ACIT5900

MASTER THESIS

in

Applied Computer and Information Technology (ACIT)

December 2023

Universal Design of ICT

An Accessible Web Calculator Facilitating Diverse Food Producers in Developing Healthier Food Products

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Acknowledgment

Before you stand the master thesis "An accessible web calculator is facilitating diverse food producers in developing healthier food products". This thesis project was proposed by Fremtidsmat (a food cluster under Nofima) which needed an accessible web-based tool that assists food industry companies and Fremtidsmat members, especially those lacking employees with nutrition expertise, in ensuring that products adhere to both Norwegian and European food safety authorities' guidelines and regulations, including the Nøkkelhullet (The Keyhole Label), Ernæringspåstander (Nutrition Claims) and Helsepåstander (Health Claims).

The Fremtidsmat web calculator was initially developed by Faisal Ahmed during his time as a master's student at OsloMet. Ahmed's prototype of the Fremtidsmat web calculator was explicitly focused on the Nøkkelhullet food categorization, specifically covering only three food categories. Building on Ahmed's foundational work, I joined the project as a junior researcher at Oslomet, entrusted with fully implementinging the Nøkkelhullet food categorization into the web calculator. Working on the Nøkkelhullet implementation sparked my interest in food labelling regulation, a curiosity that led me to take on this thesis project.

Having already been a part of the collaboration between OsloMet and Fremtidsmat became an advantage, especially when needing quick insights from the team regarding the integration of Ernæringspåstander. This collaboration made the development process of this project smoother, which was quite significant given the tight timeline typically expected for short thesis work. But the most fulfilling part of working on this project was being able to apply what I had learned in my master's courses about web accessibility, heuristic evaluation (HE), and user-centered design (UCD) in real life.

I want to express my most sincere thanks to my supervisor, Way Kiat Bong, for his endless patience, support and guidance throughout the research process. I would also like to express my gratitude to the experts who provided insights on developing the User Interface (UI) and integrating sugar-related Ernæringspåstander, Vibeke Telle-Hansen and Ida Synnøve Grini. Additionally, I extend my thanks to my fellow team member, Lars Hammer, for sharing user-based testing feedback on each iteration and allowing me to address issues that might have otherwise gone unnoticed.

Last but not least, I owe a huge thank you to my parents, my brother and my partner for their love, motivation, and never-ending support. Their encouragement was a constant source of strength behind my work.

Anna Batzeri

Oslo, December 15, 2023

Abstract

This thesis project further develops the Fremtidsmat web calculator prototype, contributing to efforts in assisting diverse food producers in confirming the adherence of their food products with complex food labelling regulations, such as Nøkkelhullet (The Keyhole label) and Ernæringspåstander (Nutrition Claims). Specifically, the thesis focuses on the implementation of the sugar-related Ernæringspåstander such as "Lavt sukkerinnhold" (low sugars), "Sukkerfri" (sugars-free) and "Uten tilsatt sukker" (with no added sugars), and the "Med et naturlig innhold av sukker" (contains naturally occurring sugars) claim. This functionality is essential for producers to avoid false or misleading labelling and reduce the risk of legal penalties, damage to reputation, mistrust, and confusion among consumers.

By employing a many-sided approach in creating the tool, the research integrates User-Centered Design (UCD), Heuristic Evaluation (HE), and web accessibility recommendations. This many-sided approach aimed to make a tool that is not only functional and compliant with regulations and recommendations but also accessible to a broad range of users, regardless of their background or level of expertise in the food and nutrition industry. Using a UCD methodology, guided by the activities mentioned in the ISO 9241-210 standards and the UCD principles proposed by Gould and Lewis, ensured that the web calculator met the needs and expectations of end-users. The development of the tool adopted an iterative process, continuously incorporating user feedback, addressing usability issues, and conforming to web accessibility standards such as WCAG 2.1 Level AA. Representatives from Fremtidsmat and its business members, nutrition experts, and OsloMet academic staff were involved during every round of user-based testing, which took place over five iterations. This continuous feedback circle guaranteed that the Fremtidsmat web calculator was functional and user-friendly for a broad user base instead of focusing only on users with specific disability types. A Heuristic Evaluation (HE) was conducted on the final version of the Fremtidsmat web calculator prototype, using the Website Accessibility Conformance Evaluation Methodology (WCAG-EM), adhering to WCAG 2.1 Level AA as guiding heuristics, for compliance with Norway's *"Forskrift om universell utforming av informasjons- og kommunikasjonsteknologiske (IKT)-løsninger" (*Regulation on universal design of information and communication technology (ICT) solutions). The Heuristic

Evaluation (HE) results showed that the web calculator failed to fully confirm Level A and Level AA of WCAG 2.1 Level A and Level AA Success Criteria.

Of high importance would be addressing the issues found on the HE and ensuring full compliance of the web calculator to WCAG 2.1 Level A and Level AA. Furthermore, future work on this project could benefit from a more multidisciplinary team, ensuring full integration of the Ernæringspåstander into the web calculator, as well as expanding the tool's applicability to include other types of food labelling regulations, such as Helsepåstander (Health Claims).

Overall, this thesis project contributes to efforts in the field of web development and accessibility within the food and nutrition industry. The combination of web accessibility recommendations, UCD, and HE established a strong base for further development of the Fremtidsmat web calculator. While the tool may not have achieved perfect accessibility at the end of the final development phase, the process highlighted critical issues, setting a path for future improvement.

Keywords:

User-Centered Design (UCD), Heuristic Evaluation (HE), web accessibility, usability, ISO (International Organization for Standardization) standards, Nøkkelhullet (The Keyhole label), Ernæringspåstander (Nutrition Claims), The European Food Safety Authority (EFSA), Web Content Accessibility Guidelines (WCAG), Website Accessibility Conformance Evaluation Methodology (WCAG-EM), and web calculator.

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List of Abbreviations

- AT – Assistive Technology
- ATAG - Authoring Tool Accessibility Guidelines
- CVD – Cardiovascular Disease
- CRPD - UN Convention on the Rights of Persons with Disabilities
- Digdir – Digitaliseringsdirektoratet (The Norwegian Digitalisation Agency)
- EFSA - European Food Safety Authority
- EU - European Union
- HCD - Human Centered Design
- HCI - Human Computer Interaction
- HE - Heuristic Evaluation
- HFI - Human Factors Integration
- ICT – Information and Communication Technology
- NFSA - Norwegian Food Safety Authority
- NHCR - Nutrition and Health Claims Regulation
- NOFIMA - The Norwegian Institute of Food, Fisheries and Aquaculture Research
- OsloMet – Oslo Metropolitan University
- SVG - Scalable Vector Graphics
- SIKT - Norwegian Agency for Shared Services in Education and Research
- ST - Success Criteria
- UAAG - User Agent Accessibility Guidelines
- UCD - User Centered Design
- UD – Universal Design
- UI – User Interface
- UN – United Nations
- Uutilsynet - Tilsynet for universell utforming av ikt (The Authority for Universal Design of ICT)
- UX– User Experience
- Website Accessibility Conformance Evaluation Methodology – WACG-EM
- WAI-ARIA - Web Accessibility Initiative - Accessible Rich Internet Applications
- WCAG - Web Content Accessibility Guidelines

- W3C – The World Wide Web Consortium

Chapter 1: Introduction

Food labelling regulations are a constantly evolving field (Binns, 2009). The EU Regulation on Nutrition and Health Claims, which Norway has adopted, is designed to ensure consumer understanding and prevent misleading claims (Mattilsynet, n.d.-c).

However, this regulation presents challenges for food companies, particularly those producing, importing, or selling food products in the Norwegian market (Mattilsynet, 2011, 2015, 2022, 2023a). One major challenge the food industry faces is avoiding false or misleading Nutrition and Health Claims, known locally as Ernæringspåstander and Helsepåstander (Berg et al., 2006). Using false or misleading claims can have serious consequences, resulting in penalties, damage to reputation, mistrust, and confusion among consumers. Furthermore, adhering to the Norwegian food labelling regulations, such as Nøkkelhullet (The keyhole label), Ernæringspåstander (Nutrition Claims) and Helsepåstander (Health Claims), introduces more than legal challenges for food producers (Lovdata, 2015, 2017). Especially for those lacking employees with nutrition expertise, assessing the compliance of their products with the Norwegian food labelling regulations becomes a complex procedure.

Given these challenges, there is an urgent need for a reliable tool that allows food producers and manufacturers to assess their products' nutritional and health value effectively, particularly when developing new, healthier options. Therefore, Fremtidsmat, a food cluster under NOFIMA (The Norwegian Institute of Food, Fisheries and Aquaculture Research), proposed the development of a web-based tool, the Fremtidsmat web calculator. The main aim of the web calculator is to assist food industry companies and members of the Fremtidsmat cluster, especially those lacking employees with nutrition expertise, in ensuring that products adhere to both Norwegian and European food safety authorities' guidelines and regulations, including the Nøkkelhullet, Ernæringspåstander and Helsepåstander (Lovdata, 2015, 2017).

When developing such a tool, it is critical to ensure not only its functionality but also its accessibility for a diverse group of users. Web accessibility is not simply an ethical requirement but a requirement in both global and Norwegian regulations, including Articles 9 and 21 from the Convention on the Rights of Persons with Disabilities (CRPD), which defines access to the Web as a fundamental human right, and the *"Forskrift om universell*

utforming av informasjons- og kommunikasjonsteknologiske (IKT)-løsninger" (Regulation on universal design of information and communication technology (ICT) solutions), which requires websites adherence to accessibility standards such as the Web Content Accessibility Guidelines (WCAG) 2.1 Level AA (DEPARTMENT OF FOREIGN AFFAIRS, 2017; HF, 2021; Lovdata, 2019; United Nations, n.d.-b, n.d.-c; W3C, 2018c). Adhering to WCAG 2.1 enhances user experience (UX) while reducing the risks of lawsuits and fines for potential discrimination against users with disabilities.

While the Fremtidsmat web calculator, is expected to facilitate food producers in verifying the compliance of their products with Nøkkelhullet, Ernæringspåstander and Helsepåstander, this thesis project focuses on the process of developing the functionality of the web calculator to assess compliance to Ernæringspåstander. From a list of 30 currently permitted nutrition claims, the project examined the process of implementing only four of those claims due to time restrictions (European Commission, n.d.). Specifically, the sugar-related claims such as "Lavt sukkerinnhold" (low sugars), "Sukkerfri" (sugars-free) and the two-part claim "Uten tilsatt sukker" (with no added sugars) with its supplementary claim "Med et naturlig innhold av sukker" (contains naturally occurring sugars) (EUROPEAN FOOD SAFETY AUTHORITY (EFSA), n.d.; Lovdata, 2017).

The research question that motivates this thesis is:

" How can web accessibility recommendations, combined with User-Centered Design (UCD) and Heuristic Evaluation (HE), ensure that the Fremtidsmat web calculator addresses the needs of diverse food producers in confirming the alignment of their products with Norwegian and European food labeling regulations?"

1.2 Ethical Consideration

Various ethical factors were considered when developing the Fremtidsmat web calculator:

The most important ethical concern was the responsible handling of personal data and the protection of participants' privacy. The responsibility for ethically processing data and privacy was particularly critical as participants were involved in the development process via a User-Centered Design (UCD) approach. Given the regulations in Norway, the "Lov om behandling av personopplysninger (personopplysningsloven)" (Act on the Processing of Personal Data (Personal Data Act)) set by the EU General Data Protection Regulation (GDPR), all collected data during user testing were anonymised, keeping

participants' identities confidential (Datatilsynet, 2021, 2022; GDPR.EU, 2018; Lovdata, 2022). The necessary approval for user testing was obtained from SIKT (Norwegian Agency for Shared Services in Education and Research), making certain that all ethical requirements related to participant involvement, data collection, and confidentiality were kept throughout the process (SIKT, n.d.). It is important to note that the tasks regarding user testing were conducted by another master's student working on this project, Hammer Lars (Hammer, 2023).

Another key ethical concern was guaranteeing proper functionality and operation of the tool. The purpose of the Fremtidsmat web calculator is to assist food producers in confirming product compliance with Norwegian and European food regulations and guidelines, including Nøkkelhullet (The keyhole label), Ernæringspåstander (Nutrition Claims) and Helsepåstander (Health Claims) (Lovdata, 2015, 2017). If the web calculator misrepresents or complicates the representation of these claims, food producers might use these claims and mislabel their food products. Such errors during the web calculator's development expose Fremtidsmat, their members and business partners to potential legal risks, such as fines, but also operational losses, since they may have to redesign and reprint packaging or, in worst-case scenarios, discard products that cannot be shelved due to false claims.

Given the gravity of these mistakes, there was an ethical duty to ensure an accurate, user-friendly, and accessible representation of the Norwegian food labelling regulations during the web calculator's development. The dedication to accuracy also extended to the ethical considerations of enhancing research validity and maintaining academic integrity. Every decision addressing participants' issues and recommendations was based on transparent processes and methodologies. User feedback was analysed and cross-checked with Fremtidsmat representatives and Oslo Metropolitan University (OsloMet) academic staff during regular meetings on each iteration to avoid biases and make sure that the Fremtidsmat web calculator was developed based on objective findings instead of speculations. These concerns highlight the gravity of ethical responsibility when trusted to develop a tool like the Fremtidsmat web calculator, which is expected to comply with all legal regulations and guidelines.

Lastly, according to academic policies and ethical standards, a Transfer Declaration Agreement was signed with OsloMet, which defined the handling of any documentation

related to the project and confidentiality rights. The details of this agreement are included in Appendix Z and have been adhered to throughout the development process. Once completing this thesis, the ownership of the GitHub repository and all related materials was transferred to the project supervisor (See Appendix X).

Chapter 2: Literature review

2.1 Norwegian food labeling regulations

2.1.1 Nøkkelhullet (The keyhole labelling scheme)

Nøkkelhullet (The Keyhole labelling scheme) is a Nordic initiative that is designed to make it easier for individuals of all ages, backgrounds, and languages to make healthier food choices while grocery shopping (The Swedish Food Agency's, 2023;Wang et al., 2016). Opposed to more complex labelling systems such as the "UK Multiple Traffic Lights" or the Australasian "Health Star Ratings", Nøkkelhullet provides information about the total product, not nutrient content (Food Standards Agency, 2020; Health Star Rating.Australia, n.d.).

Figure 2- 1. Nøkkelhullet (The Keyhole) graphic design (Mattilsynet, 2023b).

Besides guiding consumers, Nøkkelhullet aims to contribute to the food industry by developing more healthy products. When food producers develop and promote products with the Nøkkelhullet label, they also promote their business by showing that they are committed to contributing to healthy eating (Mattilsynet, n.d.-a; Nordic Co-operation, 2021).

It is essential to understand that the Nøkkelhullet label is voluntary and free to use, and it is the responsibility of food producers to follow the criteria established by the authorities. Misleading labelling revealed during spot checks results in punishment by fine or imprisonment (Lovdata, 2021a; Mattilsynet, n.d.-a). Helsedirektoriatet (The Norwegian Directorate of Health), and Mattilsynet (The Norwegian Food Safety Authority (NFSA)), are responsible for Nøkkelhullet (The Keyhole label) in Norway (Helsedirektoratet, n.d.-b;

Helsenorge, 2022; Mattilsynet, 2023b). The Norwegian Directorate of Health provides recommendations on nutrition and diet that serve as the basis for the criteria for the label, whereas the NFSA ensures that food products bearing the Nøkkelhullet comply with the regulation.

However, adhering to the Nøkkelhullet regulation introduces more than legal challenges for food producers. The regulation is divided into 11 major groups and 32 subgroups, including a vast range of food products (Mattilsynet, n.d.-a, 2023b;Lovdata, 2015). Assessing the compliance of these food products with Nøkkelhullet regulations can be a complex procedure for food producers, especially those without employees with nutrition expertise.

To address these challenges and optimise product development processes, NOFIMA (The Norwegian Institute of Food, Fisheries and Aquaculture Research) proposed the development of the Fremtidsmat web calculator. A former master's student, Faisal Ahmed, initially developed the tool, and the design was explicitly based on the Nøkkelhullet food categorization (Ahmed, 2022). Building on the foundational design of the Fremtidsmat web calculator, the 11 major food groups, this thesis project aims to develop the tool's capability to assess food product compliance to Ernæringspåstander (Nutrition Claims) (European Commission, n.d.; Lovdata, 2017).

2.1.2 Ernæringspåstander (Nutrition Claims)

Understanding the complexities of nutrition claims regulation is vital when it comes to the further enhancement of the Fremtidsmat web calculator. As this thesis project focuses on developing the functionality of the web calculator to assess food product compliance with these claims, familiarizing oneself with these regulations is necessary. A detailed comprehension not only minimizes the chance of errors related to nutrition claims but also ensures that the implementation of nutrition claims and the overall functionality of the web calculator remain accurate. Recognizing the significance of these claims, it becomes essential to define and clarify their role in food labelling.

Nutrition claims refer to any statement, implication, or suggestion that a food product possesses specific beneficial nutritional properties (European Commission, n.d.). These claims can include information about the energy (caloric value) a food provides, the presence or proportion of certain nutrients or substances it contains, or the absence of certain nutrients or substances.

Research studies have shown that nutrition claims can effectively promote healthier food choices and raise consumer awareness of foods' nutritional content (Grunert et al., 2009; Hoefkens et al., 2011; Lähteenmäki et al., 2010; Øvrum et al., 2012; Kleef & Dagevos, 2014; Campos et al., 2011).

The European Food Safety Authority (EFSA) established guidelines based on scientific evidence to ensure that nutrition claims on food products are truthful and not misleading to consumers (Your Europe, 2023). As of 2023, EFSA provides a list of 30 permitted nutrition claims (European Commission, n.d.). These regulations aim to promote fair competition in the food industry, increase legal certainty for financial investment, and promote and protect innovation in the food industry (The Ministries' Security and Service Organization (DSS), 2012).

In Norway, Mattilsynet (The Norwegian Food Safety Authority (NFSA) is responsible for enforcing these regulations and monitors the use of Ernæringspåstander (Nutrition Claims) on food products (Lovdata, 2017; Mattilsynet, 2013, 2018; The Ministries' Security and Service Organization (DSS), 2010, 2012). It is important to note that businesses must familiarize themselves with these regulations when using Ernæringspåstander through voluntary labelling and marketing their food products (Mattilsynet, 2018). They must make sure that the claims comply with the provisions of the regulation and are not ambiguous, incorrect, or misleading. Furthermore, applying these claims must not raise doubts about other foods' safety or nutritional adequacy, encourage overconsumption, exploit fear in the consumer or discourage a balanced and varied diet (Mattilsynet, n.d.-c).

Incorporating Ernæringspåstander into the Fremtidsmat web calculator requires careful attention to detail. It must test the adherence of food products to the set regulations and assist food producers in reducing the gap between regulatory knowledge and real-life applications.

2.2 Accessibility in web design

2.2.1 Definition, importance, and components of web accessibility

Understanding web accessibility is critical for developing accessible websites, including the Fremtidsmat web calculator. This section provides an overview of these standards and support materials, as established by the World Wide Web Consortium (W3C) Web Accessibility Initiative (WAI)W3C, n.d.-h, n.d.-a, n.d.-e;DanielD, 2009; W3C, n.d.-b, 2023n).

The concept of web accessibility, as defined by the W3C, refers to the design of websites, tools, and technologies that can be easily perceived, interacted with, and navigated by everyone, including individuals with auditory, cognitive, neurological, physical, speech, and visual disabilities (W3C, 2022b). However, an officially accepted definition of web accessibility remains a challenge until today. A study by the University of York in London in 2015 highlighted the need for a clear definition when the researchers found 50 interpretations from 21 countries (Petrie et al., 2015).

Based on these findings, they proposed a unified definition of web accessibility (Petrie et al., 2015):

"All people, particularly disabled and older people, can use websites in a range of contexts of use, including mainstream and assistive technologies; to achieve this, websites need to be designed and developed to support usability across these contexts."

For this thesis, understanding these interpretations of web accessibility becomes crucial as they guide the design and functionalities of the Fremtidsmat web calculator, making sure it can be accessible to a wider audience. To achieve this web accessibility, various development and interaction components must work harmoniously (W3C, 2018a). These essential components are the foundational basis for the design and development of the web calculator.

- **Content**: All the information on a website, such as texts, images, and sound, and the code that structures them. Fremtidsmat's web calculator is a representation of all these features. It combines text, FontAwesome icons, the Nøkkelhullet logo, drop-down lists, and buttons, all developed using React (Font Awesome, n.d.-a; React, n.d.-a).
- **Users**: Individuals whose diverse experiences, knowledge, and adaptability shape their Web use. In the Fremtidsmat web calculator context, the users are primarily food producers aiming to develop food products aligning with the Norwegian food labelling dietary regulations (Lovdata, 2015, 2017). These users approach the web calculator with a diverse background of familiarity with these regulations, with some being experts while others might be beginners seeking insights and clarity.
- **Developers**: Professional individuals who design, develop, code, and maintain websites, as well as users who contribute to the web content. The team working on the Fremtidsmat web calculator includes nutrition and food experts, OsloMet

professionals, and two master students. One student is responsible for the development and heuristic evaluation, while the other focuses on user testing. This diverse team develops and ensures the web calculator is designed to assist each user, regardless of their knowledge levels or potential disability types, according to web accessibility standards.

- **Authoring and Evaluation tools**: Software tools that assist developers in creating websites and assessing their accessibility, including HTML verifiers, CSS validators, and more. The Fremtidsmat web calculator project's development environment is Visual Studio Code, with the React library as the primary coding framework. All code is hosted on GitHub and deployed through Vercel. Additionally, Faisal Ahmed, a former master's student, used the WAVE tool for web accessibility evaluation (Ahmed, 2022).
- **User agents**: Browsers, media players, and other software tools for users. Developed using the Bootstrap front-end toolkit, the web calculator is designed to be responsive across various significant browsers, be it on mobile devices or desktop browsers, such as Chrome, Firefox, Safari, Microsoft Edge, Opera and Internet Explorer and Android Browser & WebView (Bootstrap, n.d.-a).
- **Assistive technologies (ATs):** Software and hardware tools such as screen readers, alternative keyboards, etc. The web calculator aims to comply with W3C accessibility guidelines and standards, which inherently means it seeks to be accessible for users using screen readers or other AT tools.

When developing the Fremtidsmat web calculator, these interdependencies play an important role in ensuring web accessibility. Recognizing and effectively benefiting from these interdependencies is critical in building a tool that meets both technical requirements regarding the food industry and the unique needs of its users, such as their varying levels of familiarity with Norwegian food labeling regulations.

A figure from the W3C webpage illustrates the interdependencies between each component (W3C, 2018a):

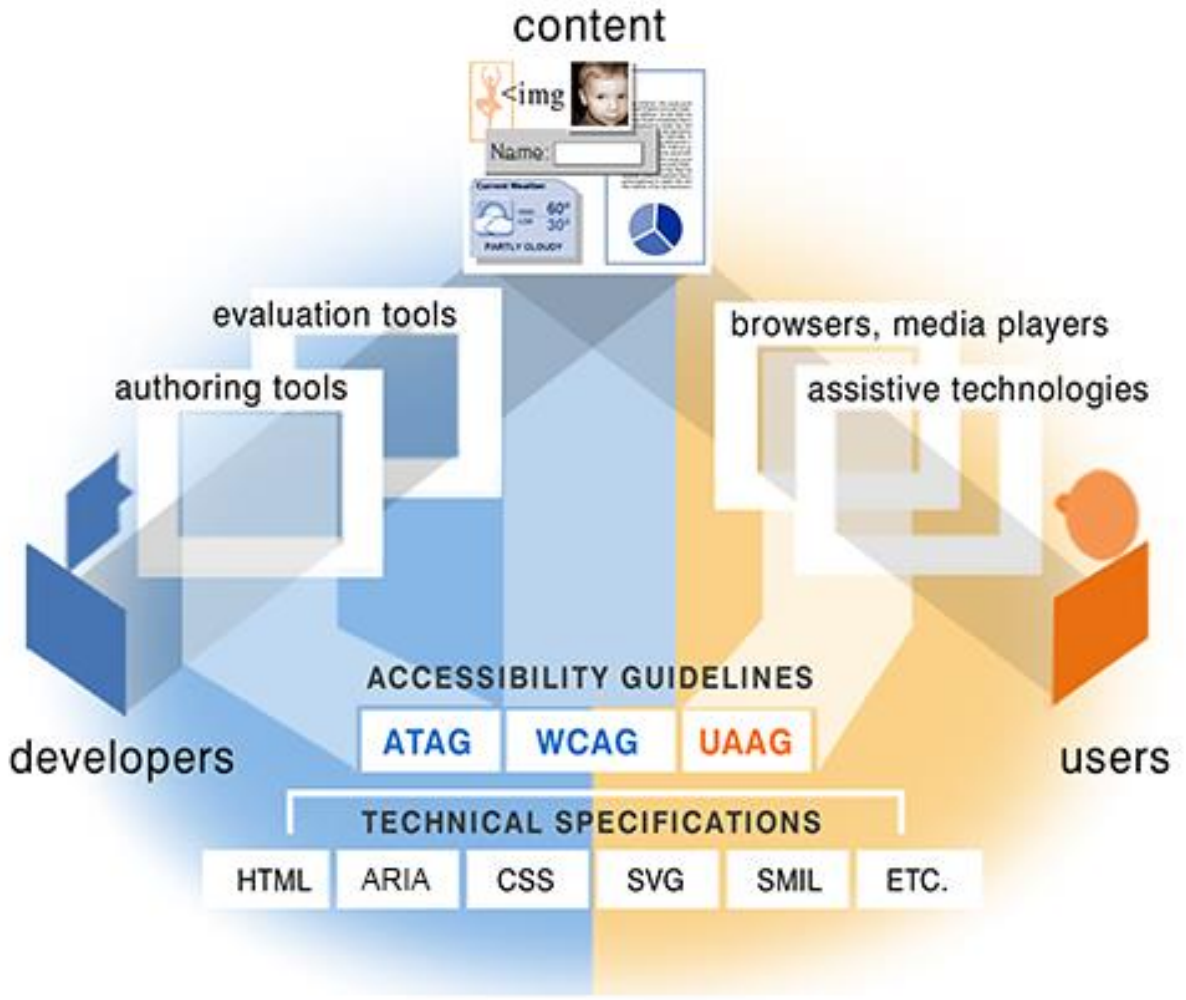


Figure 2- 2. Image of different components of web development and how they work together (Duffy M, n.d.).

2.3 Guidelines and standards of web accessibility

The W3C Web Accessibility Initiative (WAI) has developed a series of guidelines and standards, such as Web Content Accessibility Guidelines (WCAG), Authoring Tool Accessibility Guidelines, User Agent Accessibility Guidelines and Web Accessibility Initiative - Accessible Rich Internet Applications (WAI-ARIA) (W3C, 2022c). While all of these guidelines are critical to enhancing the accessibility of different web components, for the purpose of developing the Fremtidsmat web calculator, this section focuses on WCAG and WAI-ARIA.

2.3.1 Web Content Accessibility Guidelines (WCAG)

The Web Content Accessibility Guidelines (WCAG) are a series of recommendations for making web content more accessible to all users, especially those with disabilities (W3C, 2022c).

2.3.1.1 Principles

The WCAG has four key principles often referred to by the acronym POUR (perceivable, operable, understandable, and robust) (W3C, 2023h):

1. **Perceivable**: Web content must be presented in ways all users can perceive, regardless of their disabilities.
2. **Operable**: The User Interface (UI) and navigation components must be operable.
3. **Understandable**: Web content and the operation of the UI must be understandable.
4. **Robust**: Web content must be robust for many user agents and ATs to interpret it.

For users with disabilities to be able to use the Web, all four principles must be met.

2.3.1.2 Guidelines, success criteria, and conformance

There is a list of guidelines for each of the four foundation principles (W3C, 2023h). Each guideline is broken down into success criteria (SC), testable statements determining whether a website conforms to WCAG.

WCAG has three Levels of conformance, A, AA and AAA. Each Level has its own set of SC, as outlined below (W3C, 2023i):

1. **Level A**: A website conforms to Level A when it meets all the Level A SC, which is the minimum Level of conformance.
2. **Level AA**: A website conforms to Level AA when both all Level A and Level AA SC are met, which is the intermediate Level of conformance.
3. **Level AAA**: A website conforms to Level AAA when all three levels of SC are met or a Level AAA conforming version of the site is offered. AAA is the most advanced Level of conformance.

