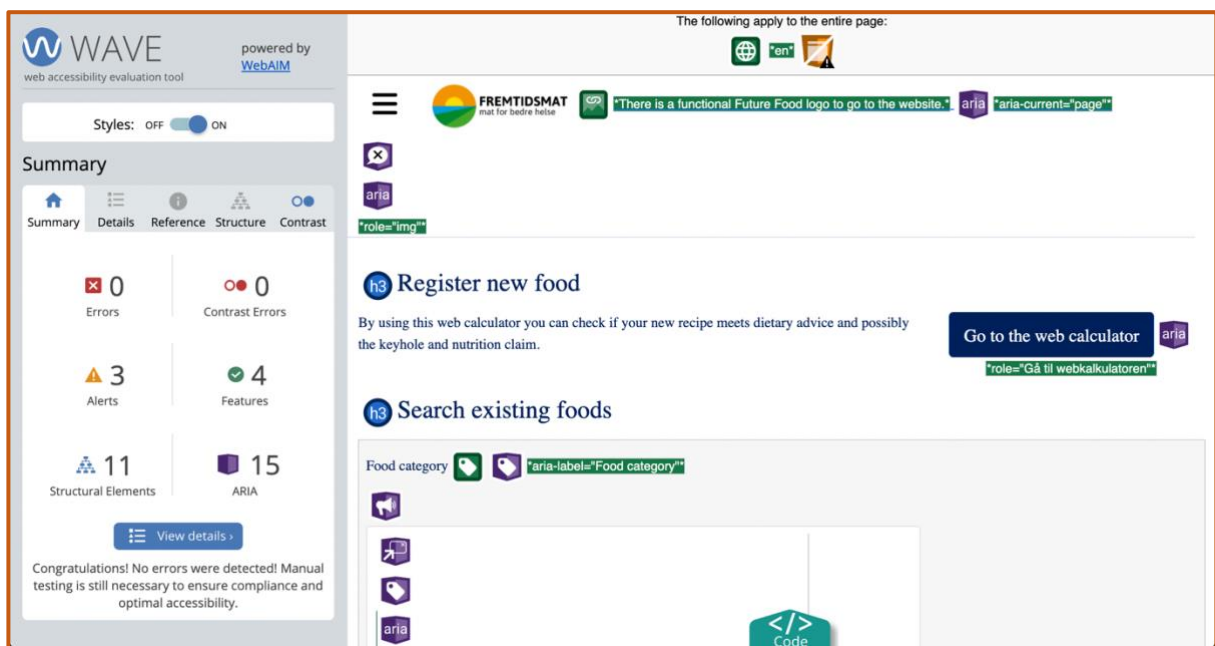
Figure 4.29 WAVE tool checker after solving accessibility issues of the home page
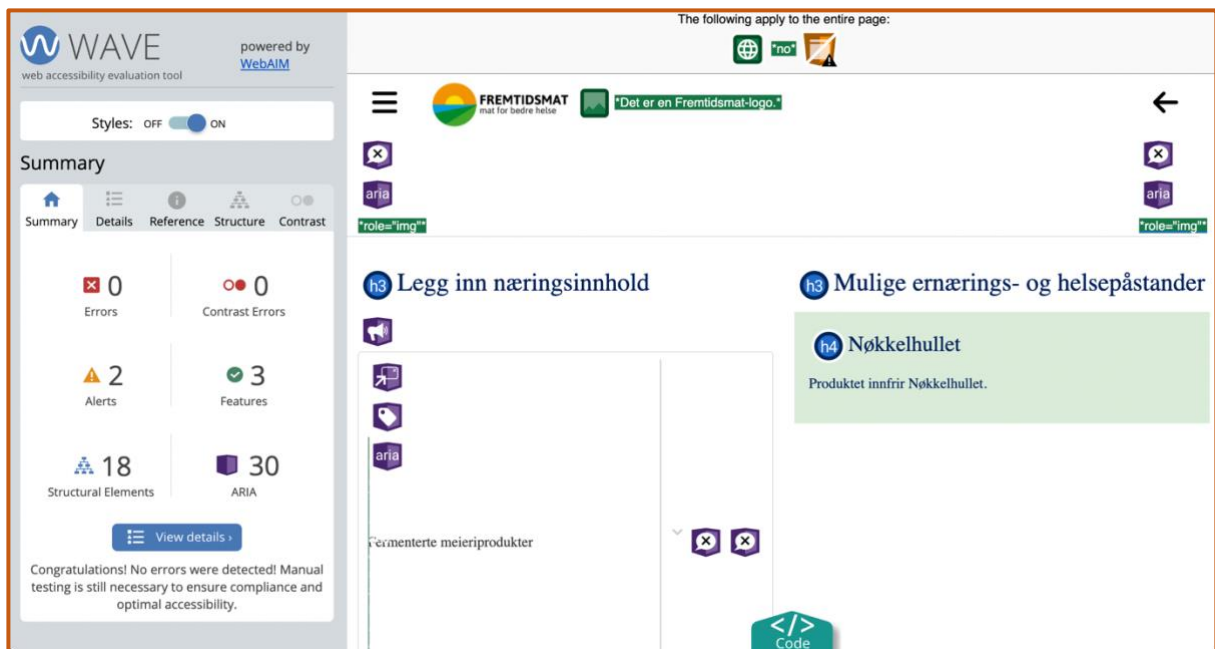
Figure 4.30 WAVE tool checker after solving the accessibility issues of the calculator page