However, only some web content can meet Level AAA SC requirements. As a result, the W3C does not recommend for all websites aim for Level AAA conformance (W3C, 2023i).

Yet, more requirements exist for evaluating WCAG conformance (W3C, 2023i). Conformance of an online site to a certain level requires that the whole webpage meet the specific SC, ncluding all variations of it and online tasks that span within a series of web pages in a site, as online shopping or calculating adherence to Ernæringspåstander (nutrition claims) in the Fremtidsmat web calculator project, meet the specific SC. Additionally, any extra content accessed via the webpage must adhere to WCAG, too. However, when the site's content is out of the web developers' control, they can issue a "Statement of Partial Conformance". Regardless, while the web content might be true for the SC, it might not

always be accessible for all disability types. Therefore, besides evaluating conformance to the SC, heuristic and usability testing are also recommended.

All Fremtidsmat web calculator UI stages must adhere at least to Level A conformance, from inputting nutrient data to receiving feedback about compliance with Ernæringspåstander. Compliance of the website with the WCAG guidelines ensures that all users, no matter their ability or disability, can have an effortless experience.

WCAG has been constantly evolving through various versions, with currently two applied versions, WCAG 2.0 and WCAG 2.1, and WCAG 2.2 almost here (W3C, 2022c). When developing the Fremtidsmat web calculator, it's crucial to consider the recommendations of WCAG 2.1. Published in 2018, WCAG 2.1 builds on WCAG 2.0 by including 13 guidelines and an additional 17 SC (W3C, 2006, 2018c, 2020b). The new recommendations address mobile device accessibility issues and the needs of users with low vision and those with cognitive and learning disabilities. Please note that WCAG 2.1 is backwards compatible with WCAG 2.0, implying that conformance to WCAG 2.1 ensures conformance to WCAG 2.0. By adhering to these guidelines, the tool not only stays compliant with up-to-date web accessibility guidelines but also serves people with any type of disability, including users with low vision, cognitive and learning disabilities, and mobile device disability issues.

2.3.2 Web Accessibility Initiative - Accessible Rich Internet Applications (WAI-ARIA)

Web developers use HTML, CSS, and JavaScript to create dynamic content. For users with different types of disabilities, interaction with this content is enabled through AT. These ATs use semantics to identify assigned roles, states, and properties that apply to the UI and content elements. However, without proper semantics, these content elements become inaccessible to people using ATs (W3C, 2022a).

The Web Accessibility Initiative - Accessible Rich Internet Applications (WAI-ARIA) is a W3C technical specification offering guidelines to developers on implementing the correct semantics and making web content elements adaptable and more accessible for ATs(W3C, 2022c, 2023g). WAI-ARIA has been constantly evolving through its various versions, with three completed versions currently: WAI-ARIA 1.0, WAI-ARIA 1.1, and WAI-ARIA 1.2 (W3C, 2022a). WAI-ARIA 1.2, published in June 2023, extends WAI-ARIA 1.1, being the most recent version so far (W3C, 2023g). For developing the Fremtidsmat web calculator, it is crucial to incorporate the recommendations of WAI-ARIA 1.2, as it represents the latest advancements in web accessibility.

2.3.2.1 Principles

"No ARIA is better than Bad ARIA": While WAI-ARIA implementation is essential for enhancing accessibility, its misapplication can have devastating effects on the user experience of people relaying to ATs (W3C, n.d.-g).

Before implementing WAI-ARIA recommendations, it is paramount to understand the two following principles (W3C, n.d.-g):

1. **"A role is a promise":** When assigning a role, the developers must also incorporate the respective JavaScript so the element provides the expected behaviour.
2. **"ARIA can both cloak and enhance, creating both power and danger"**: WAI-ARIA can enhance or override content elements or semantics. WAI-ARIA gives developers the power to create accessible content that, otherwise, people using ATs wouldn't have the chance to use. However, the possibility of overriding HTML and Scalable Vector Graphics (SVG) elements presents a risk, as misapplication can lead to inaccessible web content.

When integrating WAI-ARIA 1.2 into a project such as the Fremtidsmat web calculator, following WAI-ARIA Principles is critical. Guided by these principles, the web calculator stays compliant with current recommendations such as WAI-ARIA 1.2 and highlights the importance of correct implementation. Careful attention must be paid to using WAI-ARIA to avoid misapplication, which can lead to the inaccessible web content of the web calculator.

2.3.3 Legal requirements for web accessibility

Being a vital resource for numerous life aspects, such as communication, education, employment, government, and health care, the Web has been regulated with various legal requirements to offer accessibility (W3C, 2018b, 2022b). Governments worldwide have implemented laws, policies, and regulations ensuring the accessibility of the Internet and other information and communications technologies (ICT), such as The UN Convention on the Rights of Persons with Disabilities (CRPD), The Accessibility for Ontarians with Disabilities Act (AODA) 2005, Section 508, the Americans with Disabilities Act (ADA), Equality Act 2010 (UK) and Norway's Regulation on Universal Design (UD) of Information and Communication Technology (ICT) Solutions (ADA.gov, n.d.; legislation.gov.uk, 2023; Lovdata, 2019; ontario.ca, 2015; section508, n.d.; United Nations, 2006). For the development of the Fremtidsmat web calculator, understanding and adhering to these legal requirements for web accessibility is crucial, as it contributes to creating a tool that can be both accessible

and inclusive. This section provides an overview of Norway's Regulation on Universal Design (UD) of Information and Communication Technology (ICT) Solutions) (Lovdata, 2019).

2.3.3.1 Norway's Regulation on Universal Design (UD) of Information and Communication Technology (ICT) Solutions

In 2009, Norway entered into force *the "Lov om forbud mot diskriminering på grunn av nedsatt funksjonsevne (diskriminerings- og tilgjengelighetsloven)"* (Act on Prohibition of Discrimination on the Ground of Disability), known as the Discrimination and Accessibility Act (Lovdata, 2008). The Act also specifically emphasised the duty to Universal design (UD) of ICT, stating that public and private businesses serving the general public, must actively incorporate UD in their ICT solutions.

By 2013, Norway provided further clarifications with the *"Forskrift om universell utforming av informasjons- og kommunikasjonsteknologiske (IKT)-løsninger"* (Regulation on universal design of information and communication technology (ICT) solutions) (Lovdata, 2019).

The regulation required specific compliance with accessibility standards:

- Private businesses and public broadcasters and their subsidiaries' online solutions: Must comply with the Web Content Accessibility Guidelines 2.0 Level AA (WCAG 2.0)/ ISO/IEC 40500:2012 standard at levels A and AA, with specific exceptions (ISO, 2012a, 2012b; W3C, 2018e).
- While public enterprises' online solutions, such as the Fremtidsmat web calculator: Must comply with the requirements of the European Union standard, "Accessibility requirements for ICT products and services.", EN 301 549 V3.2.1 (2021-03), which includes WCAG 2.1 Level AA (HF, 2021; uutilsynet, n.d.-b;W3C, 2005, 2018d).

Failure to comply with the 2013 Regulation can result in fines, pointing out the importance of accessibility evaluation during the development of the Fremtidsmat tool. The *"Digitaliseringsdirektoratet"* (the Norwegian Digitalisation Agency), referred to as Digdir, and the *"Tilsynet for universell utforming av ikt"* (The Authority for Universal Design of ICT), referred to as uutisynet, are responsible for supervising the adherence to the 2013 Regulation on UD of ICTs, further emphasising the legal responsibility of building an accessible web calculator (Digdir, n.d.; uutilsynet, n.d.-a).

In 2018, Norway enforced the *"Lov om likestilling og forbud mot diskriminering (likestillings- og diskrimineringsloven)"* (the Equality and Anti-Discrimination Act) (Lovdata, 2021). While it covered the general regulations or non-discrimination under a single legal act, for specific requirements on web accessibility, it refered to the 2013 Regulation on UD of ICT solutions and the 2009 Discrimination and Accessibility Act.

Considering all these national regulations, and the fact that the Fremtidsmat web calculator will be in co-ownership between Fremtidsmat and OsloMet, there is a need for compliance with the regulations concerning public enterprises' online solutions. Particularly since the tool is not only intended for research but also for future collaboration with the Helsedirektoriatet (The Norwegian Directorate of Health) and Mattilsynet (The Norwegian Food Safety Authority (NFSA)), it must adhere to the legal guidelines as specified under section "§ 4b" of "Forskrift om universell utforming av informasjons- og kommunikasjonsteknologiske (IKT)-løsninger", which requires compliance with the EN 301 549 V3.2.1 (2021-03) standard (Helsedirektoratet, n.d.-a; HF, 2021; Lovdata, 2019; Mattilsynet, n.d.-b). Ensuring compliance with EN 301 549 V3.2.1(2021-03), therefore WCAG 2.1 Level AA, not only enhances the user experience (UX) but also lowers the risk of potential lawsuits and fines for discrimination against users with disabilities (W3C, 2018c).

2.4 User-Centered Design (UCD) and usability.

Following a user-centered design (UCD) approach can result in good usability. This design approach aims to create systems that are accessible and usable through the active involvement of end users during the development process (Interaction Design Foundation, n.d.; Juárez-Ramírez, 2017; Shawn Lawton Henry, 2003). According to the International Organization for Standardization (ISO), usability refers to the extent to which a system, product, or service can be used effectively, efficiently, and satisfactorily by specified users in a particular context. Therefore, in the context of UCD, usability plays a crucial role in the design process to ensure that the end product meets the users' needs (ISO, 2019). The following sections provide an overview of UCD, its principles, and its activities.

2.4.1 Origins and principles of UCD

The term "UCD" originated in the 1980s from Donald Norman in his research laboratory at the University of California, San Diego (UCSD) (Don Norman, 1988, 2013). Furthermore, Jhon

D. Gould and Clayton Lewis also introduced the three key principles for UCD (Gould & Lewis, 1985):

1. **Early focus on users and tasks**: Which involves collecting information about the user characteristics and tasks to be performed. For the development of the Fremtidsmat web calculator, focusing early on users ensures that the calculator is designed with a clear understanding of their needs and expectations, ensuring that both experts and beginners in food production can understand functionalities easily.
2. **Empirical measurement**: Which requires the use of prototypes and simulations while observing, recording, and analysing users' performance. This principle is fundamental in developing the web calculator, as it allows the use of prototypes in real-life scenarios, ensuring a data-driven approach to UI improvements.
3. **Iterative design**: Which aims for continuous evaluation and modification of the UI based on user feedback and performance. In developing the Fremtidsmat web calculator, following this principle would mean that each iteration would help minimise risks when it comes to failing to meet user or organisational needs, enhancing the final prototype's usability and accessibility.

Since this thesis aims to develop an accessible web calculator for diverse food producers, following these three principles for UCD is crucial.

2.4.2 UCD in ISO 9241-210:2010

UCD is often used as a synonym for Human-centered design (HCD) (Frank E. Ritter, 2014; Holeman & Kane, 2019; ISO, 1999, 2010b; Juárez-Ramírez, 2017; Tero Väänänen, 2022). The ISO develops and publishes International Standards, including guidelines on UCD (HCD) activities, principles, and their integration into the design and development of interactive systems (ISO, n.d.). The 200 series of ISO 9241 standard focuses on human-system interaction processes, with Part 210 specifically discussing UCD for interactive systems (ISO, 2010a; Nikolay Nikolov, 2023; Wikipedia, n.d.). ISO 9241-210:2010 highlights that the planning of UCD should involve identifying methods, resources, and responsible individuals and organisations for the activities, as well as establishing communication and feedback procedures, milestones, and a schedule for iteration and design changes (ISO, 2010a).

2.4.3 Activities according to ISO 9241-210:210

The following UCD activities have been reviewed because of their relevance to developing digital tools, particularly Fremtidsmat web calculators. Understanding these activities sets the foundation for the specific methodologies used in developing the web calculator.

Based on the ISO 9241-210:2010 standard, the following UCD activities should be taken into consideration when developing the Fremtidsmat web calculator (ISO, 2010a):

1. ***Understanding and specifying the context of use.***

   A thorough description of the context in which a system will be used should cover four areas, such as:

   - Users and stakeholders:

     Relevant user groups and stakeholders should be identified, and their needs, goals, and limitations concerning the system should be defined.
   - User characteristics:

     User characteristics such as knowledge, skills, experiences, education, physical characteristics, habits, preferences, and abilities should be identified. Legal requirements and other accessibility design requirements should be considered for users with different levels of experience or physical capabilities. The ISO/IEC 29138-1 standard can be used to identify user accessibility needs when applied to the information technology domain (ISO, 2018).
   - User goals and tasks:

     Users' and systems' goals, potential risks, and safety concerns regarding task completion should be identified.
   - System environment :

     Technical characteristics (hardware, software, materials), along with physical (temperature, lighting, space, and furniture), social, and cultural aspects of the environment, should be identified and described.

When developing the Fremtidsmat web calculator, understanding the user, stakeholders, their goals and their tasks is crucial, as the purpose of the tool is to assist food developers, each with different levels of expertise with the Norwegian food labelling regulations, with some users being experts while at the same time, others might be

beginners seeking insights and clarity regarding why their food product adheres or not to these regulations.

2. ***Specifying the user requirements.***

   Identifying the context of use in UCD should be further expanded into a clearer statement of user requirements. The user requirements specifications should include the following:

   - Requirements specified by the context of use.
   - Requirements based on user needs and the context of use.
   - Requirements based on standards and guidelines.
   - Requirements based on usability and objectives.
   - Requirements based on any organizational requirements that affect the user.

Any potential conflicts between user requirements must be resolved and documented to ensure future understanding. During the development of the Fremtidsmat web calculator, usability and accessibility requirements should be prioritised, as the calculator would be built to assist a broad range of users while balancing the needs of experts and beginners in the food industry.

3. ***Producing design solutions.***

   Producing the design solution should involve these sub-activities:

   - Designing user tasks, interactions, and interfaces that meet user requirements, while considering the whole user experience.
     User experience is strongly impacted by design decisions. In order to give the user a good experience, the seven principles introduced in ISO 9241-110, such as task suitability, self-descriptiveness, user expectation conformity, learnability, controllability, error tolerance, and individualization, should be considered when designing (ISO, 2020).
   - Making design solutions more concrete.
     Using scenarios, simulations, prototypes, or mock-ups when making design solutions has several benefits, such as:
     - Helping the design team communicate with each other and users from the early stages.

    - Giving designers a chance to explore different design solutions before selecting one.
    - Enabling early integration of user feedback into the design during the development process.
    - Enabling the evaluation of multiple design iterations.
    - Boosting the quality and clarity of the functional design specification.
- Adjusting design solutions based on user-centered evaluation and feedback.
- Communicating design solutions to those responsible for implementation.

When developing the Fremtidsmat web calculator, creating design solutions and prioritising the user experience is essential. This involves ensuring nutrient data is easily inputted, adherence results of the food product with Nøkkelhullet, Ernæringspåstander and Helsepåstander are clear, and the overall experience is intuitive.

4. ***Evaluating the design.***

User-centred evaluation can gather information about user needs, offer feedback regarding design strengths and weaknesses, determine if user requirements are met, and establish baselines or compare designs.
The process of user-centred evaluation applies to providing resources for feedback, fitting the evaluation into the project schedule, conducting comprehensive testing, analysing and prioritising results, and communicating solutions to the design team. The ISO/TR 16982 standard can be used to find detailed information on user-centred evaluation methods and various techniques. The two most popular user-centred evaluation approaches according to the standard are user-based testing and inspection-based evaluation (ISO, 2002a, 2002b, 2002c).

Evaluation is an essential step in the development process of the Fremtidsmat web calculator. When developing the Fremtidsmat web calculator, it is essential to conduct both evaluation approaches, user-based testing and inspection-based evaluation, enhance the tool's functionality, usability, and

accessibility. Note that the team working on this thesis project consisted of two master's students. Hammer Lars, another master's student, focused on user-based testing as detailed in his thesis paper (Hammer, 2023). Consequently, it is vital that this thesis paper focuses on incorporating an inspection-based evaluation of the web calculator.

As mentioned by the ISO 9241-110 standard, inspection-based evaluation using usability and accessibility guidelines includes:

- Document-based methods: Involves having usability specialists evaluate existing documents to form a professional system assessment.
- Model-based approaches: These approaches involve the prediction of users' performance using abstract models of the product being evaluated.
- Expert evaluation: Relies on the usability specialist's knowledge, practical experience, and expertise in the field of ergonomics.
- Automated evaluation: Involves detecting product flaws compared to predetermined rules, using algorithms that focus on usability guidelines or ergonomic knowledge-based systems.

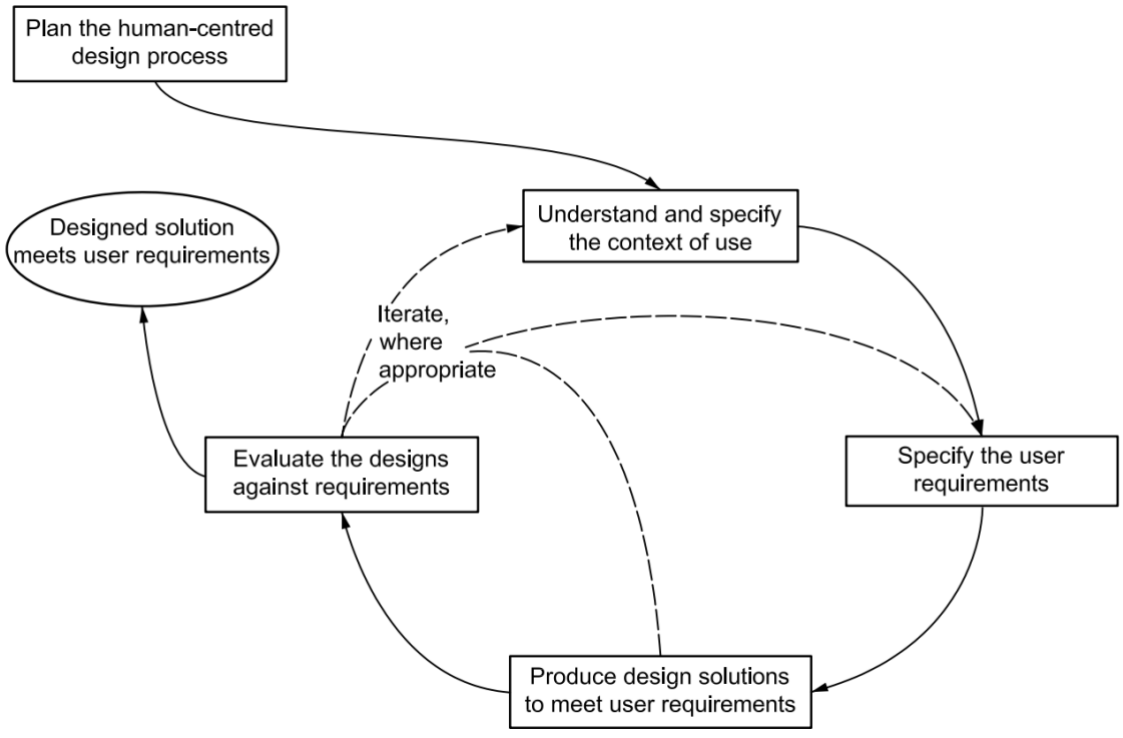


Figure 2- 3. The processes involved in designing interactive systems that prioritize User-Centered Design (UCD) (ISO, 2010a, 2010b).

Figure 2-3, the interdependence of UCD activities, pointing out that there does not have to be a strictly linear process, just continuous iterative refinement when appropriate (ISO, 2010a, 2010b). In the development process of the Fremtidsmat web calculator, the flexibility offered by UCD methodology is crucial. This adaptability allowes the development team to quickly address usability and accessibility issues and continuously update UI elements, ensuring an accessible and user-friendly web calculator.

2.5 Heuristic evaluation (HE) in web development

Heuristic Evaluation (HE) is a usability inspection method where evaluators find usability issues within a UI to ensure compliance with basic usability principles, referred to as "heuristics" (Moran Kate, 2023; Nielsen, 1992; Nielsen Jakob, 1994). The goal of this "debugging" method is to identify usability problems and provide suggestions for how to solve them (Nielsen, 1992). Many practitioners have categorized it under "discount" usability evaluations since it uses straightforward and approximate methods without requiring many resources instead of the other testing methods (Muller J. Michael et al., 1998; Nielsen, 1992; Nielsen Jakob, 1994; Nielsen Norman Group, n.d.-a). When it comes to constrained research environments, such as the Fremtidsmat web calculator master's thesis project, HE is the ideal approach. However, it becomes crucial to understand the heuristics being applied, not only for conducting a thorough evaluation but also for recognizing the potential limitations and biases that follow their application.

Initially, HE was invented for engineering inspectors who knew usability, implying regular specialists are considered better than novice evaluators when conducting HE sessions (Nielsen, 1992). Research also shows that a single inspector often identifies only 20-51% of the usability issues during an evaluation (Nielsen et al., 1990). Therefore, when inspecting an interface, depending exclusively on the results of one single individual is not recommended (Nielsen Jakob, 1994). However, the detection increases significantly when there are up to five inspectors, with about 75% of the usability issues being found (Kiliç Delice & Güngör, 2009; Moran Kate, 2023; Nielsen et al., 1990). Beyond this, more specifically for up to ten inspectors, the lowest peak point is being reached. As a result, the HE is recommended to be conducted with a team of three to five inspectors with a regular expertise level or with a team of two to three "double" experts, typically those experts in software engineering, usability, or both (Muller J. Michael et al., 1998;Nielsen, 1992).

Unfortunately, organizing a team and finding double experts can be challenging and costly, especially for a thesis project like this one.

In the early stages of the Fremtidsmat web calculator's development, adopting the HE approach and ensuring alignment with WCAG 2.1 principles is vital. Therefore, this section focuses on HE and highlights Accessibility Conformance Evaluation Methodology (WCAG-EM), where WCAG 2.0 is used as a heuristic (See 2.3.1 Web Content Accessibility Guidelines (WCAG)) (W3C, 2014b).

2.5.1 Website Accessibility Conformance Evaluation Methodology (WCAG-EM)

The Website Accessibility Conformance Evaluation Methodology (WCAG-EM) is one such methodology designed to evaluate the conformance of web content to WCAG. In 2014, the W3C published the Website Accessibility Conformance Evaluation Methodology (WCAG-EM) 1.0 to guide the evaluation process of conformance to WCAG 2.0 (W3C, 2005, 2014). For this master's thesis project, WCAG-EM 1.0 should be used as a testing guide. Using this conformance evaluation methodology, the developers can conduct a heuristic evaluation to test the website's adherence to WCAG 2.1 AA standards (W3C, 2018c).

2.5.1.1 WCAG-EM procedure

The WCAG-EM has five steps. These steps illustrated in Figure 2-4, might not always be in a particular order, as their order varies based on the type of website, the evaluation purpose, and the evaluator's methods.

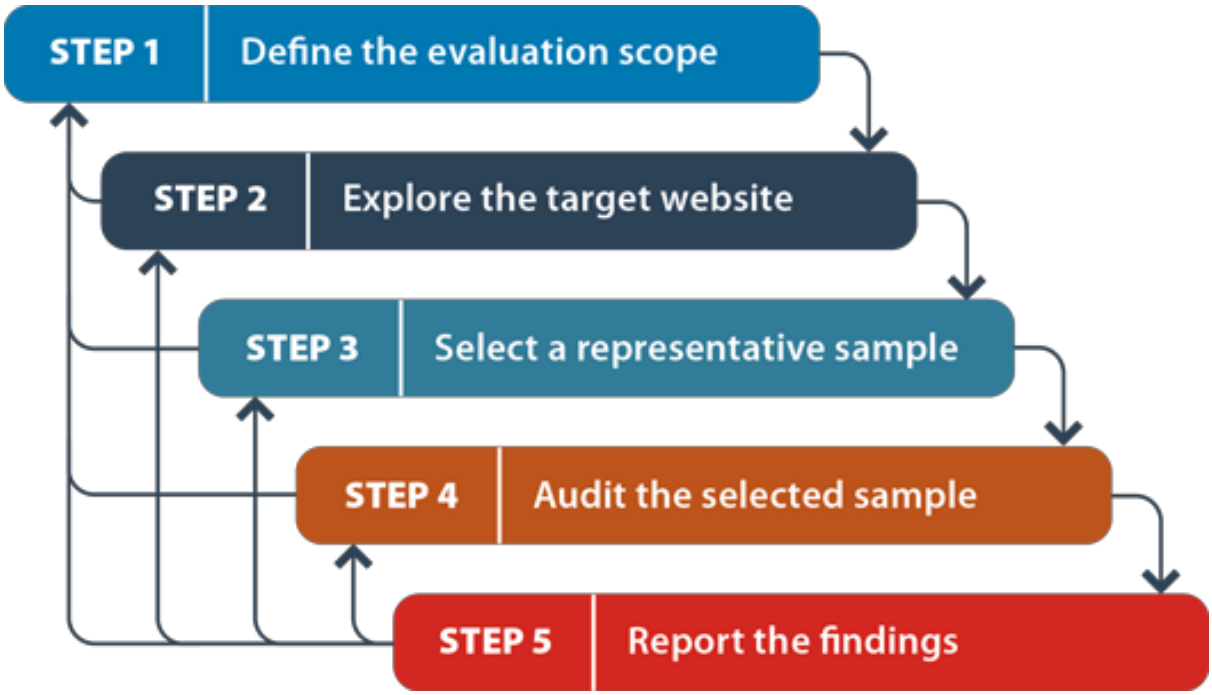


Figure 2- 4. The figure illustrates the five steps and activities of a conformance evaluation procedure (W3C, 2014).

The five steps of the WCAG-EM are (W3C, 2014):

1. **Define the evaluation scope**: During this step, the target website is defined, the target WCAG 2.0 conformance level is determined, the web browser, ATs, and user agents that are supposed to be supported on the target website are identified, and optionally, any additional criteria are outlined, such as specific user groups, use cases, reporting templates, or adherence documentation. For the Fremtidsmat web calculator project, the primary aim is to achieve conformance to WCAG 2.1 AA standards according to the Norwegian *"Forskrift om universell utforming av informasjons- og kommunikasjonsteknologiske (IKT)-løsninger"* (Regulation on universal design of information and communication technology (ICT) solutions) (Lovdata, 2019).
2. **Explore the target website**: During this step, the essential web pages of the target website are explored by identifying the basic functionality of the site and the main web pages, categorizing the various types of these web pages, recognizing the primary web technologies, and pointing out pages relevant to accessibility and individuals with disabilities.
3. **Select a representative sample**: During this step, evaluators pick a web page sample that is 10% random, and the rest includes specific key criteria. Since the Fremtidsmat web calculator is a small website, there is no need for a 10% random sample. The entire site should be examined because of its limited scope. Only functional and implemented features should be evaluated.
4. **Audit the selected sample**: During this step, all the web pages from the sample are evaluated using five primary WCAG 2.0 conformance criteria according to the agreed conformance level.
5. **Report the findings**: During this step, evaluation findings documented throughout the whole process, together with the methods used to test compliance, are reported in a detailed

statement with the evaluation results in a machine-friendly format.

The Fremtidsmat web calculator is currently in its developmental phase, with additional enhancements planned for the near future. While this thesis represents only a portion of the overall development plan for the website, it is crucial to use the WCAG-EM methodology during this stage. By conducting this conformance evaluation early on, potential accessibility barriers can be pointed out and addressed, making it easier for future updates to stay accessible.

Chapter 3: Methodology

This chapter presents the methodologies and techniques used to develop the Fremtidsmat web calculator.

3.1 User-Centred Design (UCD) approach

This thesis uses a User-Centred Design (UCD) approach to the development of the web calculator. The methodology was guided by the activities mentioned in ISO 9241-210:2010 (see 2.4.3 Activities according to ISO 9241-210:210 and complemented by the key principles proposed by Gould and Lewis (see 2.4.1 Origins and principles of UCD (ISO, 2010b; Gould & Lewis, 1985)

1) **Understanding and specifying the context of use (Early focus on users and tasks):**

   To gain an understanding of the user characteristics and tasks to be performed, an initial meeting was held with employees of Fremtidsmat and OsloMet academic staff relevant to this project. During this meeting, Fremtidsmat detailed their collaboration partners, business members, their future goals, and the challenges that food producers face in developing healthier food products that adhere to labelling regulations. It was emphasised that the purpose of the tool is to be designed for food producers, not the general population. All this information provided a foundational understanding of the end users, the tasks they would perform with the web calculator, and the challenges they expected to overcome using the tool. By laying out this preparatory work and gaining an understanding of the users and their tasks, the project successfully aligned with the UCD principle of "Early focus on users and tasks".

2) **Specifying the user requirements (Early focus on users and tasks):**
   In line with the UCD principle of "Early focus on users and tasks", and based on the context of use, specifications of user requirements were further identified. These requirements included usability and accessibility of the web calculator. In particular, the tool should be easy to use for a broad range of users, from experts to beginners in food labelling regulations. In order to make web calculator accessible to these diverse users, it must also adhere to the accessibility regulations, such as the *"Forskrift om universell utforming av informasjons- og*

kommunikasjonsteknologiske (IKT)-løsninger" (Regulation on universal design of information and communication technology (ICT) solutions), which requires websites adherence to accessibility standards like the Web Content Accessibility Guidelines (WCAG) 2.1 Level AA (Lovdata, 2019; W3C, 2018c). Another requirement would be ensuring reliable functionality, as the tool must accurately perform calculations and assessments of food products related to Norwegian and European food safety guidelines and regulations. These requirements were a basis for developing the web calculator, guiding the design and functionality decisions in the following stages.

3) Producing design solutions (Empirical measurement and Iterative design):

A combination of the UCD principles of "Empirical measurement" and "Iterative design" was applied to ensure that the web calculator evolved while simultaneously becoming responsive to the needs and expectations of its end users through a collaborative strategy. The team working on this thesis project consisted of two master's students. Hammer Lars, one of the students, was responsible for conducting user testing, gathering empirical data and feedback from Fremtidsmat employees and business members, both first-time users and more familiar with the prototype (Hammer, 2023). After every round of user testing, a usability issues report was prepared and shared with the team. The team would discuss and review the reports on user feedback, identify usability issues, and prioritise development tasks. Afterwards, the developer would address these usability issues and integrate new UI features within the web calculator's development iterations.

This collaborative approach ensured that the web calculator was developed based on empirical evidence gathered directly from end-users. Specifically, the Fremtidsmat web calculator's development was structured in five iterations, with iterations building on the insights and feedback from the prior one:

1. The first iteration involved tasks such as understanding the state of the project as it was inherited from its previous developer and laying the ground for future development. Improvements included addressing code readability and implementing a drop-down list for energy unit selection.

2. The second iteration involved tasks such as addressing usability issues reported by users during the first round of user testing. The main implementations included adding a button for new products, renaming the search button for clarity, and reordering nutrients for better user comprehension. The second iteration also initialised the integration of Ernæringspåtander (Nutrition Claims), particularly the "Uten tilsatt sukker" (With no added sugars) claim.
3. The third iteration continued with the integration of Ernæringspåstander with the implementation of the "Lavt sukkerinnhold" (Low sugars) claim according to EFSA guidelines, addressing usability issues reported by users during the second round of user testing, and addressing accessibility issues based on personal notes.
4. The fourth iteration continued addressing usability and accessibility issues reported during the third round of user and considering the tester's observations and feedback, particularly modifying the presentation and functionality of the Ernæringspåstander results container and other UI elements.
5. The fifth iteration included implementing the last of the sugar-related Ernæringspåstander, such as the "Med et naturlig innhold av sukker" (Contains naturally occurring sugars) and the "Sukkerfri" (Sugars-free) claim according to EFSA guidelines, while also addressing usability issues reported during the fourth round of user testing.

Representatives from Fremtidsmat and business members were actively involved during each iteration, contributing via user testing sessions and offering feedback on the usability and functionality of the web calculator. Additionally, through regular consultations and meetings, academic staff from OsloMet provided valuable insight, reviewed user feedback, and offered guidance on prioritising and addressing accessibility and usability issues. Therefore, each iteration allowed the developer to enhance the user interface (UI) and functionality of the Fremtidsmat web calculator. Based on the feedback and insights gathered, the developer would implement design modifications and advancements, such as addressing the identified usability issues

and introducing new dynamic features, emphasising integrating sugar-related Ernæringspåstander (Nutrition Claims).

4) Evaluating the design (Empirical measurement and Iterative design):

For evaluating the Fremtidsmat web calculator design, two popular user-centred evaluation approaches were conducted: user-based testing and inspection-based evaluation.

Managed by another master's student, Hammer Lars, user-based testing of the web calculator employed the UCD principles of "Empirical Measurement" and "Iterative Design" (Hammer, 2023). As outlined in Hammer's thesis, this approach included a multimethod strategy, utilising Nielsen's heuristics and feedback from five participants (Nielsen Norman Group, n.d.-a). The testing was executed in four iterations, where in each iteration, participants completed several tasks, questionnaires, and interviews. Moreover, users were shown mockup prototypes during these testing sessions, allowing them to provide insights into potential UI features and the overall functionality of the tool. These insights were critical to the development of the web calculator. In collaboration with OsloMet and using services from SIKT (Norwegian Agency for Shared Services in Education and Research), it was made sure that legal requirements for processing personal data were met (SIKT, n.d.). The participants' data for this research included names, ages, occupations, and audio/video recordings from the testing sessions.

As part of following the "Empirical measurement" principle, and to compliment user-based testing, a Heuristic Evaluation (HE) was conducted by the developer to ensure a coverage of accessibility issues. The HE was conducted using the Website Accessibility Conformance Evaluation Methodology (WCAG-EM), adhering to Web Content Accessibility Guidelines (WCAG) 2.1 Level AA as guiding heuristics (W3C, 2014, 2018c). A checklist was created, and findings were documented using the WCAG-EM Report Tool (W3C, n.d.-f). By conducting a HE at the end of the final iteration, several accessibility issues were uncovered and noted to be addressed for future work.

By combining these two methods, a thorough evaluation of the web calculator's usability and accessibility was achieved.

3.2 Heuristic Evaluation (HE)

This section provides a comprehensive overview of the methodology employed for conducting a Heuristic Evaluation (HE) of the Fremtidsmat web calculator. The evaluation used the Web Content Accessibility Guidelines (WCAG) 2.1 as heuristics, in alignment with Norwegian legal requirements for web accessibility (W3C, 2018c). Specifically, it was aimed at a conformance target of Level AA, as highlighted by *"Forskrift om universell utforming av informasjons- og kommunikasjonsteknologiske (IKT)-løsninger"* (Regulation on universal design of information and communication technology (ICT) solutions) (Lovdata, 2019). This step was crucial not only to enhance the user experience but also to reduce the risks of potential lawsuits and fines related to potential discrimination against users with disabilities disabilities (Lovdata, 2008, 2019, 2021; W3C, 2020a).

The evaluation methodology followed the five-step process detailed in Website Accessibility Conformance Evaluation Methodology (WCAG-EM) 1.0, a procedure developed by the World Wide Web Consortium (W3C) for assessing a website's adherence to the WCAG (W3C, 2014). Given that the Fremtidsmat web calculator is a small site with only two web pages and a few functionalities, the entire website, including the homepage and the nutrition calculator page, was evaluated. Considering the developmental phase of the tool, only the current functional features within these web pages were assessed.

Due to regulations in Norway, specifically, the "Lov om behandling av personopplysninger (personopplysningsloven)" (Act on the Processing of Personal Data (Personal Data Act)) set by the EU General Data Protection Regulation (GDPR), and the short timeframe of this thesis, collecting data about the potential users' disabilities becomes restrictive (Datatilsynet, 2021, 2022; GDPR.EU, 2018; Lovdata, 2022). Therefore, not having this information about the food producers, adjusted the evaluation strategy and focused on a broad user base instead of specific disability types. Consequently, disability-oriented testing and assistive technology evaluations were not carried out.

The evaluation was conducted using a major desktop browser, Google Chrome, on Apple devices, specifically a MacBook Pro 13 and an iPhone 13. This choice was based on the

availability of these devices, and constraints in budget and time for testing on other devices or browsers.

To ensure a careful evaluation, the website was explored to fully understand core functionalities, layout, and user interaction capabilities. A checklist created for this evaluation, in combination with the WCAG-EM Report Tool provided by the W3C, was used to document findings and generate the evaluation report (W3C, n.d.-f).

3.3 Development

The Fremtidsmat web calculator was initially developed by Faisal Ahmed during his time as a master's student at OsloMet (Ahmed, 2022). When the project was passed to continue its development for the current thesis, it involved several steps and technical considerations, as discussed below:

Ahmed's prototype of the Fremtidsmat web calculator was specifically focused on the Nøkkelhullet guidelines (Ahmed, 2022). The prototype allowed users to input data related to the nutritional content of food products, which are organized according to the Nøkkelhullet scheme. Upon clicking the "search" button, the calculator would display the results and inform the user if the product complies with the Nøkkelhullet criteria. When one or more nutritional values do not meet the criteria, the calculator would highlight the corresponding row on the nutritional content column and provide the user with a hyperlink to the Lovedata website, where they can access detailed information on Nøkkelhullet regulations.

The following figures illustrate the various functionalities of the previously developed Fremtidsmat web calculator prototype:

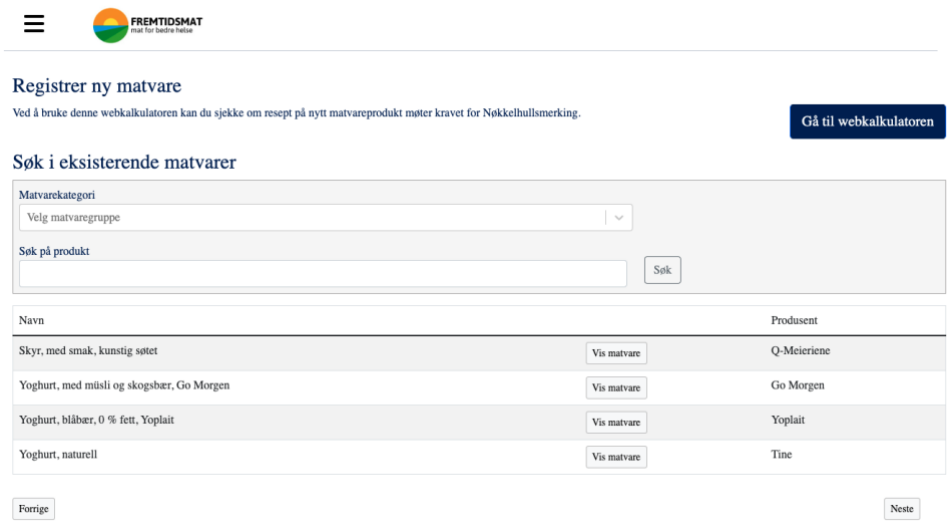


Figure 3- 1. A screenshot of the user interface (UI) on the homepage of the Fremtidsmat web calculator's pre-existing prototype.

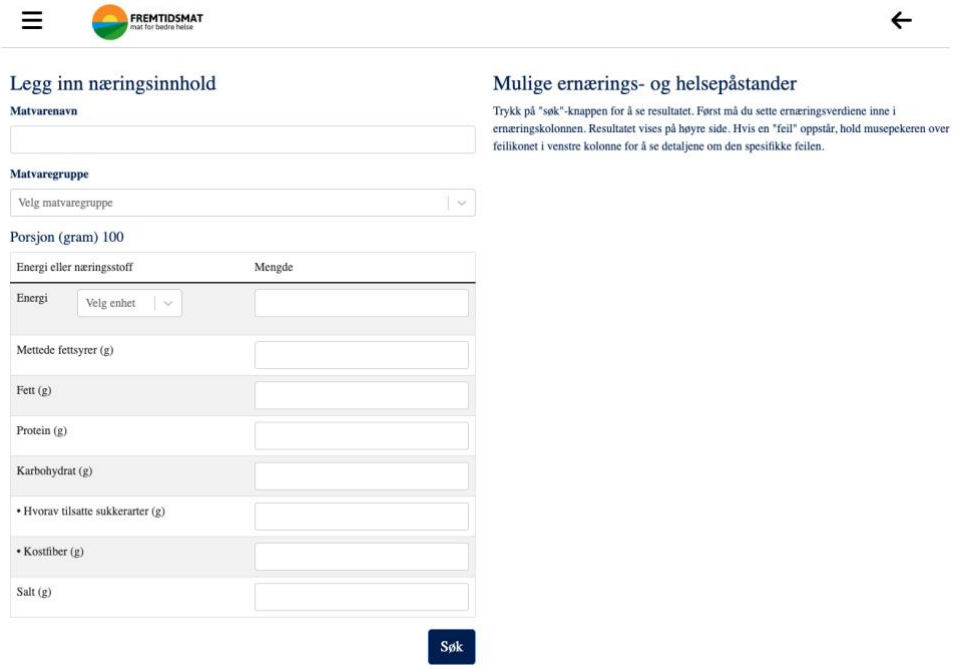


Figure 3- 2. A screenshot of the nutrition calculation webpage UI within the Fremtidsmat web calculator's website.

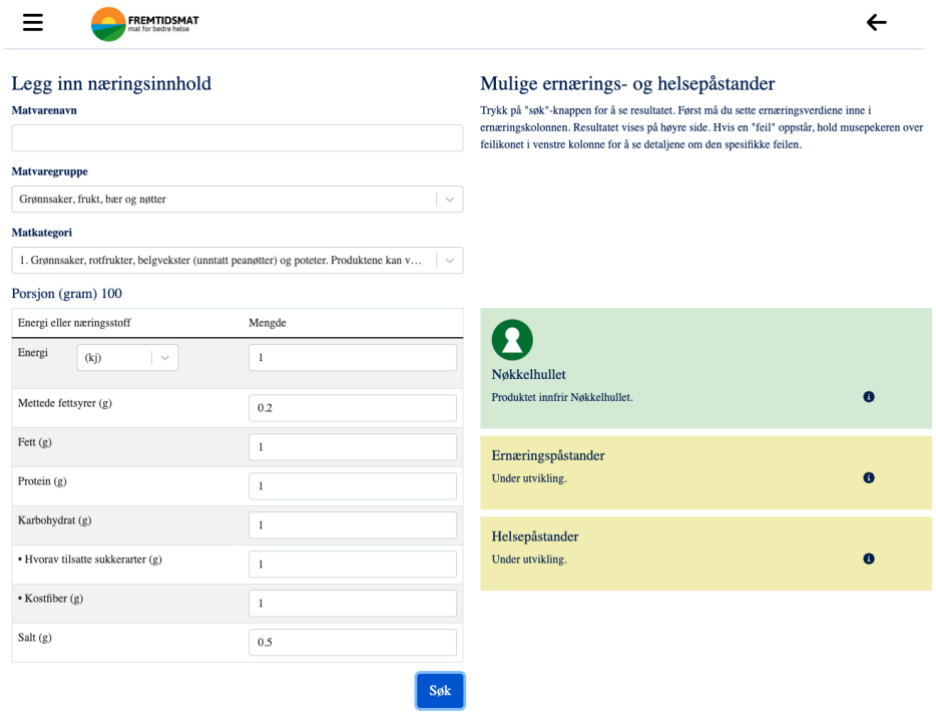


Figure 3- 3. Screenshot of the Fremtidsmat web calculator UI, highlighting the results container when a food product conforms to the Nøkkelhullet criteria.

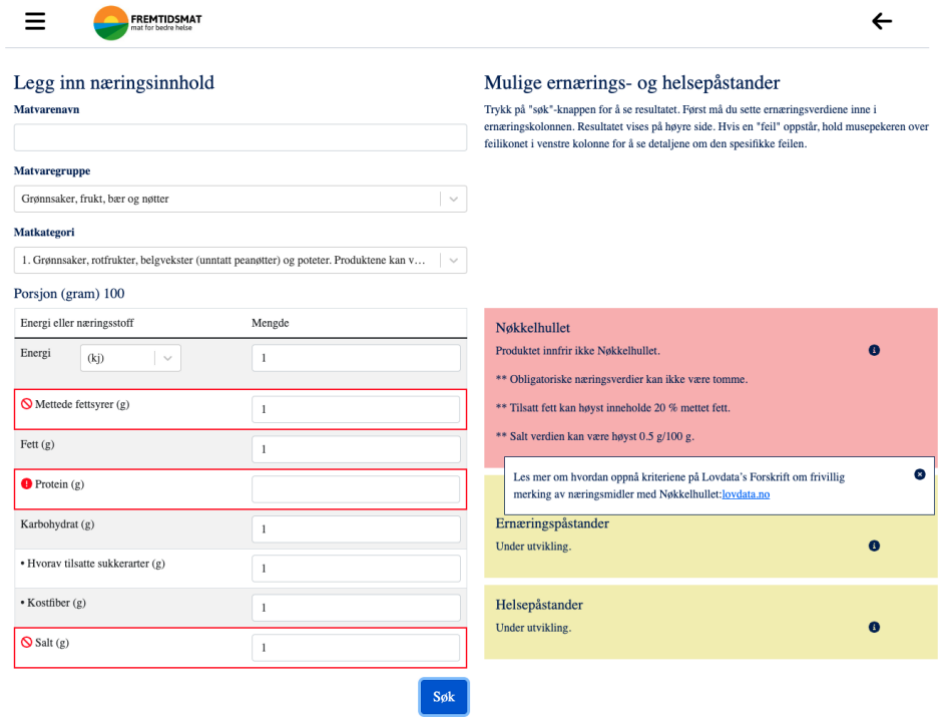


Figure 3- 4. Screenshot of the Fremtidsmat web calculator UI, highlighting the results container when a food product does not conform to the Nøkkelhullet criteria.

After the knowledge transfer, a detailed analysis of the calculator's existing structure was conducted. This thorough analysis included understanding its components and identifying potential improvements, especially regarding code readability and usability.

Next, the code was synced with GitHub using GitHub Desktop, allowing the development team to collaborate more efficiently, track changes, and manage revisions. GitHub Desktop simplified pushing changes, creating branches, and managing pull requests. The web calculator was also deployed online via Vercel, a platform directly linked to GitHub. Vercel was chosen mainly for the zero cost of use, offering a live website for testing and gathering real-time user feedback, which is essential in developing an interactive webpage like the Fremtidsmat web calculator.

3.4 Incoporation of sugar-related Ernæringspåstander

After a meeting with Fremtidsmat and OsloMet academic staff, this thesis project's focus was limited to implementing sugar-related nutrition claims. Specifically, the nutrition claims integrated into the web calculator were: "Lavt sukkerinnhold" (low sugars), "Sukkerfri" (sugars-free) and "Uten tilsatt sukker" (with no added sugars), and the "Med et naturlig innhold av sukker" (contains naturally occurring sugars) claim (European Commission, n.d.; Lovdata, 2017; Mattilsynet, 2013). The decision to implement only sugar-related claims was taken due to time constraints.

These sugar-related nutrition claims were integrated into the web calculator across five iterations, each synchronized with user testing. This iterative approach ensured the tool was developed by continuously incorporating user feedback, addressing usability issues, and conforming to web accessibility standards like WCAG and WAI-ARIA (W3C, 2022a, 2023h).

Chapter 4: Results

The process of developing an accessible web calculator for Fremtidsmat occurred in five iterations. This chapter provides a thorough overview of the tasks completed during each iteration.

4.1 First Iteration

4.1.1 Addressing code readability

When taking over the project, it was noticed that the previous developer, Faisal Ahmed, had not included any comments in the code (Ahmed, 2022). As a result, understanding the functionality of different code sections took more work and time.

The code was carefully reviewed, and comments were added to clarify the purpose and functionality of various sections, functions, and variables. Please see Appendix A for detailed code snippets and their respective comments.

Adding these comments to the code not only improved the understanding of the code during this iteration but will also make it easier for other developers to work on the project. These comments can help the development team have a better collaboration and knowledge transfer, while saving time and effort when updating, fixing bugs, or implementing new features.

4.1.2 Implementing drop-down list for energy unit selection

Based on feedback from the project supervisor and to enhance the user experience (UX), a new feature was introduced, specifically creating a functional drop-down list for energy units, kilojoules (kj) and kilocalories (kcal).

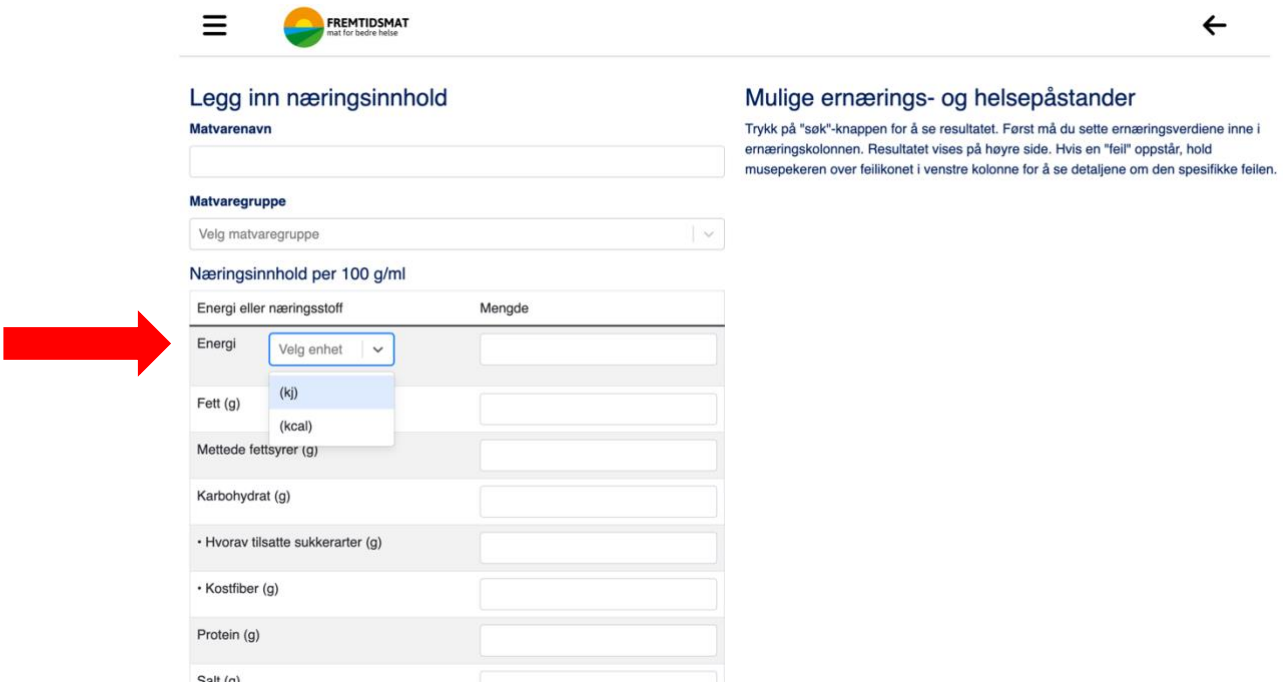


Figure 4- 1. A screenshot the "Velg enhet" (Choose unit) feature with the options "kilojoules (kj)" and "kilocalories (kcal)".

Detailed code snippets about the changes made during the first iteration can be found in Appendix B.

4.2 Second iteration

4.2.1 Addressing usability issues

4.2.1.1 Report on usability issues – user-based testing iteration 1

The following is the user-based testing feedback collected from first iteration of user-based testing as reported by the tester, Hammer Lars:

"

- *The biggest issue both participants faced was the order of the nutrients. They found it confusing that the order they need to put in the nutrients is not the same way as it is supposed to be listed.according to the regulations.*
    - *The order of the calculator now is: Energi, mettende fettsyrer, fett, protein, karbohydrat, hvorav tilsatte sukkerarter, kostfiber, salt.*
    - *How it should be: Energi, fett, mettende fettsyrer, karbohydrater, hvorav tilsatte sukkerarter, kostfiber, protein, salt..*
- *A bug was found as well. When karbohydrater is not meeting the requirement, the results is showing the wrong label. It shows that "tillsatte sukkerarter" is to high in sted of karbohydrater.*

- *One of the participants also said that it was unclear how they should go forward with trying to add another product. So the participant want a button they can click, (such as try again, add a new product, add a different product etc).*
- *Another mention was the button "søk", or search. One participant said that they often deal with other forms where they need to "apply" in order to use them. So instead change the name on the button to "Beregn" (calculate).*
- *One participant also mentioned a feature where it could be possible to make a screenshot of the product. They want the ability to save the product so that they can show it to others. An alternative they would like is to convert it to a PDF file, or a link that they can send to others.*
- *Supervisors notes:*

  "Fremtidsmat has talked about the function to add the product to the member's saving lists. So for now, I suggest Anna to implement a button like that "lagre resept" (on the left) just for visualization – without function. Another button can be added as well, which is to key in another product "Beregn nytt product". Put it on the right…. We are going to test their placement & the wording in the next iteration."

This was the biggest "issues" that came up with the calculator. Other then that they liked the calculator very much. The design is good, and also the usability. And they think that this is a great tool."

4.2.1.2 Addressing user-based testing feedback

4.2.1.2.1 Adding a button for new products

In the context of this thesis, "components" refer to the individual pieces of the UI in the Fremtidsmat React-based web calculator (*React*, n.d.-b). Each component corresponds to a different food group category in the Nøkkelhullet guidelines and is identified with a unique name, such as Kategori1, Kategori3, Kategori4, and so on. These components were named following the pattern "Kategori<number>.js".

On the first round of user-based testing, participants found it unclear how to add another product. To address this issue, a "Legg til et nytt produkt" (Add a new product) button was added in all relevant components to facilitate this process and to ensure consistency across the entire web calculator. When the button is clicked, the page is reloaded, allowing users to add another product more easily.

Since the implementation is consistent across all components, below are examples from Kategori1 and Kategori2 components UI, to show how the "Legg til et nytt produkt" button was integrated across different categories.

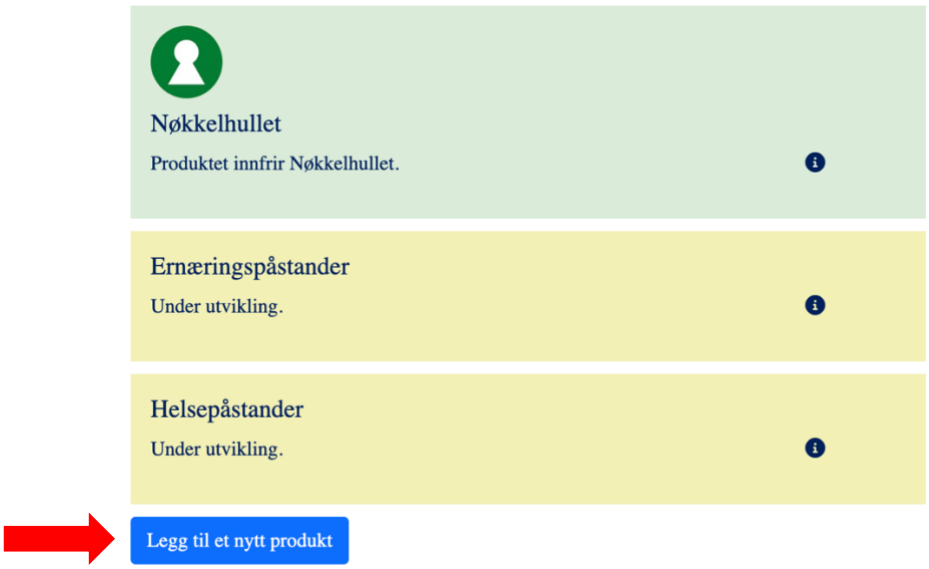


Figure 4- 2. Screenshot of the website displaying the "Legg til et nytt produkt" button in Kategori1 component.

This button appears when the results are displayed, regardless of whether they meet the requirements. When the button is clicked, the page is reloaded, allowing users to input information for a new product.

Please see Appendix E for the detailed code snippets used for the implementation of the “Legg til et nytt produkt” button in the Kategori1 and Kategori2 components.

4.2.1.2.2 Renaming the search button

During the first round of user-based testing participants found the term "apply" more familiar when dealing with form submission on other platforms. Due to this, the search button, labelled initially "Søk"(Search), caused some confusion.