After finishing the third iteration, the web-based calculator was deployed into a server to make user testing easier. The link for the third iteration tool is https://master-thesis-fremtidsmat-dfibwsoe5-faisal12101123.vercel.app/. My other fellow member conducted the user testing again with TINE SA and Fremtidsmat. During the user testing, they came up with a few suggestions. We considered their feedback and solved it in the next iteration.

4.4 Fourth Iteration

The fourth iteration aimed to implement the feedback received during the user testing from Tine SA and Fremtidsmat. Firstly, the user input type was fixed to only numbers. The user would only be able to input numbers inside the user input fields. Figure 4.31 shows the updated input field type of the web-based calculator.

Figure 4.31 The user input type taking numbers only

Secondly, the link provided in the text box of the result section of the calculator page redirects the user to a new website. The website previously used to open on the same tab. This led the user to lose their data on the calculator page and took them to a new website. This was not user-friendly to come back to the calculator page. Now the link in the text box opened in a new tab. This helps the user to keep their existing data on the calculator page. Figure 4.32 below shows the current appearance after clicking the link.
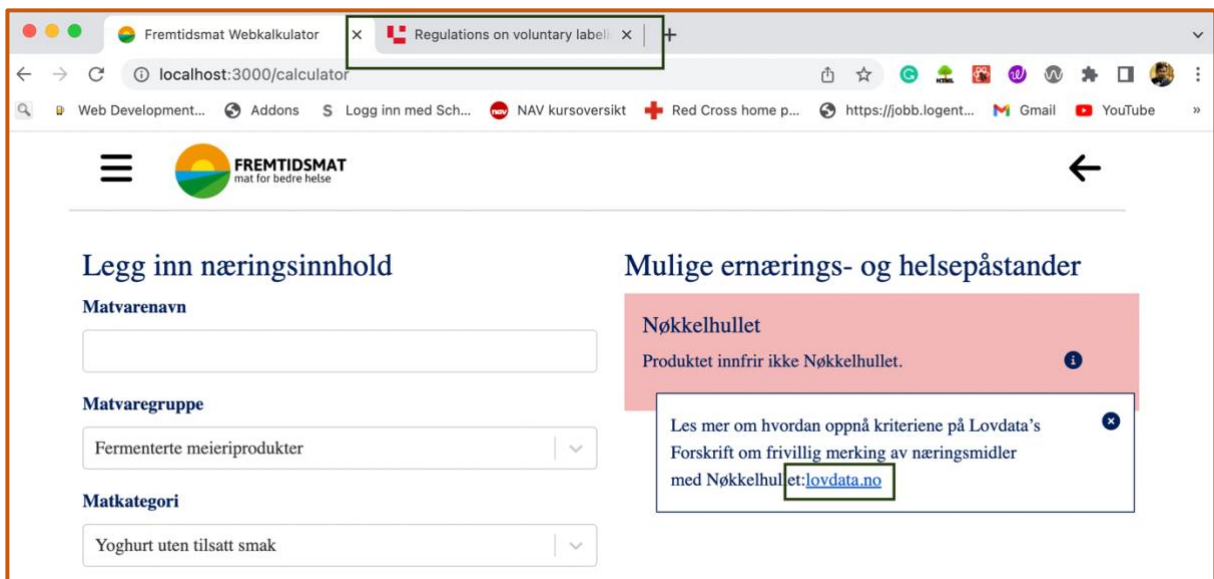
Figure 4.32 Link is opening on a new tab

Thirdly, several texts were changed on the calculator page. The energy nutrition parameter changed to "kJ" from "KJ". After that, "grams" changed into "gram". Then the texts for the hove-over effects were reversed. Before, it showed the same nutrition names

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for all, but now it was showing the names for different nutrition. Figure 4.33 and Figure 4.34 show the updates made and marked with the black box.