In response to this feedback, it was decided to rename the button to "Beregn", which translates to "Calculate". The "Beregn" button was accordingly integrated into all necessary components, replacing the original "Søk" button.

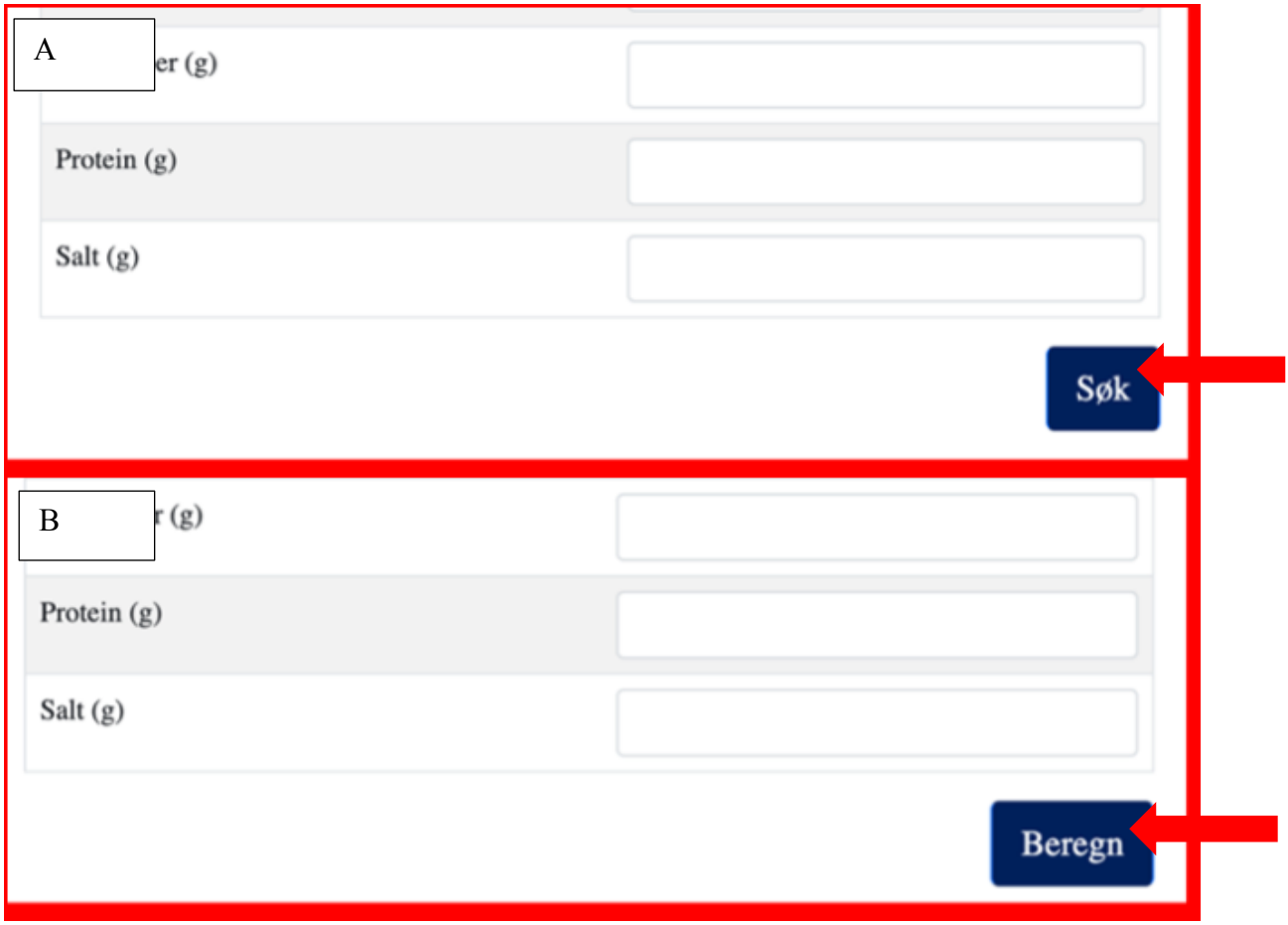


Figure 4- 3. Screenshot of the before and after renaming the button. A) Before version with "Søk" button. B) After version with "Beregn" button.

This change aimed to align with user expectations, reducing confusion and improving the form's usability, making it more intuitive.

Please see Appendix F for the implementation code for the "Beregn" button.

4.2.1.2.3 Reordering nutrients

In the initial version of the web calculator, the order of the nutrients was as follows:

- Energi (Energy)
- Mettede fettsyrer (Saturated fatty acids)
- Fett (Fat)
- Protein (Protein)
- Karbohydrat (Carbohydrate)
- Hvorav tilsatte sukkerarter (Of which added sugars)
- Kostfiber (Dietary fiber)
- Salt (Salt)

Based on the feedback from the first round of user-based testing, the web calculators' nutrient order was adjusted to align it with the order in the Nøkkelhullet (the keyhole label) guidelines. The updated order of nutrients is:

- Energi
- Fett
- Mettede fettsyrer
- Karbohydrater
- Hvorav tilsatte sukkerarter
- Kostfiber
- Protein
- Salt

To implement these changes, the order of the nutrients was adjusted in the code accordingly Appendix D.

4.2.1.2.4 Adding mockups for save and share features

During the first round of user-based testing, participants expressed the desire for features allowing them to save and share products. One participant specified that they would like the ability to save the product as a screenshot or PDF, or have the option to share a link to the product with others.

To address these user needs, two mockup buttons were introduced: "Lagre produkt" (Save Product) and "Del produkt" (Share Product).

These mockup buttons were designed as placeholders, representing potential future functionality. For the "Lagre produkt" button, these functionalities could include "Save as PDF" to enable easy document sharing and printing, "Save as Image" for creating quick visual references, "Save to Cloud" for access across devices via cloud storage like Google Drive or Dropbox, and "Save to profile" for keeping product data within the user's Fremtidsmat account. Similarly, for the "Del produkt" button, the functionalities could be "Send via e-mail", "Share to collaborative platforms" such as Microsoft Teams, Slack, or Google Workspace, and "Copy Link" to offer users a convenient way to share product data via a direct link."

The buttons were positioned to the left of the existing "Legg til et nytt produkt" (Add New Product) button for easy and intuitive navigation. Although these new buttons are non-

functional in this iteration, the placement and wording of these buttons will be evaluated in the next iteration based on further user feedback.

The figures below illustrate these changes:

Figure 4- 4. Screenshot of the website displaying the "Lagre produkt", "Del produkt", and "Legg til et nytt produkt" buttons.

For the code implementation of these mockup features, see Appendix G.

4.2.1.2.5 Fixing incorrect "sukkerarter" (total sugars) and "tillsatte sukkerarter" (added sugars) representation

A bug in the web calculator resulted in incorrect nutrient information being highlighted to users. Specifically, the nutrient row "Hvorav tillsatte sukkerarter" (of which added sugars), should have been representing the Nøkkelhullet criteria regarding "tillsatte sukkerarter" (added sugars). However, the nutrient row "Karbohydrat" (carbohydrate) was displayed with a ban icon and tooltip instead (See Appendix C). This misrepresentation led to participants receiving incorrect feedback, which is critical for checking food product adherence with Nøkkelhullet.

To fix this issue, a thorough inspection of the code was conducted. During the inspection, this issue was found in 14 components, including:

- Kategori1,
- Melk13a (Kategori 13 a),
- Kategori18,

- Kategori24b1,
- Kategori24b2,
- Kategori24b3,
- Kategori24c1,
- Kategori24c2,
- Kategori25a,
- Kategori25b,
- Kategori26,
- Kategori27,
- Kategori29,
- Kategori30.

The misrepresentation was found specifically in these 14 components because their food groups have Nøkkelhullet criteria regarding "tillsatte sukkerarter" (added sugars). To correct the misrepresentation, the code was updated to ensure that the "Karbohydrat" row represented the criteria for "sukkerarter" and the "Hvorav tillsatte sukkerarter" row represented the criteria for "tillsatte sukkerarter".

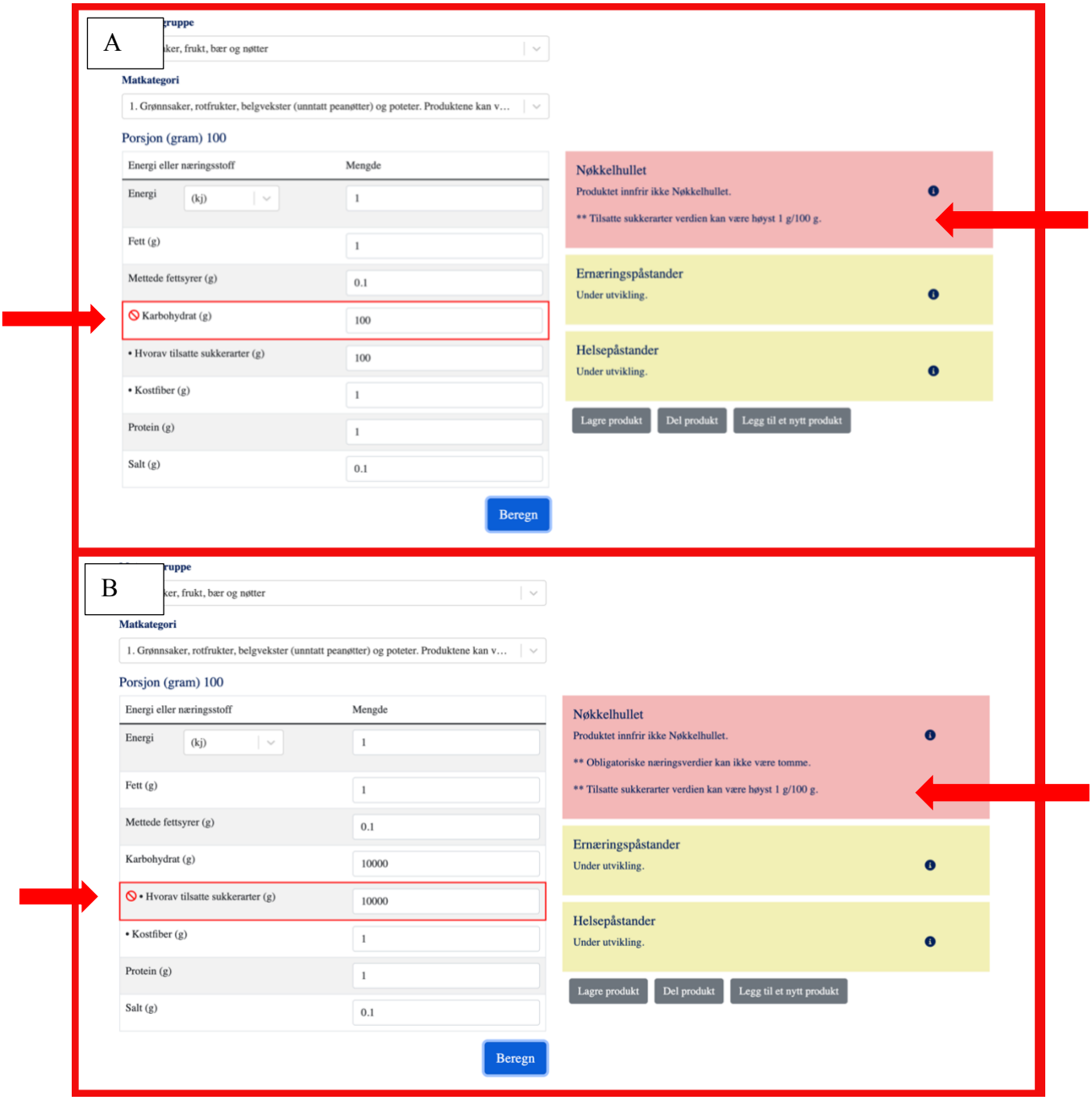


Figure 4- 5. Screenshots of before and after the misrepresentation fix: A) Incorrect label results from the user feedback report, showing the bug where the web calculator incorrectly displays the "Karbohydrat" row, when the label has the message "tillsatte sukkerararter verdien kan være høyst 3 g/100g" (the value of added sugars can be up to 1 g/100g). B) Corrected nutrient row "Hvorav tillsatte sukkerarter" being displayed for Kategori1 component.

After fixing the misrepresentation, the web calculator was made more reliable and gave users accurate feedback when inputting nutrition data. A comprehensive list of the affected components and before and after screenshots can be found in Appendix H, along with code snippets with all revisions and explanations of the changes made

4.2.2 Implementing Ernæringspåstander (nutrition claims)

4.2.2.1 Implementing the " Uten tilsatt sukker" (With no added sugars) claim

Incorporating Ernæringspåstander (nutrition claims) within the Fremtidsmat web calculator started with " Uten tilsatt sukker" (With no added sugars) claim. According to EFSA, this claim contains two linked nutrition claims: " Uten tilsatt sukker" and "Med et naturlig innhold av sukker" (Contains naturally occurring sugars) (European Commission, n.d.; Lovdata, 2017). To summarize:

1. " Uten tilsatt sukker": This claim can be made when the product does not contain any added mono- or disaccharides or any other food used for its sweetening properties.
2. "Med et naturlig innhold av sukker": This claim can be made when sugars are naturally present in the food, even if there are no added sugars.

In this iteration, the implementation of the first part of the claim, " Uten tilsatt sukker" was initiated in the "Kategori1" component of the web calculator. Adjustments were made to validate this claim based on the user's input. If the added sugar amount is zero while the total sugar amount is greater than zero, the message "** Without added sugar: This product does not contain any added mono- or disaccharides or other foods used for their sweetening properties." is displayed within the "Ernæringspåstander" results container.

At this stage of the implementation process, the Ernæringspåstander results container continues to display an "Under utvikling" (Under development) message. However, the " Uten tilsatt sukker" claim is operational and visible only within the "Kategori1" component.

For a detailed explanation of the code changes and additions during the implementation process, please see Appendix I.

The figures below illustrate these changes:

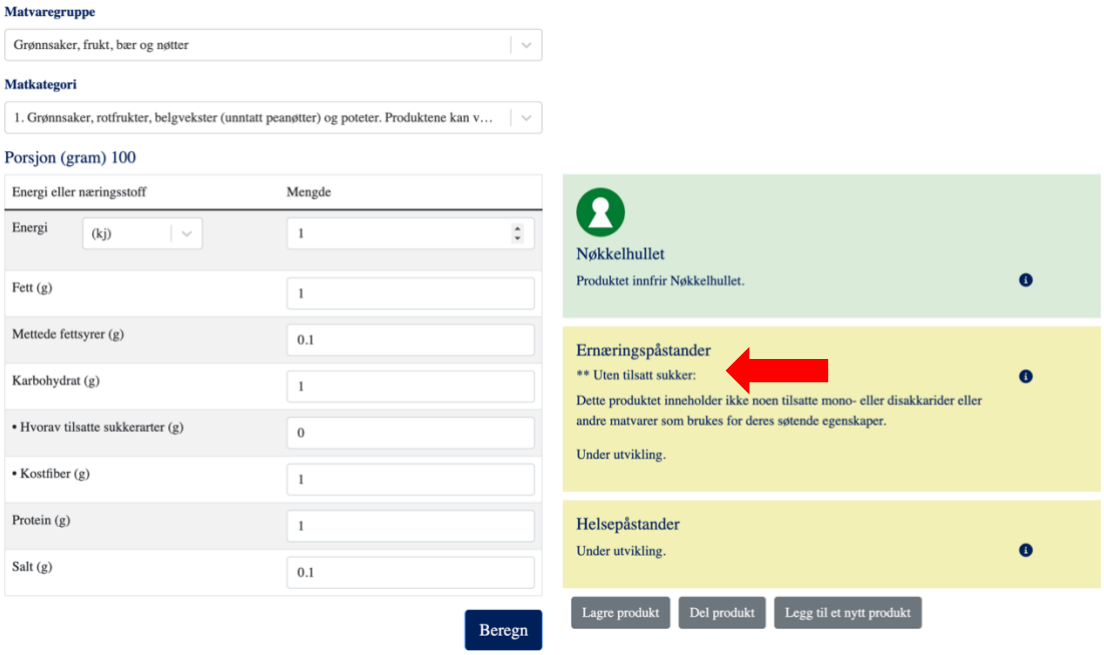


*Figure 4- 6. "KATEGORI 1" component UI showing the message "** Uten tilsatt sukker: Dette produktet inneholder ikke noen tilsatte mono- eller disakkarider eller andre matvarer som brukes for deres søtende egenskaper." (This product does not contain any added mono- eller disakkarider eller andre matvarer som brukes for deres søtende egenskaper" (This product does not contain any added mono- or disaccharides or other foods used for their sweetening properties.) within the "Ernæringspåstander" results container when the product meets the "Uten tilsatt sukker" claim.*

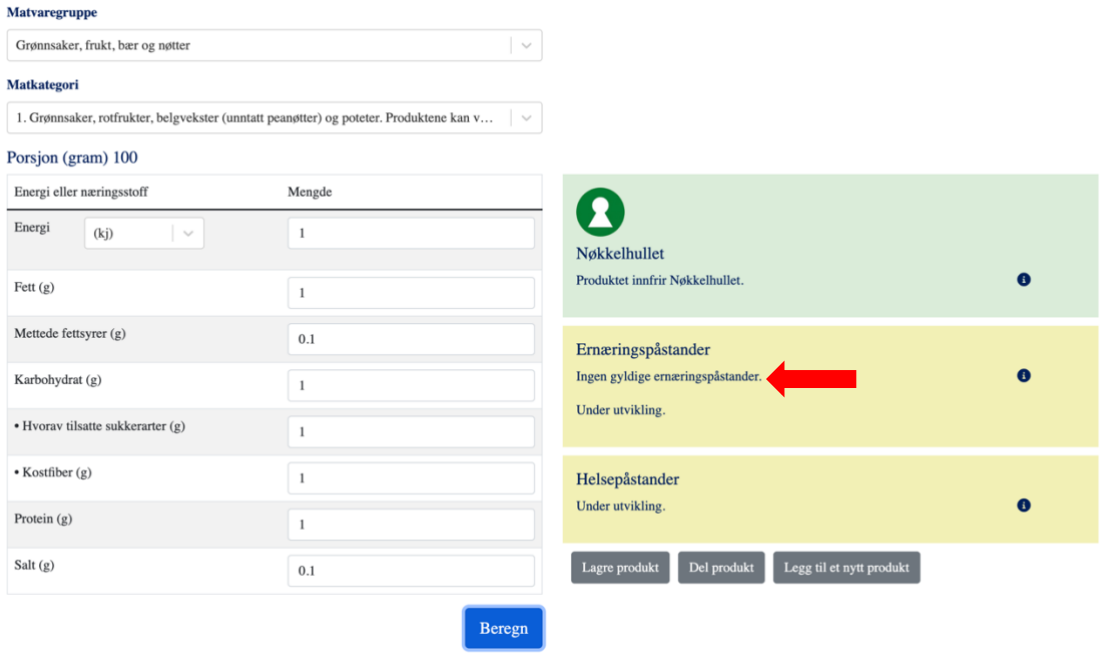


Figure 4- 7. "Kategori1" component UI showing a message "Ingen gyldige enaringspåstander." (No valid nutrition claims.) in the "Ernæringspåstander" results container, indicating that the product does not meet the " Uten tilsatt sukker" claim.

In this iteration, the implementation of the "Uten tilsatt sukker" claim is limited to the "Kategori1" component.

4.2.2.2 Implementing the "Med et naturlig innhold av sukker" (Contains naturally occurring sugars) claim (part 1)

Implementing the "Med et naturlig innhold av sukker" claim proved challenging due to the need for detailed, ingredient-specific data. The challenge lies in accurately identifying naturally occurring sugars in a food product based on the limited user input. Currently, the user is asked only for added and total sugars, making it difficult to confirm the presence of naturally occurring sugars.

A meeting was held with the project supervisor and other academic members at OsloMet to understand these nutrition complexities better and seek advice on the appropriate approach. During the meeting, it was acknowledged that expanding the user input fields to collect more data on the sugars present in the ingredients would require:

- A list of all ingredients used in the product.
- Specific types of sugars and sweeteners.
- Amount of each type of sugar and sweetener.
- Ingredients containing naturally occurring sugars.
- Amount of naturally occurring sugars in each ingredient.

Given the challenging nature of this task and the implications for the web calculator's UI, the expertise of a food and nutrition specialist was considered essential. Because of the limited time frame of this iteration, receiving a nutrition expert's assistance in implementing the "Med et naturlig innhold av sukker" claim was not possible. Consequently, it was decided that the implementation of the "Med et naturlig innhold av sukker" claim would be revisited in future iterations when feedback from a nutrition expert is received (see 4.5.1.1 Implementing "Med et naturlig innhold av sukker" (Contains naturally occurring sugars) claim (part 2)).

4.2.2.3 Resolving interface bug

During the development process of incorporating the " Uten tilsatt sukker" claim, a bug was discovered that affected the UI experience. The bug was related to the information buttons for the "Nøkkelhullet"(The Keyhole Label), "Ernæringspåstander" (Nutrition Claims), and "Helsepåstander" (Health Claims) result containers of the web page. When one information button was clicked, all the information sections opened simultaneously, rather than the

expected behaviour of just opening the relevant container. Moreover, when one info button was closed, all the information sections closed.

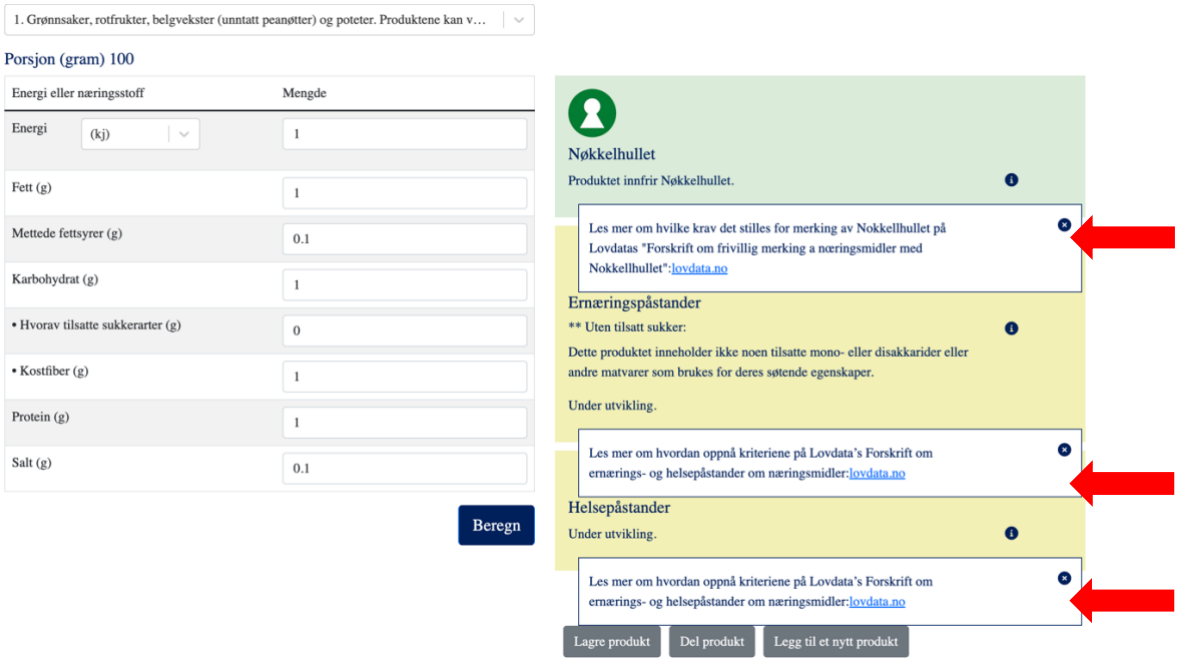


Figure 4- 8. A screenshot displaying the interface bug where all info buttons would open and close simultaneously upon clicking any button.

During a thorough inspection, the cause of the issue was identified in the code: the 'info' variable, which controls the visibility of the information sections, was being shared between the different containers, leading to the simultaneous opening or closing of all sections.

Three separate state variables were introduced to fix this bug: 'infoNokkelhullet', 'infoErnaerings', and 'infoHelsepåstander'. These state variables allowed each information section to be controlled independently. Further, two new functions, 'onClickInfo' and 'onClickClose' were developed, allowing each info button to control the visibility of its corresponding information section.

For a detailed explanation of the code changes during the implementation process, please see Appendix J.

After the bug fix, each Nøkkelhullet, Ernæringspåstander and Helsepåstander information buttons independently control their corresponding information section.
The figure below shows the change:

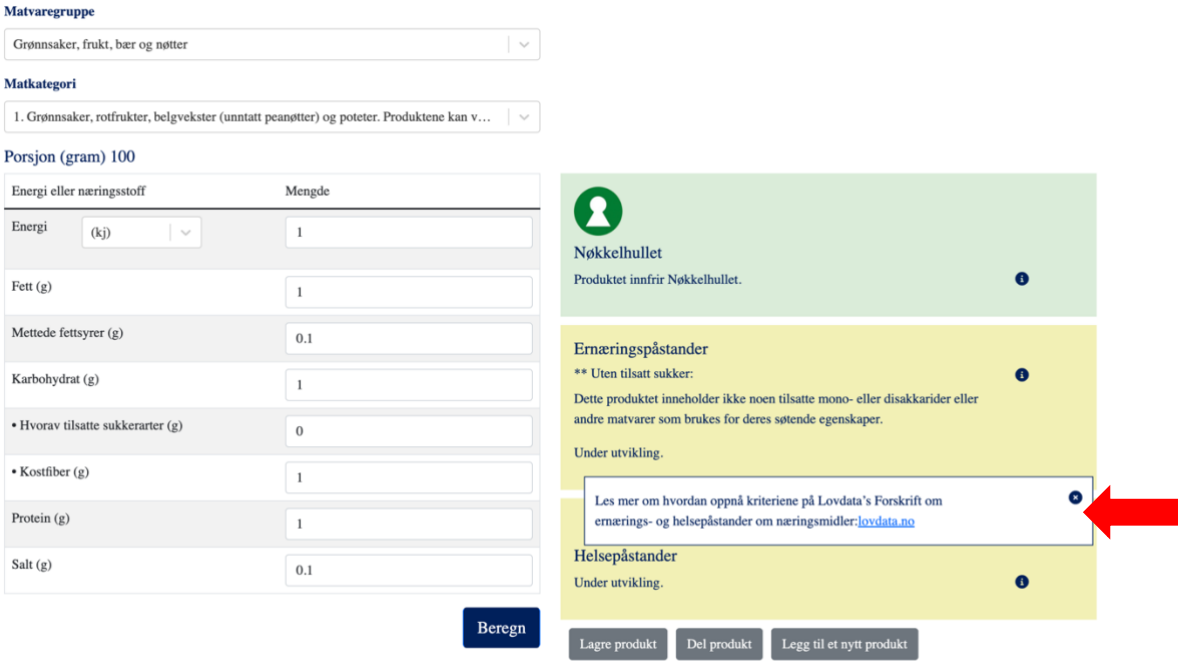


Figure 4- 9. A screenshot displaying the resolved functionality of the "Ernæringspåstander" results container information button showing that it now operates independently of other buttons.

4.3 Third iteration

4.3.1 Implementing Ernæringspåstander

4.3.1.1 Implementing the "Lavt sukkerinnhold" (Low sugars) claim

According to the EFSA guidelines, the "Lavt sukkerinnhold" claim can be used for food products that contain no more than 5 g of sugars per 100 g for solids or 2.5 g of sugars per 100 ml for liquids) (European Commission, n.d.; Lovdata, 2017). The implementation of the "Lavt sukkerinnhold" claim was specifically incorporated into the "Kategori1" component of the web calculator.

The incorporation required several important changes to the UI of the "Kategori1" component. The first change was introducing a new selector that allows users to specify the type of food product, solid or liquid. This feature is critical as the requirements for the "Lavt sukkerinnhold" claim vary based on the physical state of the food product.

Additionally, the previous yellow colour for the "Ernæringspåstander" results container was replaced by a three-colour system, designed to enhance the intuitive usability of the interface. The green colour shows full compliance with all claims, in this case, "Lavt sukkerinnhold" and "Uten tilsatt sukker." Red represents non-compliance with either claim, while orange indicates compliance with some claims.

Furthermore, the "Under utvikling." (Under development) message was removed, and the generic "Ingen gyldige ernæringspåstander" (No valid nutrition claims) message was replaced with new messages offering specific feedback based on the food product's compliance with the "Lavt sukkerinnhold" and "Uten tilsatt sukker" claims.

When the user's input complies within the "Lavt sukkerinnhold" claim parameters, the message "** Low sugar: This product contains at most 5 g sugar per 100 g for solids or 2.5 g sugar per 100 ml for liquids." appears in the "Ernæringspåstander" results container and when the user's input does not compy within the "Lavt sukkerinnhold" claim parameters, the message "** The product does not meet the 'Low sugar content' claim. For solid foods, the sugar content must be at most 5 g per 100 g. For liquid foods, the sugar content must be at most 2.5 g per 100 ml." appears in the "Ernæringspåstander" results container.

Figures illustrating these changes are shown below:

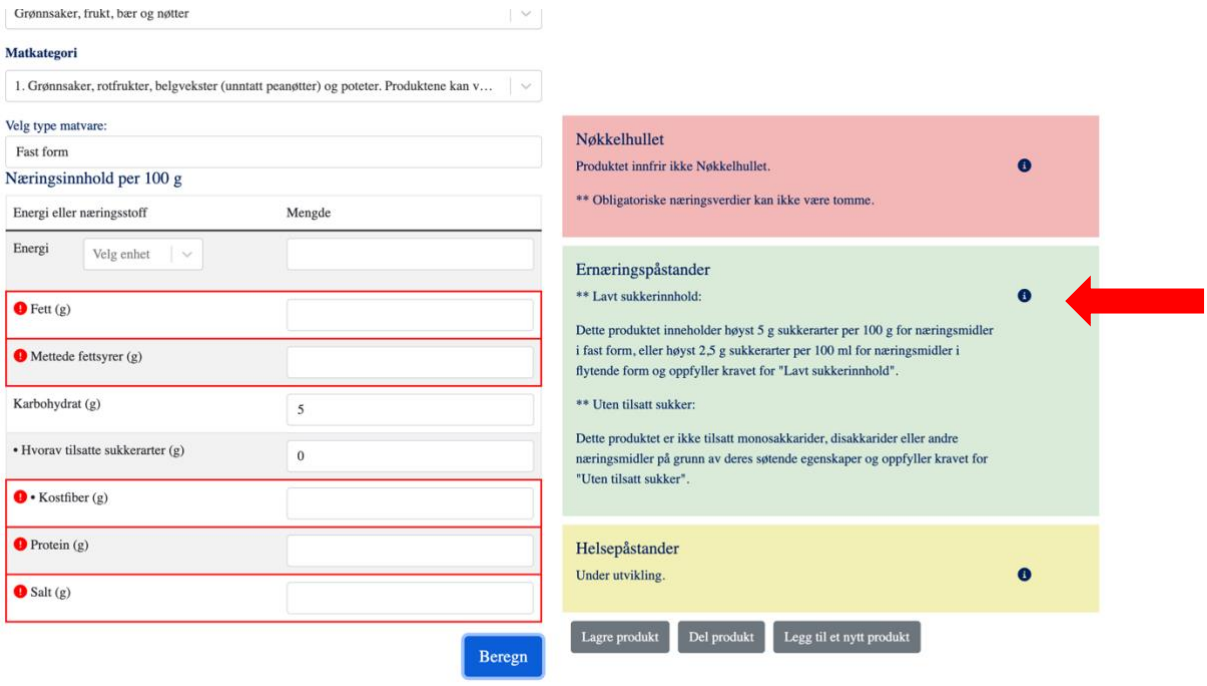


Figure 4- 10. The updated "Kategori1" component UI showing a green "Ernæringspåstander" results container. The container displays messages indicating that the product meets both the "Lavt sukkerinnhold" and "Uten tilsatt sukker" claims.

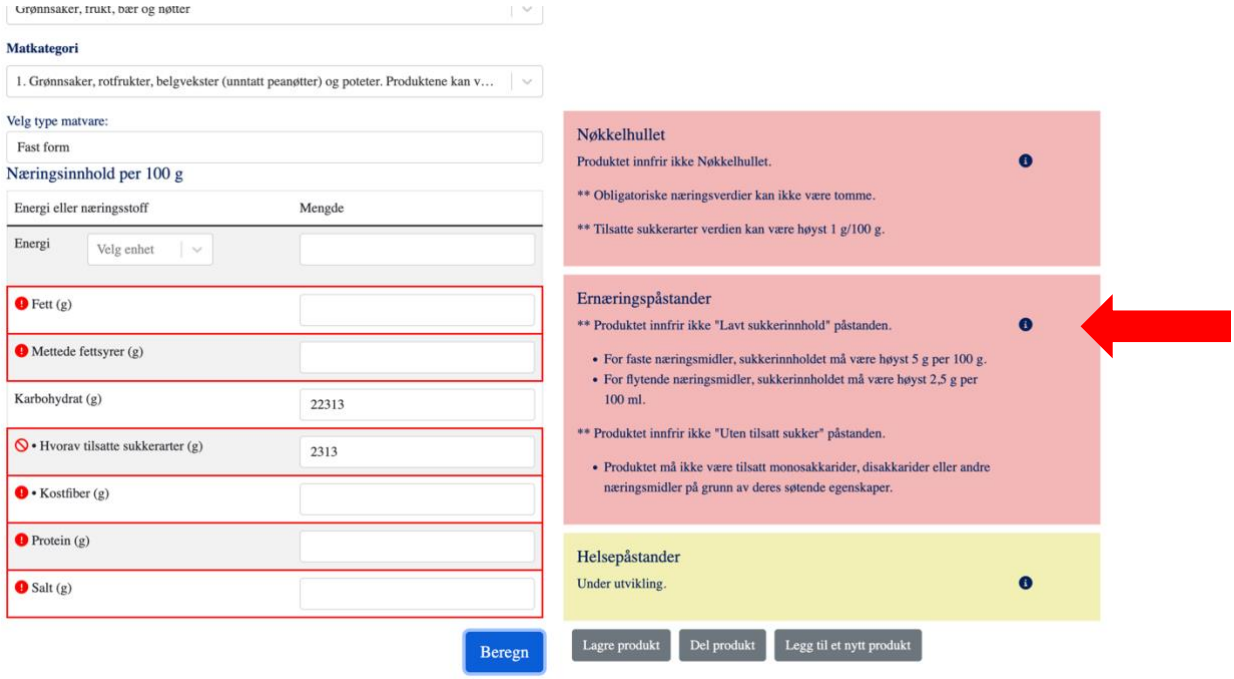


Figure 4- 11. The updated "Kategori1" component UI showing a red "Ernæringspåstander" results container. The container displays messages indicating that the product does not meet either the "Lavt sukkerinnhold" or "Uten tilsatt sukker" claims.

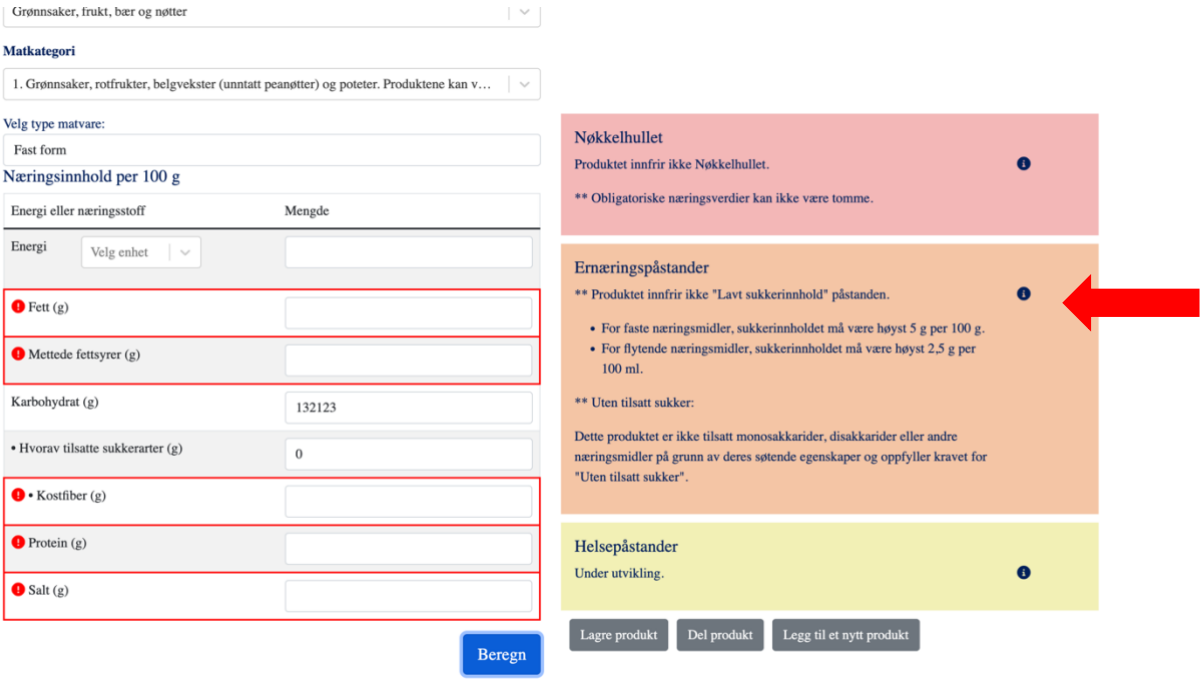


Figure 4- 12. The updated "Kategori1" component UI showing an orange "Ernæringspåstander" results container. The container displays a message that the product does not meet the "Lavt sukkerinnhold" claim but meets the "Uten tilsatt sukker" claim.

For a detailed explanation of the code changes and additions, please see Appendix K.

In this iteration, the implementation of the "Lavt sukkerinnhold" claim is limited to the "Kategori1" component.

4.3.2 Addressing usability and accessibility issues

4.3.2.1 Report on usability issues – user-based testing iteration 2

User-based testing feedback from the second iteration of user-based testing, conducted by fellow master's student Lars Hammer:

"This is the result that came back from the testing. There was only one participant for this test.

- The first thing that she mentioned was that the subcategories under meat products were a bit weird. But I do not think that there are anything to do with this problem. As it was just an issue for a first-time user, but when she knew how it worked there was no problem after all.
- The second thing was with the new ernæringspåstander. As the function is only working for vegetables, and without added sugars. This is actually a false claim as you cannot use "with no added sugar" on a vegetable, it is misleading for the consumers.
- She also mentioned the "Add a New Product" button was not easy to find, and did not see it before it was pointed out. So maybe move the button to a different place. When she was to try again, she automatically scrolled to the top of the page, meaning she could not see the button. She said it could be beneficial to have the button higher up on the page.
- She also said that it is hard mentioning the ernæringspåstander, without adding vitamins, calcium, iron and other input fields. This is of course, difficult to do anything about now. Maybe focus on protein as the next ernæringspåstand to focus on, and this might be the most relevant, because of the nutrients that we ask for in the nutrient list."

4.3.2.2 Addressing user-based testing feedback

4.3.2.2.1 Visibility of the "Legg til et nytt produkt" (Add a new product) button

The first usability issue was that the "Legg til et nytt produkt" (Add a new product) button was not easily noticed by the participant. Following a meeting held with the project supervisor and other academic members at OsloMet, it was decided to improve its visibility and intuitiveness by adding Font Awesome icons (*Font Awesome*, n.d.-b).

A plus sign icon, universally recognized as a symbol for adding something new, was added to the "Legg til et nytt produkt" button. Additionally, to make other buttons on the

interface easily identifiable, the "Lagre produkt" (Save product) button was enhanced with a floppy disk icon and the "Del produkt" (Share) button was given a share icon.

Figure 4- 13. The "Legg til et nytt produkt", "Lagre produkt", and the "Del produkt" button before and after the addition of icons: A) Displaying the original interface without any icons associated with the buttons. B) Showing the updated interface where each button has been given corresponding icons for enhanced usability and intuitive understanding.

The technical details of how these icons were implemented, including the specific code snippets and use of the Font Awesome library, can be found in Appendix N.

4.3.2.2.2 Suggestions on expanding nutrient input fields

The participant found it difficult to apply the "Ernæringspåstander" without having input fields for vitamins, calcium, iron, and other nutrients. The existing input fields available to the users included Energi, Fett, Mettede fettsyrer, Karbohydrater, Hvorav tilsatte sukkerarter, Kostfiber, Protein and Salt. The participant suggested protein-based claims should be the next step when implementing new Ernæringspåstander.

According to EFSA, the permitted protein-based claims are two) (European Commission, n.d.; Lovdata, 2017).:

1. "SOURCE OF PROTEIN": Protein must provide at least 12% of the food's energy value.
2. "HIGH PROTEIN": Protein must provide at least 20% of the food's energy value.

As stated by the participant, these protein-based claims might be the most relevant for incorporation, given the existing nutrient input fields of the calculator.

However, upon discussion with the project supervisor and other academic members at OsloMet, it was decided that while expanding the nutrient input fields would enhance the overall functionality of the web calculator, it would also increase the project's complexity.

The inclusion of additional nutrient input fields, such as monounsaturated, polyunsaturated, and unsaturated fats, salt/sodium, vitamins, minerals, and Omega-3 fatty acids, would need the assistance of a nutrition expert in the process. However, the limited time frame for the thesis made solving this issue and receiving the assistance of a nutrition expert in the process impossible at this stage.

Consequently, this issue has been noted as a limitation in the current research and a recommendation for future work, highlighting the complexity of integrating Ernæringspåstander to the web calculator.

4.3.2.2.3 Misleading " Uten tilsatt sukker" (with no added sugars) claim

The participant found the "Uten tilsatt sukker" (with no added sugars) claim to be misleading when applied to vegetables. This feedback has implications beyond simple usability as it touches on user trust and the credibility of the UI. To clarify the problem and seek advice on the appropriate approach, a meeting was held with the project supervisor and academic members at OsloMet.

During the meeting, it was recognized that implementing Ernæringspåstander requires a great understanding of the Nøkkelhullet guidelines. These guidelines classify food products into 11 main groups and 32 subgroups, each potentially requiring specific nutrition claims as defined by EFSA (See Chapter 2, 2.1 Norwegian food labeling and claims). Given the situation's complexity, a food/nutrition expert's involvement could significantly improve the accuracy of nutrition claim assignment across these categories and subgroups.

However, the limited time frame for the thesis made it impractical to conduct a thorough investigation of each food category or receive the assistance of a nutrition expert in the process. Consequently, this issue has been noted as a limitation in the current research and a recommendation for future work, acknowledging the complexity of implementing Ernæringspåstander.

4.3.2.2.4 Subcategories of meat products

The participant initially found the subcategories under meat products confusing and challenging to navigate. The confusion might be connected to the detailed text description of the meat product subcategories, as it has been directly sourced from the "Lovdata" website, which offers legal information for Norwegian laws and regulations, including those about the "Nøkkelhullet" label.

This feedback touches on the organization and presentation of information, which is essential for a usable and accessible UI. However, after a discussion with the project supervisor and the tester, it was acknowledged that while there might be some initial confusion, it is only a limitation for first-time users, as the participant adapted to the interface with time. Moreover, the structure of meat product subcategories is bound to legal requirements, restricting the flexibility for changes. Therefore, it was decided that the meat products subcategories remain the same in the third iteration.

4.3.2.3 Addressing accessibility issues personally noticed

4.3.2.3.1 Consistency in the design of the drop-down list

A thorough review of the UI revealed a difference in the design of the "Velg type matvare:" drop-down list, compared to the design of other drop-down lists such as "Matvarenavn", "Matvaregruppe", and "Matkategori". This internal inconsistency conflicts with the standards of the World Wide Web Consortium (W3C), more specifically the SC WCAG 3.2.4, "Consistent Identification" (W3C, 2023e). To adhere to these guidelines, changes were made to the "Velg type matvare:" drop-down list design to make it consistent with the other drop-down lists on the web calculator (Appendix P).

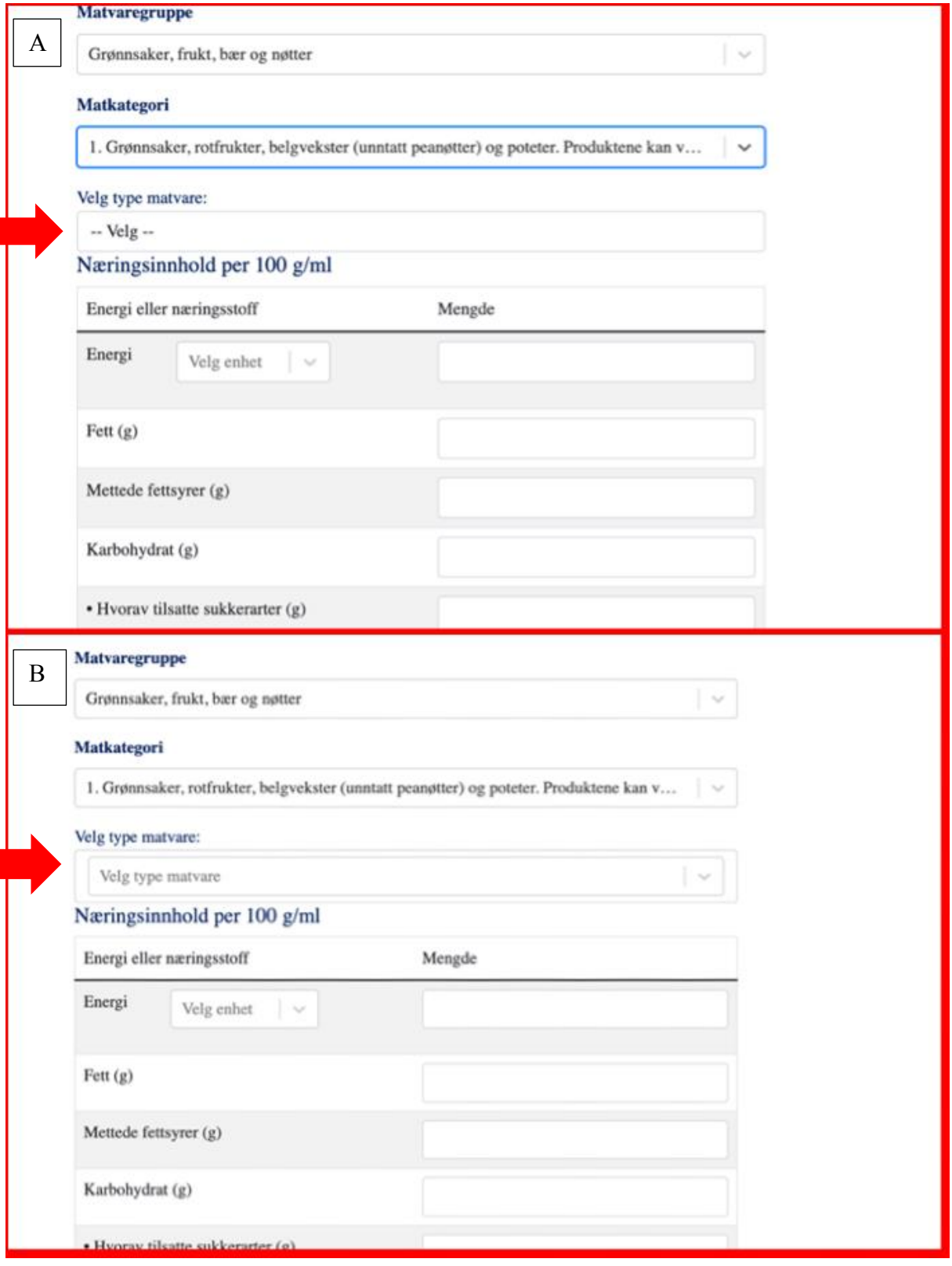


Figure 4- 14. The "Velg type matvare:" drop-down list design before and after change: A) The original design of the "Velg type matvare:" drop-down list, highlighting its inconsistency. B) The updated design of the same drop-down list, which now matches the other selectors' styles.

These changes ensured consistency in the design of the drop-down selectors, making the web calculator a more accessible UI by conforming to SC WCAG 3.2.4 "Consistent Identification".

4.3.2.3.2 Consistency in font size and size

In a thorough evaluation of the UI, it was noticed that there was inconsistency in font and type size across the web calculator. This internal inconsistency conflicts with the World Wide Web Consortium (W3C) standards, more specifically, the SC WCAG 1.4.12, "Text Spacing" and WCAG 3.2.4, "Consistent Identification" (W3C, 2023c, 2023e).

Following the WCAG 1.4.12, and WCAG 3.2.4, several changes were made to the CSS of the web calculator to establish and maintain a consistent font and style size throughout the UI. In detail, the changes included setting a base font size to enhance the readability of the text through the web calculator, defining specific font sizes for heading 1 to heading 6 to set clear visual hierarchies and specifying font sizes for paragraphs, list items, and smaller texts. Additionally, focus styles were added to all buttons, improving keyboard navigation and overall accessibility.

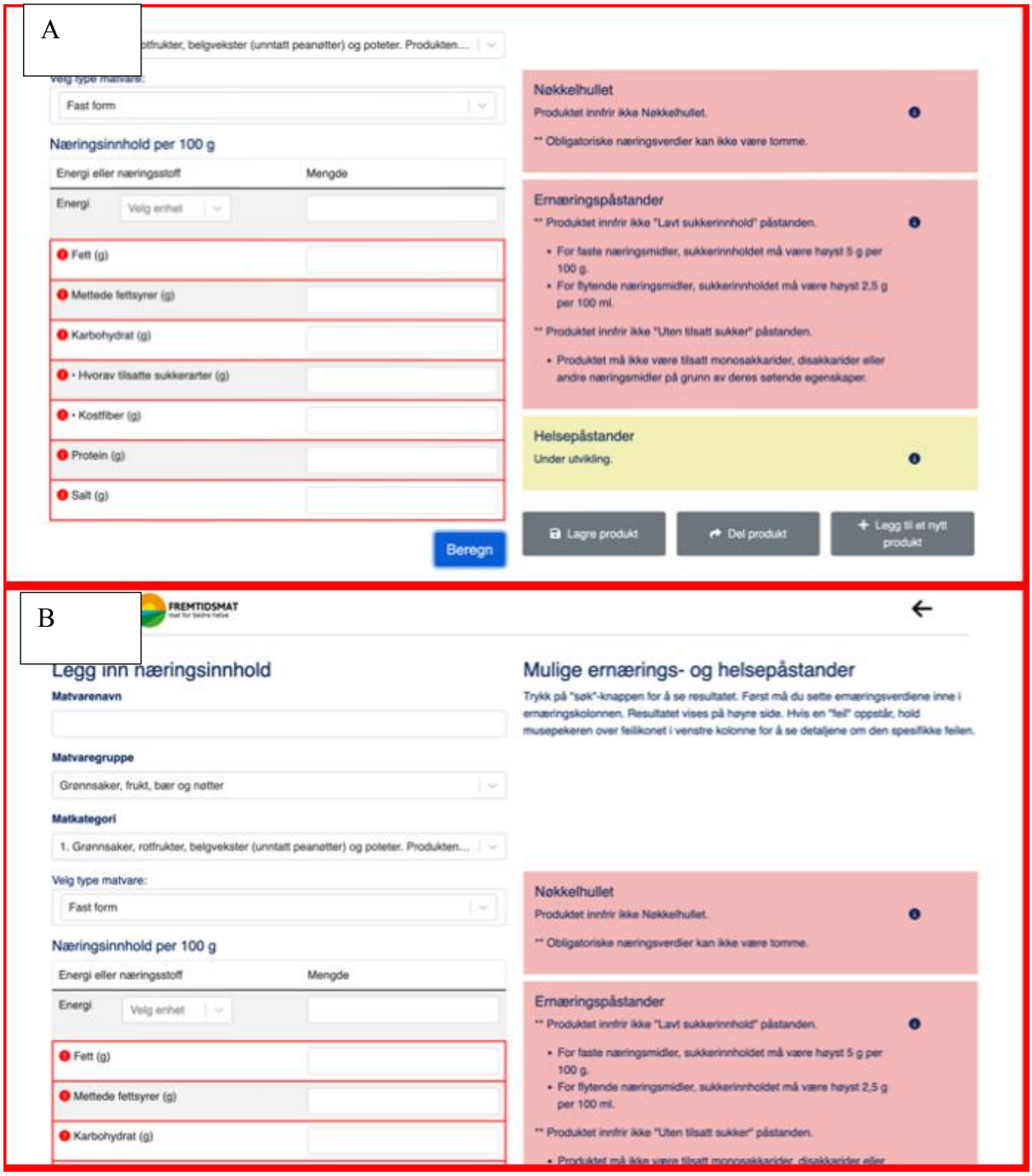


Figure 4- 15. The font size and style before and after modifications: A) The screenshot illustrates inconsistent font sizes and styles used in the web calculator's interface. B) The screenshot illustrates the web calculator with a consistent use of font size and style.

Details about the changes made to the CSS code can be found in Appendix Q.

4.3.2.3.3 Button placement and spacing adjustments

An evaluation of the UI pointed out that the placement and spacing of the buttons "Lagre produkt", "Del produkt", and "Legg til et nytt produkt" were visually off-putting, mainly due to the excessive space to the right of the most right button, the "Legg til et nytt produkt"

button. Ensuring proper placement and spacing of these buttons is essential not only for aesthetic purposes but also for accessibility and usability, as they directly impact the understandability of the UI and may affect users' interaction with the system.

In accordance with the WCAG 2.1 SC 2.5.5,"Target Size", the size of the target for pointer inputs should be at least 44 by 44 CSS pixels, excluding certain exceptions that do not apply in this case (W3C, 2023d). Moreover, these targets must have sufficient spacing around them to prevent any misclicks. Initially, the code for these buttons did not specify width or height size, allowing the browser to use its default size. This size could be smaller than 44 pixels, which may create accessibility challenges, especially for users with mobility and vision impairments or those using touch screens.

To address these issues, the CSS styling of the buttons was updated (see Appendix S). Specifically, the "width" of the buttons was set to 200 pixels, the "minHeight" was set to 44 pixels and the "marginRight" was set to 5 pixels. These modifications have provided each button with uniform placement and spacing in accordance with the WCAG 2.1, SC 2.5.5, thereby significantly improving the accessibility of the interface.

Figure 4- 16. The before and after "Lagre produkt", "Del produkt", and "Legg til et nytt produkt" buttons placement: A) The screenshot illustrates the varying widths and unusual placement of the buttons, particularly the excessive space to the right of the "Legg til et nytt product" button, before the changes were made. B) The screenshot shows the uniform placmet and spacing of the buttons after the update.

4.3.2.3.4 Spacing between the drop-down list and the subsequent heading

The drop-down list "Velg type matvare:" and the subsequent heading "Næringsinnhold per 100 g/ml" were placed too close together. Ensuring adequate spacing between different elements on a web page is important not only for aesthetic purposes but also for accessibility and usability. This issue also conflicts with the WCAG 2.1, SC 1.4.8, "Visual Presentation", which emphasizes the need for sufficient spacing between lines and around blocks of text for better visual presentation (W3C, 2023b).

To improve the spacing between these elements, a modification was made to the CSS of the ".form-group" class, setting a bottom margin of 1rem (see Appendix R). The increased spacing improved the visual presentation and usability of the web calculator, ensuring compliance with the WCAG 2.1, SC 1.4.8.