Figure 4.33 Updated texts on the calculator page

Figure 4.34 Hover-over effect's text update

After that, the logo of Nøkkelhullet was added to the result box. The logo was only added to the result box that was for meeting the Nøkkelhullet guidelines. Figure 4.35 below shows the appearance of the result box after the update.

Figure 4.35 The result box with the Nøkkelhullet logo

The final update of the fourth iteration was changing the food type names. The Nøkkelhullet guidelines were different for different food types, so selecting the correct names for each food type was essential. For instance, yogurt with added flavor had other Nøkkelhullet guidelines. Figure 4.36 is the screenshot of the updated dropdown menu for the food type marked with the black box.

Figure 4.36 Updated food type names for the dropdown menu

End of the fourth iteration, the calculator deployed to: https://master-thesis-fremtidsmat-fq8jt9vpu-faisal12101123.vercel.app/. My fellow member again conducted the user testing to show the changes had been done following their feedback.

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Chapter 5: Discussion

5.1 The web-based calculator development

After the fourth iteration, my fellow group member again had the user testing with TINE SA and Fremtidsmat. The user testing went well, and they were happy to see the updates that they wanted to have on the tool. The user testing aimed to determine if the calculator met its user requirements. During the development of the tool, several sets of targets were achieved. Due to the UCD approach, it was easier to identify the user requirements. The users were the focused group during the development. This continuous communication with the users helped make the tool user-friendly and accessible for the members and clusters of Fremtidsmat. Each feature was developed according to their requirements and changed following their feedback.

Firstly, the web-based calculator was developed using the UCD approach. The feedback from the users was always prioritized. As per the UCD approach, users were in close connection and participated during the development process. Before starting and finishing the iteration, my other group member had meetings and conducted user testing with the users to understand the requirements properly. This is how the tool became user-friendly to the users. According to Doroftei et al. (2017), the UCD approach during the development of a tool makes it user-friendly because the target user group is always at the center of the development process.

Secondly, the web-based tool worked well in different screen ratios. Frick's (2020) article states that a robust website needs to be responsive to work fine across other devices, browsers, and platforms. The responsiveness of the calculator worked well, so there were no screen size limitations for the calculator. The hover-over effect of checking the exact error message worked with the cursor only and didn't work for the touch screens. Responsiveness was an essential feature of the accessible website. Then, the website was checked for accessibility issues using the WAVE tool. Waight & Oldreive's (2015) research shows that using different font styles, no proper color contrast, lack of text alternatives, and many other minor issues in a web page make it inaccessible. The WAVE tool measures the features like alternative texts, color contrast issues, ARIA labels, etc., according to the WCAG guidelines. After the WAVE tool evaluation, the highlighted errors were fixed for the web-based calculator.

Finally, writing the coding of the calculator was understandable. For example, I was using proper variable names according to the usage. Any other developer could grasp the codes in a short time. It will help to make changes and the further development process more manageable. There were thirty-two food types in Nøkkelhullet guidelines, and some food types were divided into sub-sections. The calculator works for three food types and provides the pattern to easily update the rest of the food types. Fremtidsmat suggested these three food types of three different food groups.

5.2 Differences with existing tools

The literature review chapter already briefly discussed a few existing food nutrition solutions. Nutritools focused on helping the researchers provide data validation of different dietary tools in the UK (Hooson et al.,2019), where this web-based calculator concentrates only on the Norwegian health diet. Then, SensoMaker was for checking the food quality, and this tool was for desktop-based software (Pinheiro et al.,2013), but this is a web-based tool that checks the nutrition values if meeting Nøkkelhullet. Another user-friendly web-based tool is named the "SENSE tool" to measure the environmental impact of food production (Ramos et al.,2015). Again, the Food Flash tool was developed to share the different food cultures and food consumption habits through the pictures (Secinaro et al., 2010). Finally, a web-based database in New Zealand to help researchers, nutritionists, and medical practitioners understand the country's food consumption habits and what nutrition they mostly intake (Sivakumaran et al.,2018). The developed calculator helps the food clusters check for the nutrition guidelines of Nøkkelhullet during new food product innovations. There were few solutions, and each of them had a different purpose. The web-based calculator has several unique features that differentiate the tool from all the existing products.

The tool provides a user-friendly and easy-to-use interface so that without having any knowledge of food nutrition, one can use the calculator. This tool focus on accessibility. The tool is designed intuitively, whereas none of the existing products talked about any accessibility. Responsiveness is vital because nowadays, different screen sizes are available. This web-based calculator is responsive, which means it will adjust its features automatically accordingly to different screen sizes. The UCD approach to the calculator development is another unique feature of the tool. This involves the users going through together with the

development process and prioritizing the user feedback. The tool is developed to help the Norwegian food clusters develop new food products by following the Nøkkelhullet guidelines. The tool also provides the food clusters with a digital platform and a user-friendly interface to check the nutrition values of a food product that meets Nøkkelhullet.