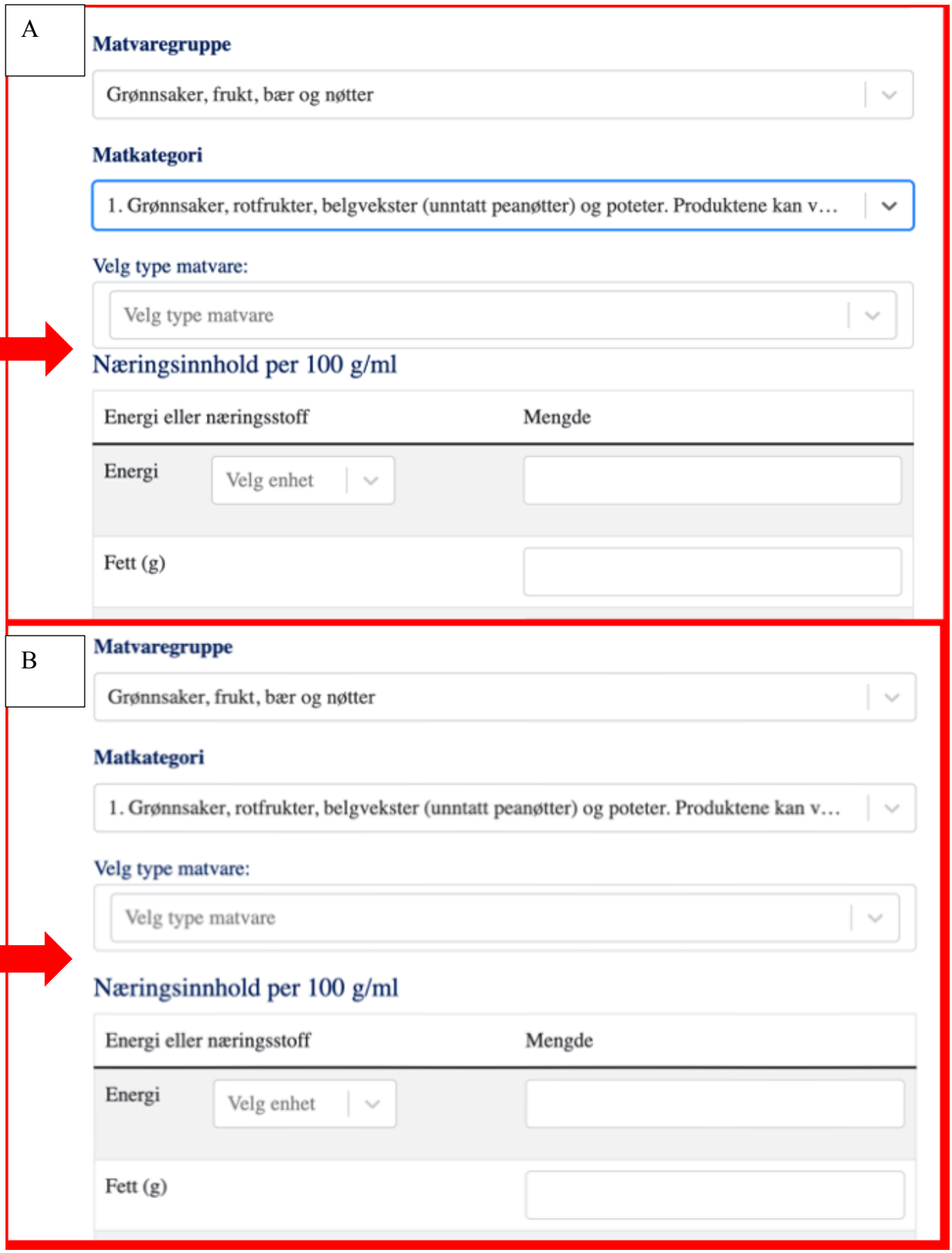


Figure 4- 17. The spacing between the drop-down list "Velg type matvare:" and the subsequent heading "Næringsinnhold per 100 g/ml" before and after changes: A) The screenshot illustrates the website before the changes were made, displaying the close spacing. B) The screenshot shows the web calculator after the changes were made, showing the adjusted spacing between the drop-down list and the "Næringsinnhold per g/ml" heading.

4.3.2.3.5 Changing the colour of the "Lagre produkt" (Save Product), "Del produkt" (Share Product), and "Legg til et nytt produkt" (Add New Product) buttons to purple

For the purpose of gathering user feedback on aesthetic preferences and design choices, a low-fidelity prototype was created, focusing specifically on the modification of the colour for the buttons: "Lagre produkt" (Save Product), "Del produkt" (Share Product), and "Legg til et nytt produkt" (Add New Product).

In the current version of the web calculator, these buttons, styled using the Bootstrap "btn-primary" class, are displayed in grey (Bootstrap, n.d.-b). For the low-fidelity prototype, a custom CSS class named "btn-purple" was created, displaying the buttons in purple. Please note that these changes were made only for the prototype and were not implemented in the existing web calculator.

A screenshot of the buttons in the new purple colour can be seen below:

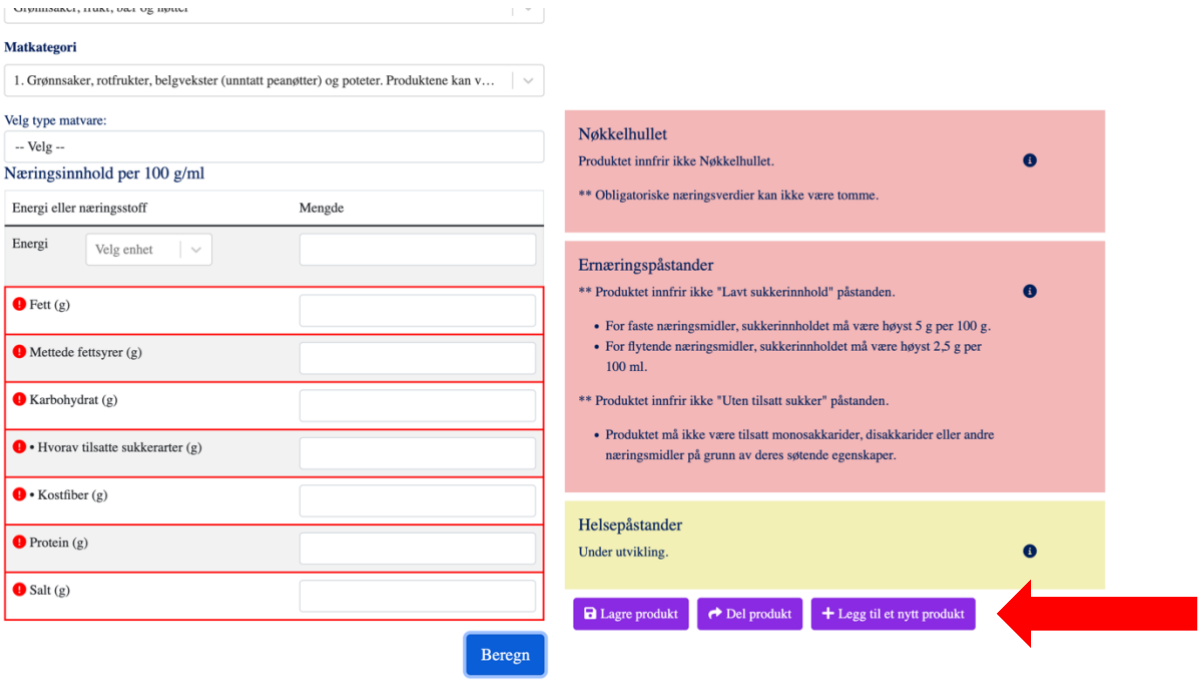


Figure 4- 18. A screenshot displaying the "Lagre produkt" (Save Product), "Del produkt" (Share Product), and "Legg til et nytt produkt" (Add New Product) buttons in their new purple colour in the low-fidelity prototype.

For a detailed explanation of the modifications made to the code for creating this prototype, see Appendix O.

4.4 Fourth iteration

4.4.1 Addressing usability issues

4.4.1.1 Report on usability issues – user-based testing iteration 3

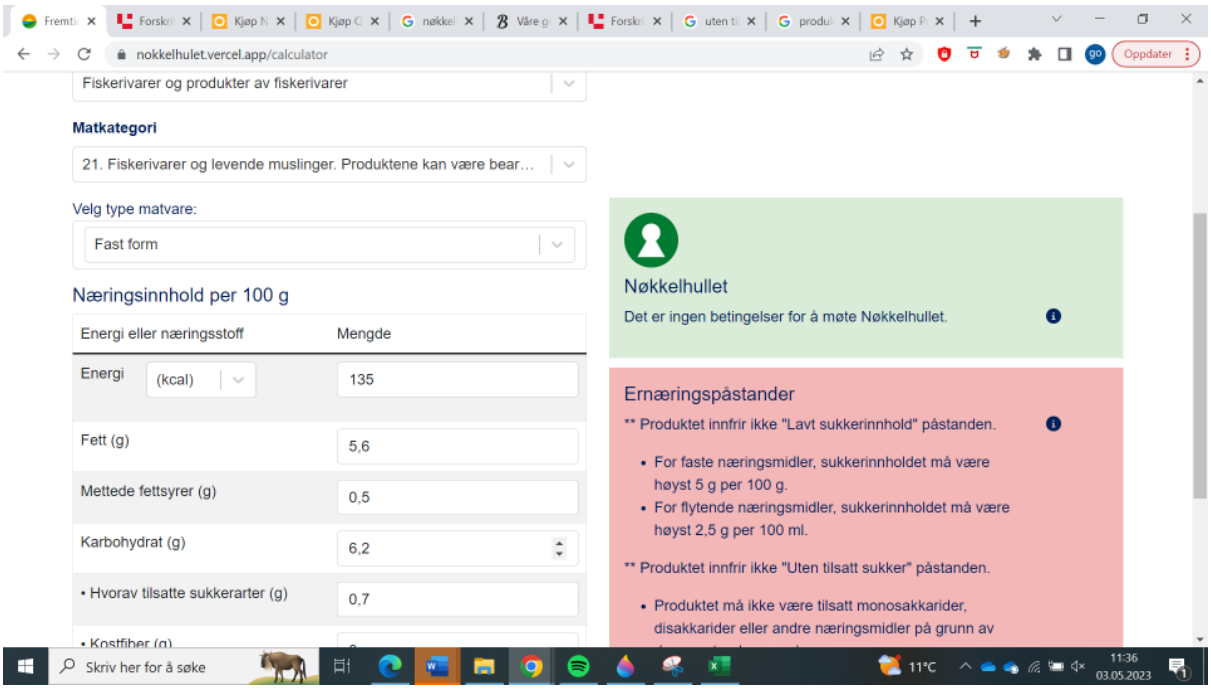
The following is the user-based testing feedback collected from third iteration of user-based testing by fellow master's student and tester, Hammer Lars:

"*Results from the user testing iteration 3:*

- *One thing that she asked about was if the "choose liquid or firm food box" will always appear, even for the categories where liquid food cannot be an option.*
- *Also, she mentioned the same thing as last time, just because a product meets the "low sugar" claim here on the calculator does not mean you can use it on every product that has less than 5g of carbohydrates per 100g. If a person who uses the calculator does not have a clear understanding of the rules, mistakes will/can be made. So, she mentioned if this problem is not fixed there needs to be added a 'warning' symbol that lets the users know that they might not be able to use that claim.*
- *She liked the color theme for the Ernæringspåstander. However, she said that if one of two claims is possible to use, the one that can be used should be green and the one that cannot be used should be red. So if possible, split the box with different colors depending on if the claim can be used or not. Another point she had was, maybe not show the claims that cannot be used. When every claim is finished, and developed, it will be a huge list, showing every claim they did not meet. It is better to only show the ones that meet, and then they can push a button that will show every claim that did not meet the requirement.*
- *For the buttons, she liked the purple color better than the grey.*
- *Also, she would like to switch the place for "save product" and "add a new product", so that "add a new product" comes first.*
- *In addition, for the button "share product", it should be renamed, because she sees it as an option for sharing on Facebook. Maybe name it 'convert to PDF' or something along that way.*

Obresvations from the tester:

- *When testing myself I spotted a mistake for when plotting in the nutrients for category 21, fish. The text in the "nøkkelhull' box is wrong (see picture).*



- *One other thing as well is when plotting in a product that already uses the claim "without added sugar", it will not work on this calculator. The reason is because a product can have natural sugar in the product. This means that when plotting in the "hvorav tilsatte sukkerarter", the amount of grams will be more than 1g, and so the claim will not trigger. What I meant was that, a product on the market today such as "vanilla yoghurt without added sugar" from Tine, see picture, it contains 3,9 “hvorav sukkerarter". So when I put in the nutrients in the calculator, the results will show that "hvorav tilsatte sukkerarter" in the calculator will be over 0,3, and therefore it will not show the claim "without added sugar". This is because the product contains natural sugar.*

Næringsinnhold pr. 100g

energi	208 kJ (49 kcal)
fett	1,5 g
-hvorav mettede fettsyrer	1,0 g
karbohydrat	4,3 g
-hvorav sukkerarter	3,9 g
protein	4,8 g
salt	0,10 g
kalsium	158 mg (20 %')
	' av referanseverdien

If any of the explanations are hard to understand, please let me know and I will try explaining it better. Other than this, she liked the calculator a lot and sees the potential it has."

4.4.1.2 Addressing user-based testing feedback

4.4.1.2.1 Suggestions on Ernæringspåstander results container colour theme and display of the Ernæringspåstander (nutrition claims)

The participant appreciated the colour theme used to present the "Ernæringspåstander" implemented in the last update (see 4.3.1.1 Implementing the "Lavt sukkerinnhold" (Low sugars) claim). This theme uses a green colour to show full compliance with all claims; red indicates none of the claims is met, while orange represents partial compliance.

However, the participant also suggested potential modifications to this system. Specifically, the participant proposed that if one of two claims can be applied to the food product, the one that can be applied should be displayed in a green Ernæringspåstander results container, while the one that cannot be applied should be displayed in a red Ernæringspåstander results container. Essentially, this would mean splitting the Ernæringspåstander results container into two different containers depending on whether the claim can be applied or not, changing from a three-colour theme to a two-colour theme. Additionally, the participant proposed to display only the claims that can be applied to the food product, instead of displaying all, including those that cannot be applied. Given the extensive list of claims that would be integrated in the future, showing every claim that did

not meet the requirement could overwhelm the users. Therefore, the participant suggested introducing a button with an option to see all those claims that did not meet the requirements.

In light of this feedback, a meeting with the project supervisor and academic members at OsloMet was held to discuss potential implementation.

While these suggestions are insightful and might enhance the UX, implementing them would contradict the design logic used in the web calculator and could introduce potential usability challenges. One crucial reason for not splitting the Ernæringspåstander results container into two different containers depending on whether the claim can be applied, is to maintain consistency across the interface. Nøkkelhullet results container and Helsepåstander (health claims) results container follow the logic of a single container where the colour changes depending on the results. Splitting the Ernæringspåstander results would contradict this established pattern and confuse users.

Therefore, this issue is against the WCAG 2.1, SC 3.2.4 "Consistent Identification" (W3C, 2023e).

The suggestion of displaying by default only the claims that can be applied to the food product, and introducing a button with an option to see all those claims that do not meet the requirements was carefully considered. Even though it might seem like a way to avoid information overload, providing information transparency for users is crucial. Some users want to understand why specific claims do not apply to their food products, and others want to know these details so they can adjust their products to meet the claim. By hiding claims that do not meet the requirements by default, we risk withholding valuable information that can help users improve their food products.

Therefore, while these suggestions provided valuable insights into the user's perspective, implementing them would not align with the web calculator's design principles and UX goals. However, these considerations are still under discussion, and the suggestions have been noted for potential future work, pending further feedback from the project supervisor and academic members at OsloMet.

4.4.1.2.2 Suggestions on "Lagre produkt" and "Legg til et nytt produkt" buttons placement

The participant suggested rearranging the place of the "Lagre produkt" and "Legg til et nytt produkt" buttons so that "Legg til et nytt produkt" comes first.

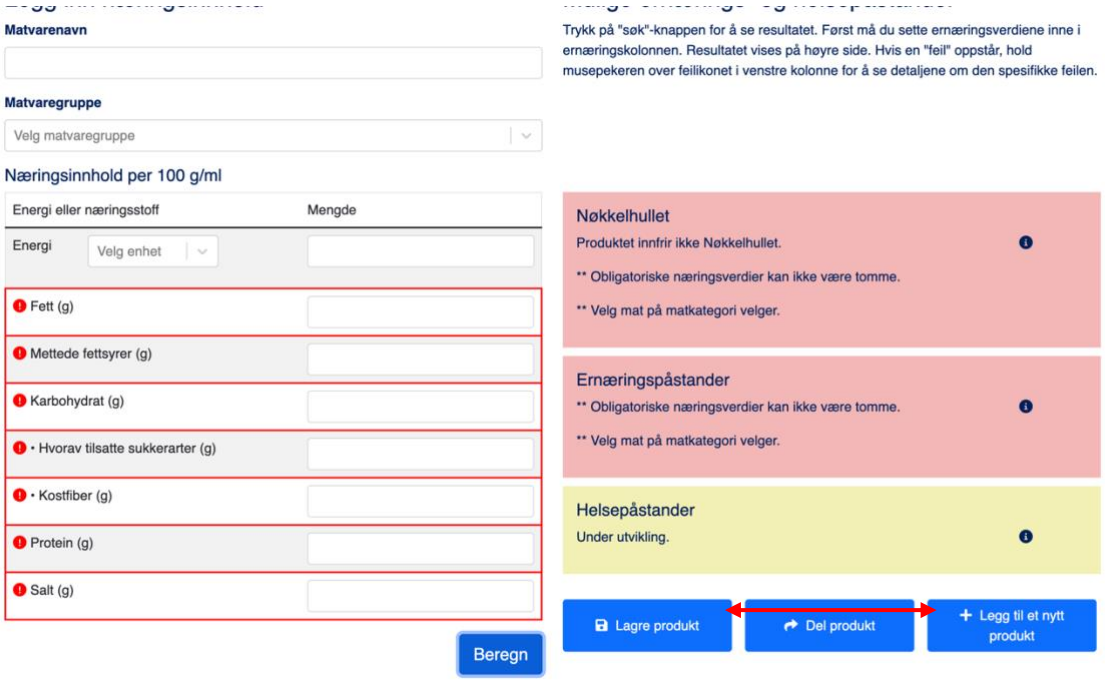


Figure 4- 19. A screenshot of the web calculator's UI where the existing placement of the "Lagre produkt" and "Legg til et nytt produkt" buttons has been displayed.

To better understand the participant's proposal, a meeting was held with the project supervisor and the tester. During the meeting, it was highlighted that the existing placement of the buttons reflects the flow of actions in the process and prioritizes data preservation. Typically, a user would save their current work before considering adding a new product. If the "Legg til et nytt produkt" button was placed first, it might confuse users, as they might think they need to click on it before saving the current product. This confusion could result in data loss and user frustration. Given the time and effort it could take for a user to input this data, preserving it should be of high priority. Keeping the "Lagre produkt" button as the first action reduces the risk of users accidentally losing their input by prematurely moving on to adding a new product. Therefore, the decision was made not to rearrange the places of the "Lagre produkt" and "Legg til et nytt produkt" buttons, as the original order appears to reasonably fit the logic of the user journey and actions within the web calculator.

4.4.1.2.3 Confusion regarding the functionality of the "Lagre produkt" and "Del produkt" buttons

The participant expressed confusion about the "Del produkt" button's current labeling. According to the participant, the button's name could be misleading, as it might be interpreted as a feature that allows users to share their food product data on social media

platforms like Facebook. As a result, the participant suggested renaming the button to "Konverter til PDF" (Convert to PDF).

It is crucial to note that share and save functionalities often work closely together, making it easy to confuse their functionality. However, in this case, the "Lagre produkt" and "Del produkt" buttons are not functional yet. As documented in "4.2.1.5 Adding mockups for save and share features", the "Del produkt" button was created as a mockup button with the future functionality of allowing users to share their product information within the Fremtidsmat company via email, collaborative platforms, and direct links. Similarly, the "Lagre produkt" button, as documented in the same section, was created as a mockup with the future functionality of allowing users to save their work in different formats, including PDF.

Given that the prototype is still under development, and not all functionalities have been implemented, a complete renaming of the "Del produkt" button would be considered incautious. However, this feedback underlines the importance of communicating the future functionalities of these buttons during testing sessions. This could help set the right user expectations and allow gathering feedback despite the buttons' non-functioning state. Consequently, this feedback will be noted for consideration in future iterations.

4.4.1.2.4 Understanding the "Velg type matvare" (Choose type of food) feature

A participant expressed concerns about the "Velg type matvare:" (Choose the type of food) feature. The feature was introduced during the third iteration when implementing the "Lavt sukkerinnhold" (Low sugars) claim (see 4.3.1.1 Implementing the "Lavt sukkerinnhold" (Low sugars) claim). The feature allows users to select between "Fast form" (solid physical state of the food product) or "Flytende form" (liquid physical state of the food product), which in turn affects the requirements for some of the Ernæringspåstander. For example, the "Lavt sukkerinnhold" claim can only be used for solid foods with a sugar content below 5g and liquid foods with a sugar content below 2.5g. Nevertheless, the participant wondered whether the "Velg type matvare:" feature would always appear, even for food categories

where the food product's liquid or solid physical state is not possible.

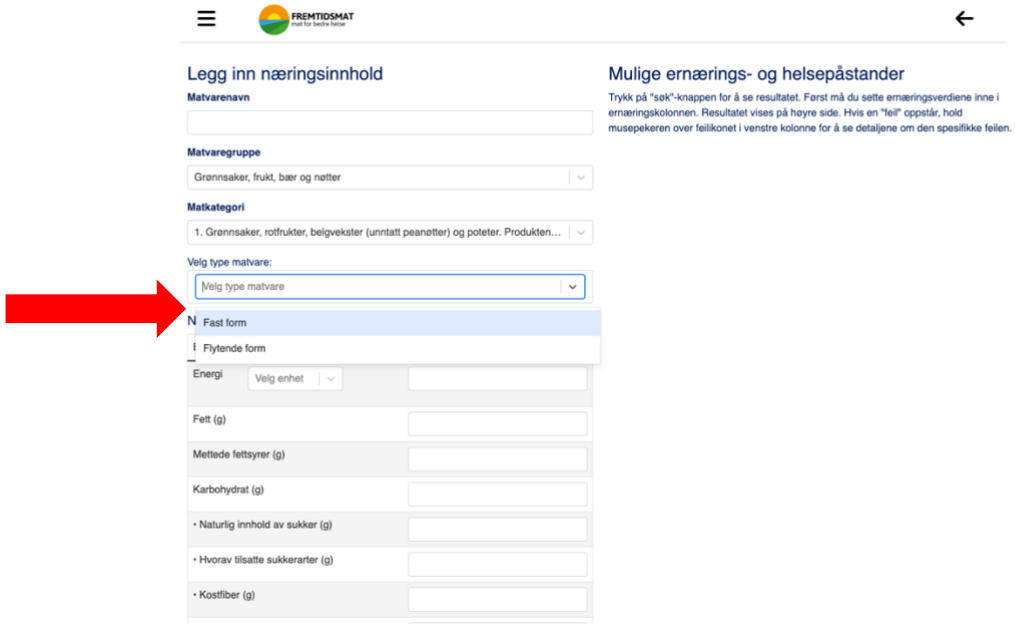


Figure 4- 20. A screenshot showing the "Velg type matvare:" (Choose food type) feature with the options "Fast form" (Solid physical state of the food product) and "Flytende form" (Liquid physical state of the food product).

Deciding whether the feature should always be visible is a complex task. It would require an in-depth understanding of the Nøkkelhullet guidelines and potentially the consultation of a food and nutrition expert. However, the limited time frame for the thesis made it impractical to conduct a thorough investigation into each food category or to consult an expert. Consequently, this issue has been noted as a limitation in the current study and a recommendation for future work.

4.4.1.2.5 Misleading "Lavt sukkerinnhold" (Low sugars) claim / Warning symbol proposal

The participant found an issue with the "Lavt sukkerinnhold" (Low sugars) claim that it might be misleading when applied to certain food products. This issue is similar to the one mentioned during the second round of user-based testing, where the "Uten tilsatt sukker" (with no added sugars) claim was considered misleading when applied to vegetables (4.3.2.1.2 Misleading "Uten tilsatt sukker" (with no added sugars) claim.). However, in this case, the participant further suggested the introduction of a "warning" symbol to alert users when specific Ernæringspåstander might not be applicable or suitable for every food product, even if the criteria according to the web calculator are met. Implementing this feature would help prevent potential misuse of the Nøkkelhullet guidelines and the Ernæringspåstander and provide users with a clear understanding of their correct application.

Despite the obvious benefits of the participant's proposal, implementing a "warning" symbol would require a deep understanding of the Nøkkelhullet guidelines and the characteristics of each food category and subgroup. This understanding is essential to accurately determining when and where the "warning" symbol should appear.

Given the situation's complexity, it was again indicated that involving a food and nutrition expert could improve the effectiveness and accuracy of developing this feature. Nevertheless, due to the limited timeline of this thesis, a thorough investigation of each food category and consultation with a specialist was not possible. Consequently, the idea of a "warning" symbol has been noted as a limitation in the current study and an important recommendation for future work. This suggestion acknowledges the complexity of using Ernæringspåstander and the carefulness needed when creating tools to simplify this process.

4.4.1.2.6 Changing the colour of the "Lagre produkt", "Del produkt" and "Legg til et nytt produkt" butons to blue

The participant preferred the purple colour for the "Lagre produkt", "Del produkt", and "Legg til et nytt produkt" buttons over the original gray colour. However, this purple colour was developed only for user-based testing purposes and was not implemented in the existing web calculator (see 4.3.2.2.1 Changing the colour of the "Lagre produkt" (Save Product), "Del produkt" (Share Product), and "Legg til et nytt produkt" (Add New Product) buttons to purple).

In light of this feedback, a meeting was held with the project supervisor and the tester to discuss the potential colour change. During the meeting, it was recognized that giving the buttons a more vibrant colour could make the interface more aesthetically pleasing and potentially enhance user engagement. However, a suggestion was made to adopt a blue colour for these buttons, instead of the tested purple. Since the "Beregn" (Calculate) button was already in blue, aligning the other buttons' colour with this current design element would ensure consistency across the UI. Following the discussion, the colour change was implemented by adjusting the original Bootstrap "btn-secondary" class associated with these buttons to match the same class used for the "Beregn" button (Bootstrap, n.d.-b). Details about the changes made to the code can be found in Appendix U.

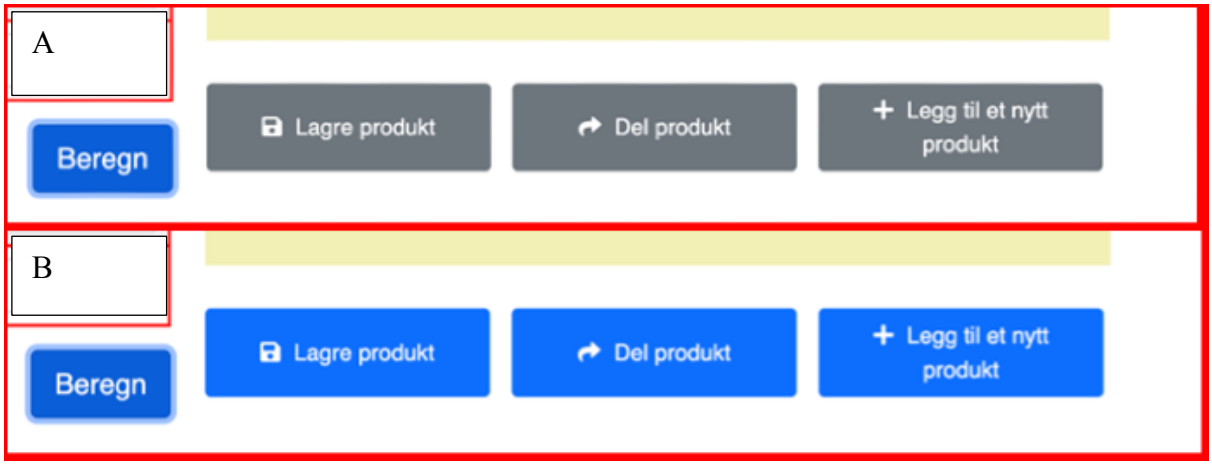


Figure 4- 21. The "Lagre produkt", "Del produkt", and "Legg til et nytt produkt" buttons colour before and after the update: A) The screenshot illustrates the web calculator before the changes were made, showing the buttons in their original gray colour. B) The screenshot shows the web calculator after the changes were made, showing the buttons in the same blue colour as "Beregn" button.

4.4.1.3 Addressing observations from the tester

4.4.1.3.1 Changing the Nøkkelhullet results container message for food groups number 2 and 21

The tester expressed confusion regarding the message displayed in the Nøkkelhullet results container for food group number twenty-one, "Fiskerivarer og levende muslinger. Produktene kan være bearbeidede." (Fishery products and live shellfish. The products may be processed.). The current message states, "Det er ingen betingelser for å møte Nøkkelhullet." (There are no conditions for meeting the Keyhole label.), which the tester perceived as incorrect. Although the message is correct since there are no specific conditions for this food group to meet the Nøkkelhullet regulations, the tester might have thought such conditions should exist, as they do for other food groups. However, this is not the case.

Even though the original message was correct, the feedback pointed out the need for a clear and detailed statement of the conditions for the "Nøkkelhullet" regulations. After a meeting with the project supervisor and the tester, it was decided to change the message to "Det er ingen vilkår som gjelder for å innfri nøkkelhullet for denne matvaregruppen." (There are no conditions that apply to meet the Nøkkelhullet for this food group.). This new message provides more context, reducing potential confusion or misinterpretation. It informs that this food group has no specific conditions to meet the Nøkkelhullet regulations, leading to a better UX of calculator.

Figure 4- 22. A screenshot showing the updated message of Nøkkelhullet results container for food group number twenty-one stating, "Det er ingen vilkår som gjelder for å innfri nøkkelhullet for denne matvaregruppen." (There are no conditions that apply to meet the Keyhole label for this food group.).

Follwing this change, the message in the Nøkkelhullet results container of food group number two, "Frukt og bær som er uforedlet. Produktene kan likevel være varmebehandlet.", (Fruit and berries that are unprocessed. The products can still be heat treated.), was also updated. The figures below display these changes:

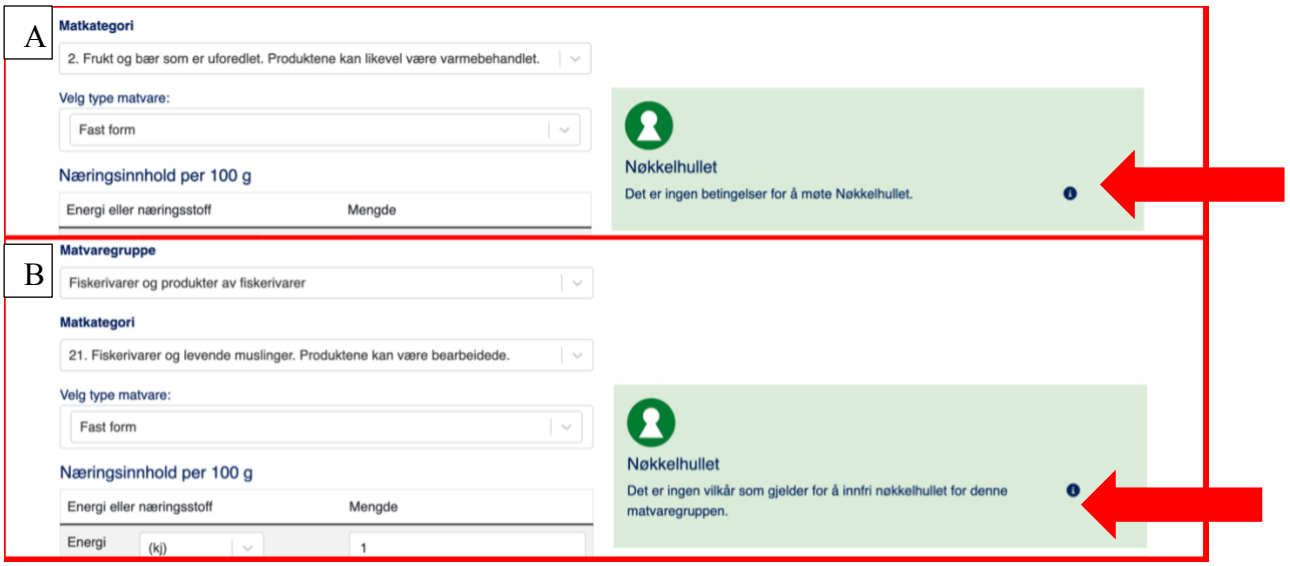


Figure 4- 23. The Nøkkelhullet results container messages for food group number two before and after the update: A) The screenshot displays the original message, stating, "Det er ingen betingelser for å møte Nøkkelhullet." (There are no conditions for meeting the Keyhole label.). B) The screenshot shows the updated message, saying, "Det er ingen vilkår gjelder for å innfri nøkkelhullet for denne matvaregruppen." (There are no conditions that apply to meet the Keyhole label for this food group).

Details about the changes made to the code can be found in Appendix V.

4.4.1.3.2 Misinterpretation of "Hvorav sukkerarter" (Of which sugars) and "Hvorav tilsatte sukkerarter" (Of which added sugars)

According to the tester's observation, the web calculator faced an issue when handling products with the "Uten tilsatt sukker" (With no added sugars) claim. This issue appeared

when the tester inputted the nutritional content per 100g of Tine Go'morgen® vanilla yoghurt into the web calculator for testing purposes (Tine, n.d.).

The tester found that the web calculator did not verify that the product met the "Uten tilsatt sukker" claim, even though the claim is clearly labelled on its packaging. While this product, as stated on its packaging, does not contain any added sugars, it has natural sugars from the milk and fruits used in its production. These natural sugars are represented in the 3.9 g "hvorav sukkerarter" (of which sugars) per 100g.

Figure 4- 24. The Tine Go'morgen® vanilla yoghurt packaging, claiming " Uten tilsatt sukker" (With no added sugars) (Tine, n.d.).

Figure 4- 25. A screenshot of the Tine official website displaying the nutritional content per 100g of the Go'morgen® vanilla yoghurt (Tine, n.d.).

In the existing prototype, the Fremtidsmat web calculator provides input fields for the user to enter the nutritional content of "Karbohydrater" (Carbohydrates) and "Hvorav tilsatte sukkerarter" (Of which added sugars). In this case, the tester appears to have misunderstood the "hvorav sukkerarter" value as "hvorav tilsatte sukkerarter", resulting in an incorrect denial of the "Uten tilsatt sukker" claim by the web calculator for the Go'morgen® vanilla yoghurt.

This incident underlined the need for a more noticeable distinction in the web calculator between total and added sugars. It also reemphasized the complexity of nutritional labelling and the potential for misinterpretation. During this iteration of the project, discussions regarding these findings took place. However, further feedback from the project supervisor and academic members at OsloMet is pending due to timeline constrains.

4.5 Fifth iteration

4.5.1 Implementing Ernæringspåstander

4.5.1.1 Implementing "Med et naturlig innhold av sukker" (Contains naturally occurring sugars) claim (part 2)

According to the EFSA guidelines, the "Med et naturlig innhold av sukker" (Contains naturally occurring sugars) claim can be used when a food product contains sugars that are

naturally present, meaning that they have not been added to the product (European Commission, n.d.).

After continuous discussing with the project supervisor and academic staff at OsloMet (see Contains naturally occurring sugars) claim (part 1)), it was decided that when implementing the "Med et naturlig innhold av sukker" claim, to ask users to provide information about the amount of total sugars, added sugars, and naturally occurring sugars present in the food product.

Incorporating this claim required several important changes to the web calculator's UI. The first change was adding a new row to the table and a new nutrient input field, allowing the user to input the amount of "Naturlig innhold sukkerarter" (naturally occurring sugars). Based on this input, specific feedback messages were designed to be displayed in the "Ernæringspåstander" results container, indicating whether the food product complies with the "Med et naturlig innhold av sukker" claim.

When the user's input complies within the "Med et naturlig innhold av sukker" claim parameters, the message "** Med et naturlig innhold av sukker: Dette produktet inneholder naturlig forekommende sukker og oppfyller kravet for "Med et naturlig innhold av sukker"." (** Contains naturally occurring sugars: This product contains naturally occurring sugar and meets the requirements for "Contains naturally occurring sugars".) appears in the "Ernæringspåstander" results container. When the user's input does not comply within the "Med et naturlig innhold av sukker" claim parameters, the message "** Produktet innfrir ikke "Med et naturlig innhold av sukker" påstanden. Produktet må inneholde naturlig forekommende sukker og ikke ha tilsatt sukker." (** The product does not meet the "Contains naturally occurring sugars" claim. The product must contain naturally occurring sugar and not have added sugar.) appears in the "Ernæringspåstander" results container. The figures below illustrate these changes:

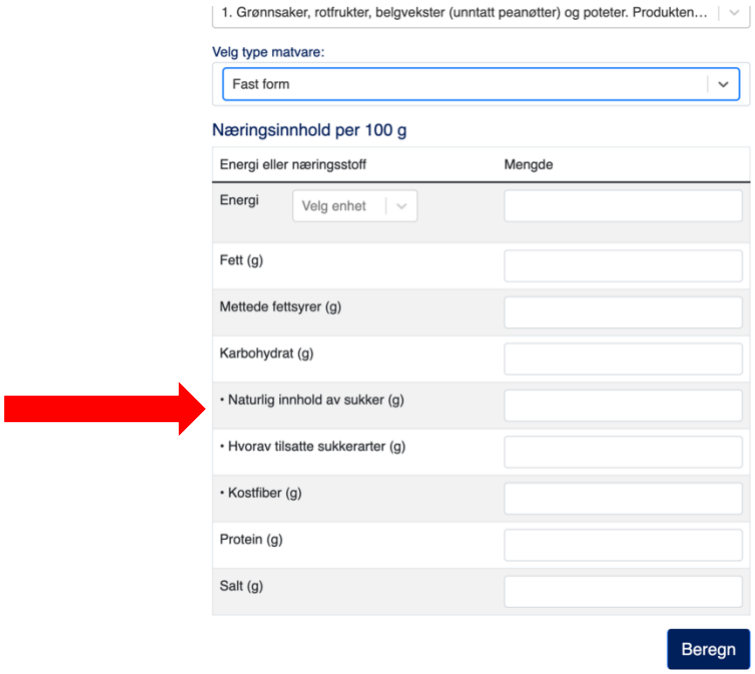


Figure 4- 26. A screenshot of the updated "Kategori1" component UI showing the new row and new input field for "Naturlig innhold sukkerarter".

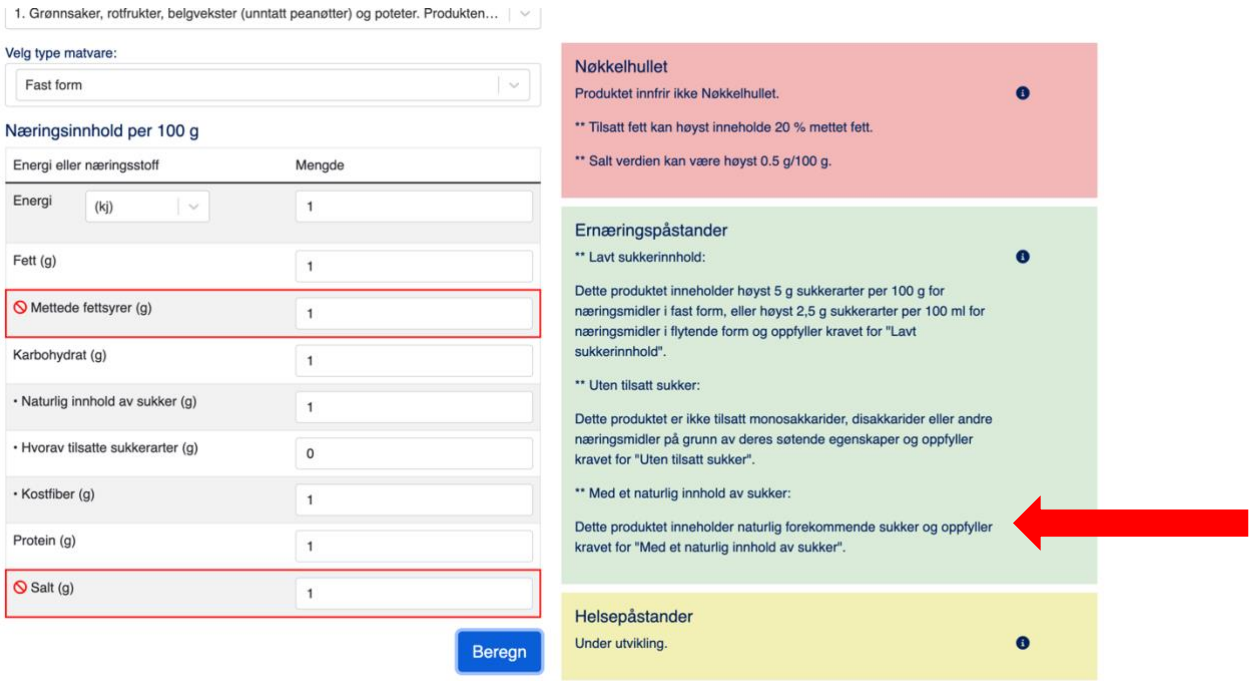


*Figure 4- 27. The updated "Kategori1" component UI, showing the "Ernæringspåstander" results containerin green, displaying a feedback message such as, "** Med et naturlig innhold av sukker: Dette produktet inneholder naturlig forekommende sukker og oppfyller kravet for "Med et naturlig innhold av sukker".", for when the product meets the "Med et naturlig innhold av sukker" claim and all the other already funcional claims.*

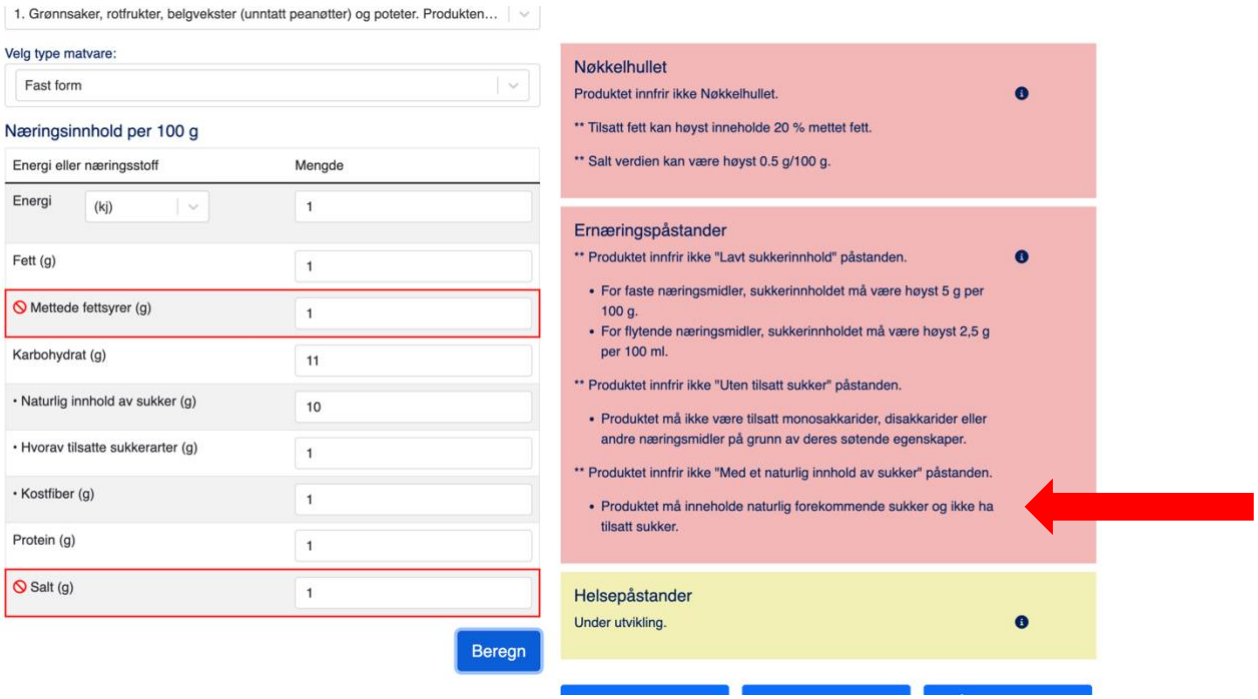


*Figure 4- 28. The updated "Kategori1" component UI, showing the "Ernæringspåstander" results container in red, displaying a feedback message such as, "** Produktet innfrir ikke "Med et naturlig innhold av sukker" påstanden. Produktet må inneholde naturlig forekommende sucker or ikke ha tilsatt sucker.", for when the product does not meet the "Med et naturlig innhold av sukker" claim and all the other already funcional claims.*

For a detailed explanation of the code changes and additions, please see Appendix W.

4.5.1.2 Implementing "Sukkerfri" (Sugars-free) claim

As per the EFSA guidelines, the "Sukkerfri" (Sugars-free) claim can be used when a food product contains a maximum of 0.5 g of sugars per 100 g or 100 ml, regardless of whether the food product is in a solid or liquid physical state (European Commission, n.d.).

To implement the "Sukkerfri" claim, several changes and additions were introduced to the web calculator's UI. The first update included a calculation to check if solid and liquid food types meet the "Sukkerfri" claim. Moreover, specific feedback messages based on the claim conditions check were added in the "Ernæringspåstander" results container. If a food product meets the claim conditions, it can be labelled as "Sukkerfri", and the user sees the following message: "** Sukkerfri: Dette produktet oppfyller kravet for "Sukkerfri" ved å inneholde ikke mer enn 0,5 g sukkerarter per 100 g/ml." (** Sugars-free: This product meets the "Sugars-free" claim by containing no more than 0.5 g of sugars per 100 g/ml.).

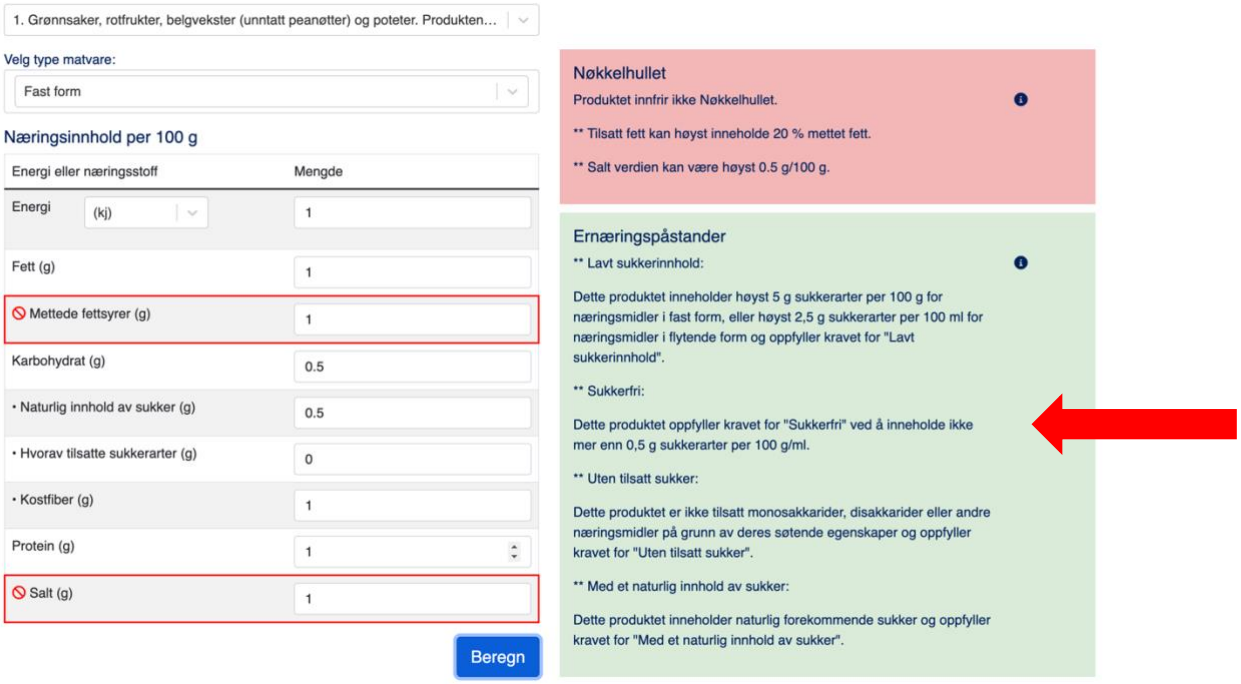


Figure 4- 29. A screenshot of the updated "Kategori1" component UI, showing the "Ernæringspåstander" results container in green, displaying a specific feedback messagenindicating that the food product meets the "Sukkerfri" and other functional claims.

In case the product does not meet the claim conditions, the user sees the message: "** Produktet innfrir ikke "Sukkerfri" påstanden måinneholde høyst 0,5 g sukkerarter per 100 g/ml for å oppfylle "Sukkerfri" påstanden." (** The product does not meet the "Sugars-free" claim. It should contain at most 0.5 g of sugars per 100 g/ml to meet the "Sugars-free" claim.).

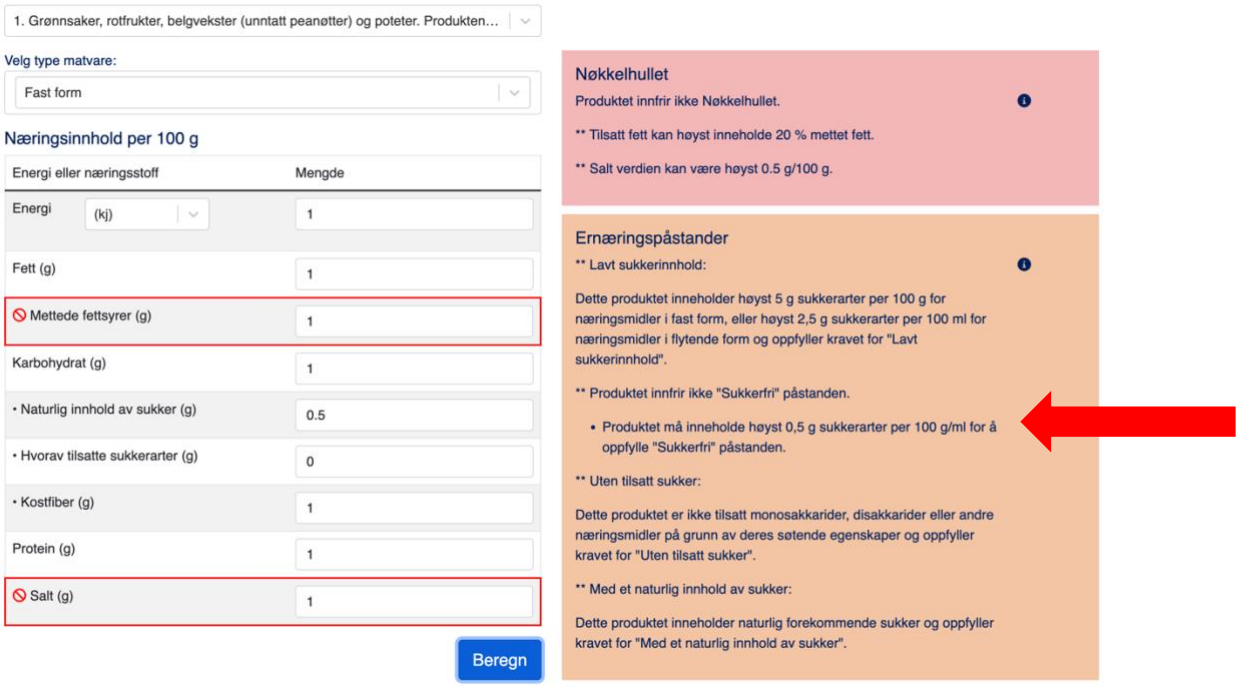


Figure 4- 30. A screenshot of the updated "Kategori1" component UI, displaying the "Ernæringspåstander" results container in orange, displaying specific feedback messages indicating that the food product does not meet the "Sukkerfri" claim but meets some other functional claims.

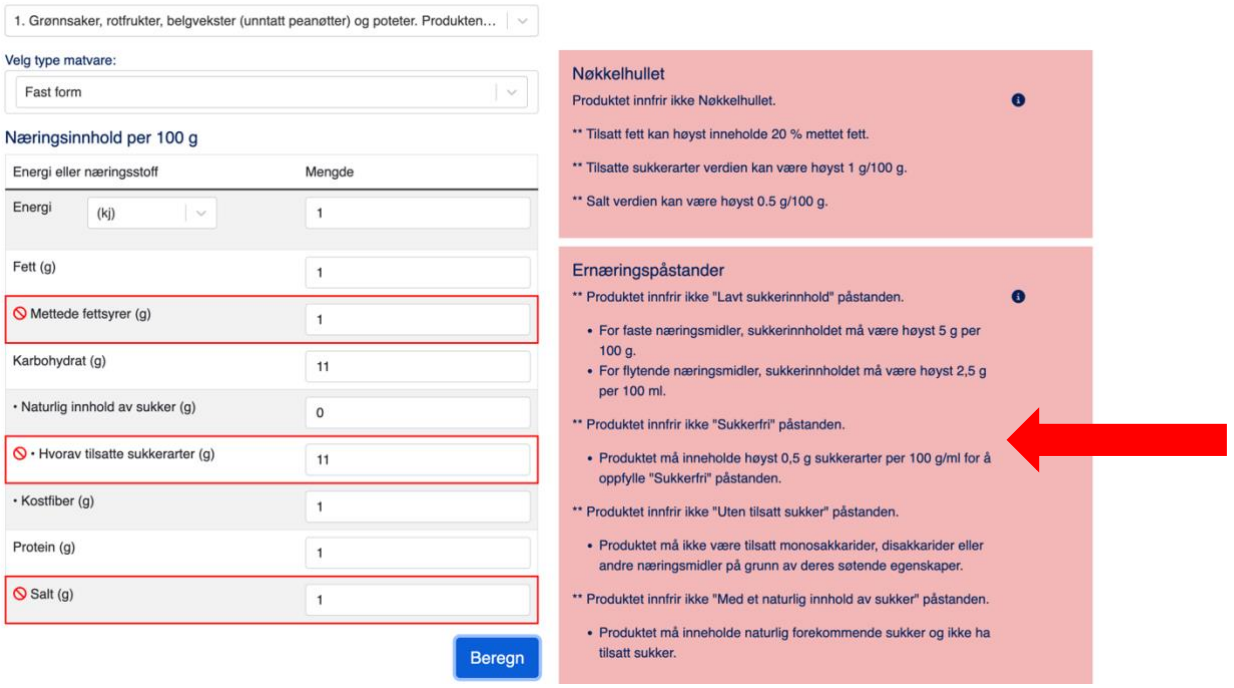


Figure 4- 31. A screenshot of the updated "Kategori1" component UI, illustrating the "Ernæringspåstander" results container in red, displaying a specific feedback message indicating that the food product does not meet the "Sukkerfri" and other functional claims.

Details about the changes and additions made to the code can be found in Appendix X.

4.5.2 Addressing usability issues

4.5.2.1 Report on usability issues – user-based testing iteration 4

The following is the user-based testing feedback collected from forth iteration of user-based testing by fellow master's student Hammer Lars:

"*Results from iteration 4 are as follows:*

- *They both think that there is much text in the food categories. I think that there is not much that can be done on this part.*
- *A thing that was pointed out in Ernæringspåstander is if "lavt sukkerinnhold" does not meet the requirement. Then it says "sukkerinnholdet må være lavere enn 5g pr 100 g", but it refers to the carbohydrates box. So, we could change the sentence to "karbohydrater må være lavere enn 5 g pr 100 g".*
- *To make things more understandable there could be an additional subcategory in carbohydrates, such as natural sweetener. We need to use a name that is easy to understand because there are natural sugars in some products but using the name natural sugars can also be misleading. (tricky)*
- *There also was an issue with the color code. They both think that it is a bit difficult to understand that one claim can be used with the orange color. It still looks like both are wrong, and they should be green if it meets the claim.*
- *Also, when lavt sukkerinnhold meets the requirement, it is unclear if it is meeting or not. It says you can use the claim in the last sentence of the paragraph. But if you change it so it gives the same statement as on added sugars, it will be more understandable. Or say at the top of each claim this can be used, or this cannot be used. Even though the blue color signifies they both meet the requirement, the users do not know this.*
- *She also said it could be a good idea to add a warning symbol at this stage of the calculator. Something that shows the users that some claims that the calculator says are fine to use, might not be right, and are misleading. One participant wanted to have this over the nøkkelhull box in the available space there. And the other said have a button in the box marked with a clear warning symbol that the users could press.*
- *Both participants thought it could be a good idea to only show the claims that meet the requirement, and then push a button in the Ernæringspåstander, that will show*

all the other claims that could not be used. This way could help differentiate between the claims that can be met and those that cannot.