5.3 Limitations

There were several limitations in the development of the web-based calculator. The accessibility features were only tested with the WAVE tool. To confirm all accessibility features of the web-based tool, it was necessary to try the calculator manually. No actual impaired user testing had been conducted to check accessibility. The testing was limited to the WAVE tool because of limited time.

Due to the time limitations, the tool was developed partially. As this was a short thesis and there were thirty-two different food-type Nøkkelhullet guidelines with sub-sections, the tool implemented functionality for three different types of food. The web-based tool was developed to measure the food nutrition values. As an information technology student without prior knowledge of food nutrition, it was challenging to create the logic for different food types meeting Nøkkelhullet guidelines.

The web-based calculator was developed in the Norwegian language. Not having adequate language knowledge, Google Translate was often used to read the Nøkkelhullet guidelines and write texts inside the tool. Translators do not always provide the exact translation of sentences, so asked for help from fellow group members and the supervisor for explanation and guidance. The design prototypes developed by my other group member were also in the Norwegian language.

Choosing a sustainable technology was another challenge for the development process. There were several different types of programming frameworks available. By doing some research, availability of online resources, and previous knowledge, the React.js framework was selected to develop the web-based calculator. Sustainable technology was considered for the product development because it will help the further development and make changes for the web-based calculator easier for developers.

Chapter 6: Conclusion

This short thesis developed a web-based calculator using the UCD approach to make the new food product innovation process digitalized. The calculator checks the nutrition values accuracy followed by Nøkkelhullet guidelines. This tool had been tested for accessibility features to some extent. The WAVE tool for accessibility checker had been used to find out the issues and then solve them accordingly. The calculator is also user-friendly. The tool was developed per user requirements and followed the UCD approach to achieve user-friendliness. Proper explanations of each feature were provided to make the tool easy to use. The color contrast used in the calculator was according to WCAG guidelines. The web-based calculator was developed using a simple user interface. Also, user feedback after each update helped to make the tool user-friendly. The responsiveness feature was also added to the web-based calculator to fit different screen sizes automatically. To achieve the responsiveness feature, Bootstrap was implemented to the tool. Bootstrap comes with the boilerplate classes that make the development easier.

React.js is a JavaScript library and one of the popular frameworks because of its usability. The front-end of the web-based calculator is developed using React.js. It is a component-based framework and loads the website faster. The icons of this tool are used from "Font Awesome". It has an extensive collection of free-to-use icons. It is added as an external library to the tool. The hover-over effect is added to the web-based calculator from "Material UI" by an external library. This library has different features, but "Tooltip" is only used to add the hove-over effect.

This thesis provides a more straightforward solution to health profile calculation during the new food product innovation process. Using this tool, anyone without prior knowledge of food nutrition can check food products to meet Nøkkelhullet. The user-friendly interface of the calculator provides the users easy to use experience. The UCD approach followed the whole development process. Before and after each iteration, user testing was conducted. The development was done according to the user feedback. This digital platform will help the food clusters to save their time checking the foods meeting Nøkkelhullet without going through all the guidelines manually, and if not, then the reasons for not meeting Nøkkelhullet.

6.1 Future work

There is enormous room for further development of the web-based calculator. These can be divided into three parts. Firstly, a few more user interface updates can be done. During the user testing, my other fellow group member got some feedback to improve the interface design in terms of the results section. The users wanted to see the needed nutrition values in the result section while the food product is not meeting Nøkkelhullet. The users provided feedback on the result box's position and some components' positions from the home page. Some title names also can be rephrased. More user testing can be conducted to get a more summarized user experience.

Secondly, several scopes of functional development need to be done. As mentioned earlier, the Nøkkelhullet guidelines are not implemented. It is implemented for three types of food, so the other types need to be implemented. The European Food Safety Authority (EFSA) also has some guidelines to help the new food innovation process. EFSA guidelines can also be added to the calculator. This will help the users to check for both guidelines on one platform. Adding a database to the tool can be done. This will enable storing food products' nutrition values for later use. The front-page functionalities will be dynamic then. It will also be possible to create a user login system. This is how users can have their security and privacy aspects.

Finally, accessibility testing can be done with different functional disabled users. Nowadays, several accessibility features are available on every device. Manual testing by turning on additional accessibility features will also add more value. For example, the tool can be tested using a screen reader to check that the functionalities are working well. These will help to improve the accessibility features of the calculator.

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