- *The two buttons save product and add new product seemed to be somewhat similar. As save product can also mean save the product and it will let you try again. She might think to rename add new product to "refresh" or something along that way. At this point, maybe remove the "save product button" as it does not have any function yet, and it can help the users press the correct button.*"

4.5.2.2 Addressing user-based testing feedback

4.5.2.2.1 Suggestion on implementing a "warning" symbol

Participants suggested implementing a "warning" symbol to alert users when various Ernæringspåstander and Nøkkelhullet guidelines might not be applicable to every food product, even if technically meeting the criteria. This feedback is similar to the one discussed in sections "4.3.2.1.3 Misleading " Uten tilsatt sukker" (with no added sugars) claim" and "4.4.1.1.5 Misleading "Lavt sukkerinnhold" (Low sugars) claim / Warning symbol proposal". As explained there, the proposed feature would help users understand the application of Nøkkelhullet and Ernæringspåstander, preventing potential labelling misuse and helping users adjust their application accordingly.

However, correctly implementing the "warning" symbol requires a complete understanding of the Nøkkelhullet and Ernæringspåstander guidelines and the characteristics of each food category and subgroup, together with professional consultation from a nutrition and food specialist. Given the timeline constraints of this thesis, it was again indicated that cooperating with an expert for their consultation was not possible. As such, being unable to implement a "warning symbol" within the calculator is acknowledged as a limitation of the current research. Nevertheless, implementing this feature is an important recommendation for future work.

4.5.2.2.2 Text amount in the food group category selectors

Both participants expressed concern regarding the overwhelming amount of text presented in the food group category selectors. However, the food group categories descriptions are directly sourced from the "Lovdata" website, which offers legal information for Norwegian laws and regulations, including those about "Nøkkelhullet". Given the legally sensitive nature of these descriptions, keeping the information accurate is crucial.

Although the primary objective of this project is to create a user-friendly interface, it is also required that the calculator's content align with legal requirements, such as the regulations on voluntary labelling of food products with the "Nøkkelhullet", in this case.

These concerns are similar to those discussed in "4.3.2.1.4 Subcategories of meat products", where the participant found the subcategories under meat products confusing and challenging. Both issues revolve around maintaining the legal accuracy of information sourced directly from the "Lovdata" website while implementing an accessible, user-friendly interface.

During a meeting with the project supervisor, it became clear that reducing the amount of text presented in the food group category selectors could lead to inaccurate or misleading information, which would compromise the web calculator's reliability and risk a violation of legal requirements. Consequently, as in "4.3.2.1.4 Subcategories of meat products", it was decided to keep the current content of the interface the same, despite the user feedback concerns regarding the amount of text. This issue has been noted as a limitation in the existing research and a recommendation for future work, which could focus on enhancing usability without compromising the legal requirements.

4.5.2.2.3 Improving the clarity of Ernæringspåstander results container messages

The participants expressed confusion regarding the messages displayed in the Ernæringspåstander results container. According to the participants, the messages describing whether a food product adheres to different nutritional claims were unclear. This lack of clarity was especially noticed for messages related to the "Lavt sukkerinnhold" claim:

The message displaying that a food product does not meet the "Lavt sukkerinnhold" claim: " ** Produktet innfrir ikke "Lavt sukkerinnhold" påstanden. For faste næringsmidler, sukkerinnholdet må være høyst 5 g per 100 g. For flytende næringsmidler, sukkerinnholdet må være høyst 2,5 g per 100 ml." (** The product does not meet the "Low Sugars" claim. For solid foods, the sugar content must be at most 5 g per 100 g. For liquid foods, the sugar content must be at most 2.5 g per 100 ml.). And the message stating that a food product meet the "Lavt sukkerinnhold" claim: "** Lavt sukkerinnhold: Dette produktet inneholder høyst 5 g sukkerarter per 100 g for næringsmidler i fast form, eller høyst 2,5 g sukkerarter per 100 ml for næringsmidler i flytende form og oppfyller kravet for "Lavt sukkerinnhold"." (** Low Sugar: This product contains at most 5 g of sugars per 100 g for solid foods, or at

most 2.5 g of sugars per 100 ml for liquid foods and meets the requirements for "Low Sugar".).

While these messages are correct, participants needed clarification as the information about whether or not the food product meets the claim was not immediately noticeable. This was specifically the case when the food product did meet the claim.
In addition, the participants suggested adjusting the opening part of each message, starting with a clear statement regarding the food product's compliance status, such as: "Produktet oppfyller kravet for "Lavt sukkerinnhold" påstanden." or "Produktet oppfyller ikke kravet forn"Lavt sukkerinnhold" påstanden." They further recommended that the second part of the message present the reasoning behind the claim's application or non-application status. Following this proposal, changes were made to the initial part of each message, including those for "Lavt sukkerinnhold", "Sukkerfri", "Uten tilsatt sukker", and "Med et naturlig innhold av sukker" claims. The consistent approach across all messages, regardless of whether a food product adheres to specific nutritional claims, provides a more precise and user-friendly UI.

For example, if a food product doesn't meet a claim, the updated message states: "** Lavt sukkerinnhold: Produktet oppfyller ikke kravet for "Lavt sukkerinnhold". For faste næringsmidler, må sukkerinnholdet være høyst 5 g per 100 g. For flytende næringsmidler, må sukkerinnholdet være høyst 2,5 g per 100 ml." (** Low Sugar: The product does not meet the requirements for "Low Sugars". For solid foods, the sugar content must be at most 5 g per 100 g. For liquid foods, the sugar content must be at most 2.5 g per 100 ml.). On the other hand, if a food product meets the claim, the modified message states: "** Lavt sukkerinnhold: Produktet oppfyller kravet for "Lavt sukkerinnhold". Det inneholder høyst 5 g sukkerarter per 100 g for næringsmidler i fast form, eller høyst 2,5 g sukkerarter per 100 ml for næringsmidler i flytende form." (** Low Sugar: The product meets the requirements for "Low Sugars". It contains at most 5 g of sugars per 100 g for solid foods, or at most 2.5 g of sugars per 100 ml for liquid foods.).

These changes enhance the user's understanding of whether the product meets the specific claim, reducing potential confusion and improving the clarity of the UI.
Solving this issue leads to conforming with the WCAG 3.1 guideline on "Readability" as well as WCAG 2.1, SC 3.2.4 "Consistent Identification (W3C, 2023e).

Figures illustrating the UI before and after adjusting the messages on the Ernæringspåstander results container can be seen below:

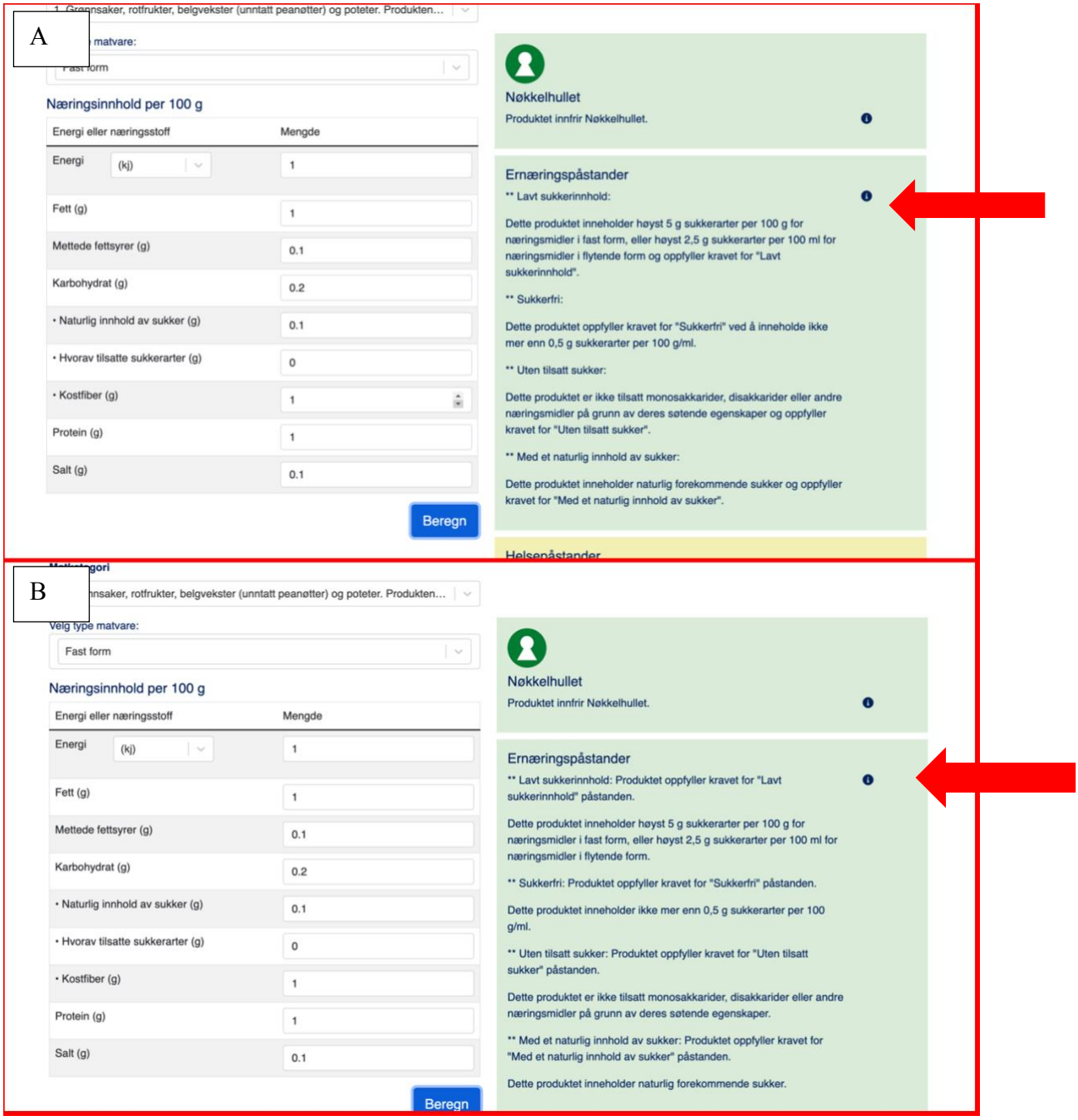


Figure 4- 32. he Ernæringspåstander results container compliance messages for food products before and after the update: A) The original Ernæringspåstander results container messages when it is not clear if the food product complies or not with

any of the claims. B) The updated Ernæringspåstander results container messages where its clear if the food product complies or not with any of the claims.

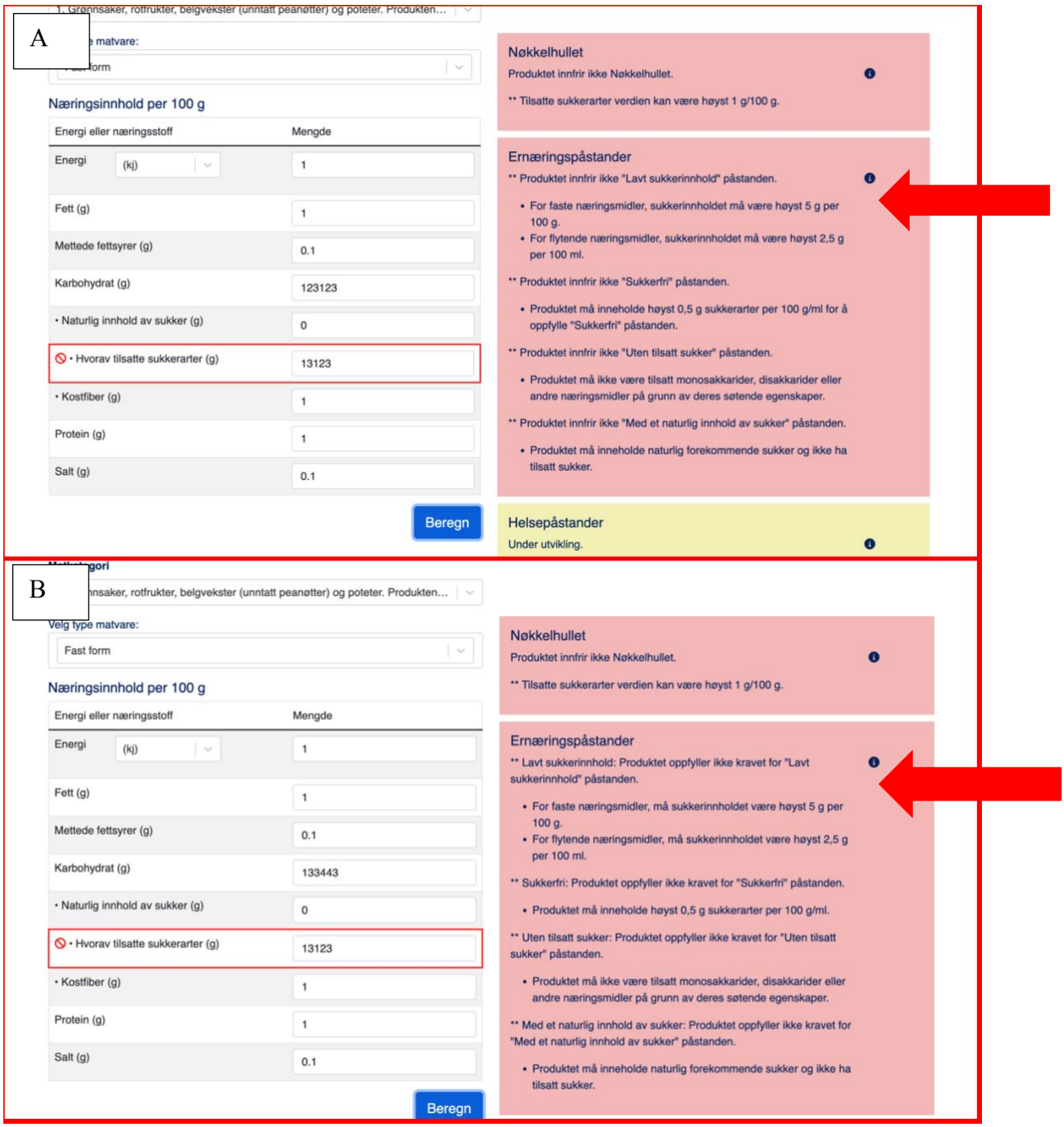


Figure 4- 33. The Ernæringspåstander results container non-compliance messages before and after the update: A) The screenshot displays the original Ernæringspåstander results container messages without any special meformation to clarify if the food product comply or not with any of the claims. B) The screenshot shows the updated Ernæringspåstander results container messages where its clear if the food comply or not with any of the claims.

Figure . The Ernæringspåstander results container non-compliance messages before and after the update: **A)** The screenshot displays the original Ernæringspåstander results

container messages when the food product does not comply with any of the claims. **B)** The screenshot shows the updated Ernæringspåstander results container messages when the food product does not comply with any of the claims.

Details about the changes made to the code can be found in Appendix Z.

4.5.2.2.4 Confusion regarding the functionality of the "Lagre produkt" and "Legg til et nytt produkt" buttons and implementation of dropdowns mockups for "Lagre produkt" and "Del produkt" buttons

Participants found the functionality of the "Lagre produkt" and "Legg til et nytt produkt" buttons confusing. According to them both, the "Lagre produkt" button could be misleading, as it might be interpreted as a feature that could save the food products data to restart the process afterwards, therefore, it could be similar to the "Legg til et nytt produkt" button function. As a result, the participant suggested either removing the "Lagre produkt" button from the web calculator since in this phase is currently non-functional or renaming the "Legg til et nytt produkt" button to "Oppdater" (Refresh) to create clear differentiation.

Confusion regarding the functionalities of the "Lagre produkt", "Del produkt", and "Legg til et nytt produkt" has been reported many times during the development process of the web calculator (see "4.4.1.1.3 Confusion regarding the functionality of the "Lagre produkt" and "Del produkt" buttons" and "4.4.1.1.2 Evaluating suggestions on "Lagre produkt" and "Legg til et nytt produkt" buttons placement"), indicating a need for a better way of communicating information when it comes to these buttons functionality.
After a thorough meeting with the supervisor, it was decided to introduce more information about the potential functionalities of the "Lagre produkt" and "Del produkt" mockup buttons. In contrast, the "Legg til et nytt produkt" button, which resets the input fields, was decided to remain unchanged.

Specifically, the "Lagre produkt" button was transformed into a dropdown with non-functional options such as "Lagre som PDF" (Save as PDF), "Lagre som bilde" (Save as Image), "Large i nettsky" (Save to Cloud) and "Lagre I profilen" (Save to profile). Similarly, the "Del produkt" button was transformed into a dropdown with non-functional options such as "Send på e-post" (Send via e-post), "Del til samarbeidsplattformer" (Share to collaborative platforms), and "Kopier lenke" (Copy Link) (see "4.2.1.4 Adding mockups for save and share features"). Adding the non-functional dropdown options may potentially lead to reduced

confusion and help users differentiate between "Lagre produkt", "Del produkt" and "Legg til et nytt produkt" buttons.

Additionally, to keep users informed about the development progress and help them understand what to expect in the future, each dropdown option was disabled and labelled with the message "(Denne funksjonen er under utvikling)" (This feature is under development).

Moreover, to ensure these new features are accessible to all users, whether they are using a mouse, keyboard, or AT, the WAI-ARIA (Accessible Rich Internet Application) semantics ("aria-labelledby" and "aria-describedby") were incorporated (see Appendix V) (W3C, n.d.-c, n.d.-d).

The figures below illustrate these changes:

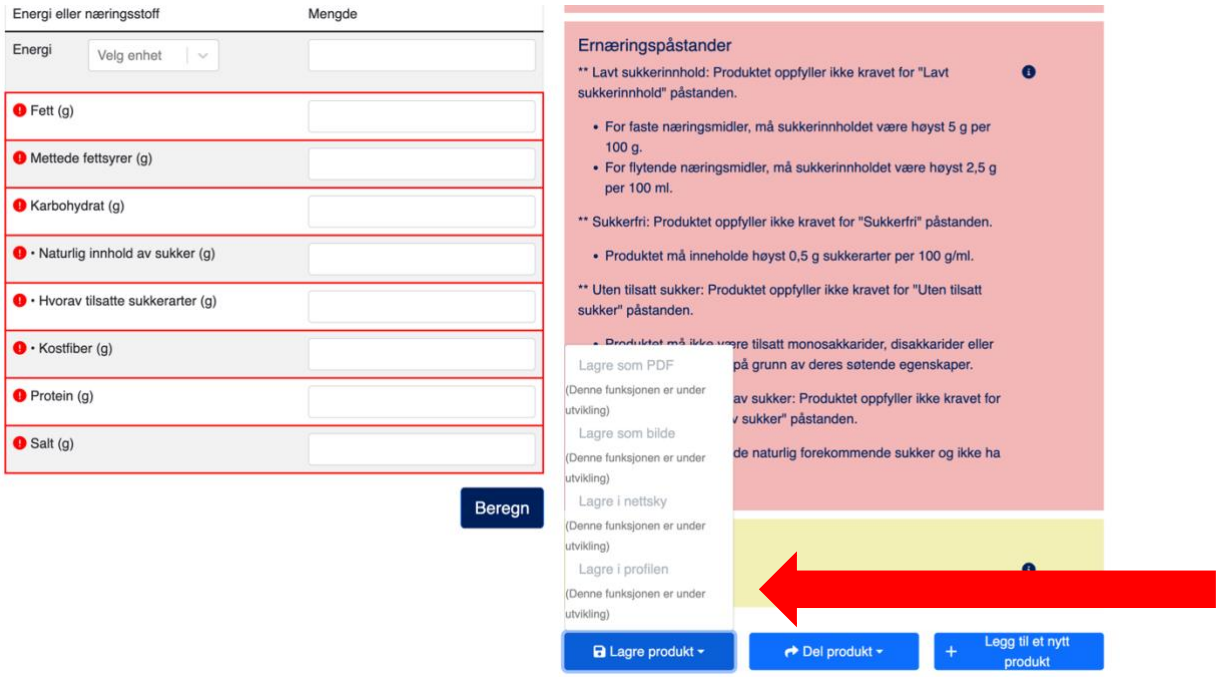


Figure 4- 34. Screenshot of the web calculator UI showing the "Lagre produkt" button with added dropdown mockups "Lagre som PDF" (Save as PDF), "Lagre som bilde" (Save as Image), "Large I nettsky" (Save to Cloud) and "Lagre I profilen" (Save to profile) with the note "(Denne funksjonen er under utvikling)" (this function is under development) next to each dropdown option.

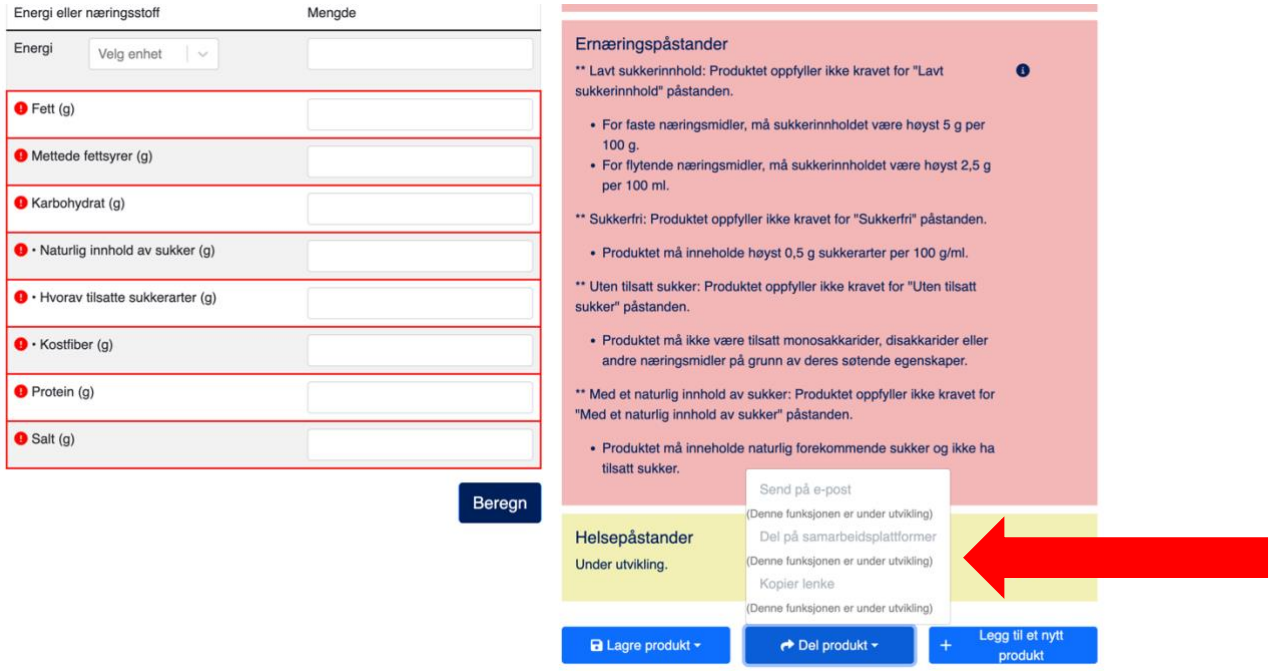


Figure 4- 35. Screenshot displaying the "Del produkt" button, offering the disabled options "Send på e-post" (Send via e-post), "Del til samarbeidsplattformer" (Share to collaborative platforms), and "Kopier lenke" (Copy Link), followed by the same "(Denne funksjonen er under utvikling)" note.

Solving this issue leads to conforming with the WCAG 2.0, SC 4.1.2 on "Name, Role, Value (W3C, 2023f). The code implementation of these mockup features is detailed in Appendix V.

4.5.2.2.5 Suggestion on the selective display of Ernæringspåstander in Ernæringspåstander results container

The participants suggested modifying the display of Ernæringspåstander on the results container. In the current version of the web calculator, Ernæringspåstander are presented using a three-colour theme: green colour for full compliance with all claims, Red for non-compliance with any claims, and orange for compliance with some claims (see 4.3.1.1 Implementing the "Lavt sukkerinnhold" (Low sugars) claim).

The proposal was that, by default, the Ernæringspåstander results container would display only the claims that can be applied to the food product. They further recommended implementing a button with an option to reveal the claims that could not be applied. According to the participants, this change could make differentiating between the applicable and non-applicable claims easier.

This suggestion is similar to the one discussed in "4.4.1.1.1 Evaluating suggestions on Ernæringspåstander colour theme and display". As explained there, this approach could

potentially limit information transparency. In the existing design, all the claims are visible, enabling the user to understand why some claims cannot be applied to their food product. This visibility might motivate users to adjust their food products to meet more claims. Hiding non-applicable claims by default risks withholding valuable information that can help users improve their food products, conflicting with the initial design logic and potentially creating usability issues.

However, the repetition of this feedback indicates users' preference for reducing the amount of information presented at once and minimising the cognitive load. Implementing such a change might disrupt consistency with other UI components, such as the Nøkkelhullet and Helsepåstander results container. This situation might lead to confusion and a complicated UX, contradicting WCAG 2.1, SC 3.2.4 "Consistent Identification" (W3C, 2023e).

Given these concerns, and after careful consideration and consultation with the project supervisor, it was decided to maintain the current design, prioritising consistency, and transparency over minimising the cognitive load. Nevertheless, this proposal provided valuable insights into the users' perspective and has been noted as a suggestion for future work.

4.5.2.2.6 Confusion regarding the interpretation of the Ernæringspåstander results container three-colour theme

The participants expressed confusion about the three-colour theme of the Ernæringspåstander results container ((see 4.3.1.1 Implementing the "Lavt sukkerinnhold" (Low sugars) claim). Specifically, the orange colour, indicating that the food product meets at least one or some of the Ernæringspåstander, was found misleading, with participants interpreting it as a sign of non-compliance with any Ernæringspåstander. As a result, the participants suggested using a two-colour theme of green and red.

This feedback is the same as the one raised in "4.4.1.1.1 Evaluating suggestions on Ernæringspåstander colour theme and display", where the participant proposed splitting the Ernæringspåstander results container into two different containers, allocating the claims that can be applied to a green Ernæringspåstander results container, while the ones that cannot be applied to a red Ernæringspåstander results container. Having the same issue again indicates that users are more prone to associate green with adherence and red with non-adherence. While the orange colour represents a middle ground, it creates confusion, implying that colour alone is not enough for users to understand the displayed information.

This issue conflicts with the WCAG 2.1, SC 1.4.1 "Use of colour", suggesting that colour should not be used as the only way of communicating information (W3C, 2023a). However, splitting the Ernæringspåstander results container into two or adding symbols or different types of outlines around this container with the intention of clear communication might create inconsistencies with other UI components, potentially leading to confusion and complicating the UX. This situation is against WCAG 2.1, SC 3.2.4 "Consistent Identification (W3C, 2023e). Since both the Nøkkelhullet and Helsepåstander containers follow the logic of a single container to convey the results, differentiating the Ernæringspåstander could interfere with the overall consistency of the web calculator's interface.

Therefore, as in "4.4.1.1.1 Evaluating suggestions on Ernæringspåstander colour theme and display", following an in-depth discussion with the supervisor, it was decided to keep the current three-colour theme of the Ernæringspåstander results container.
This decision was mainly guided by the need to ensure design consistency.
This issue has been noted as a limitation in the existing research and a recommendation for future work, which could focus on experimenting with other forms of visual signs besides colour, to enhance the clarity of communication without disrupting the already established design consistency.

4.5.2.2.7 Confusion regarding the terminology of "Sukkerarter" and "Karbohydrater"

The participants expressed confusion regarding the terms "sukkerarter" (total sugars) and "Karbohydrater" (Carbohydrates). According to the participants, the messages about compliance with "Lavt sukkerinnhold" and "Sukkerfri" claims in the Ernæringspåstander results container use the "sukkerarter" term. However, the web calculator does not provide an input field for users to enter the nutritional content of "sukkerarter". Instead, the web calculator asks for the nutritional content of "Karbohydrater", a term used for combining starches, sugars, and fibres (Joanne Slavin* and Justin Carlson, 2014).

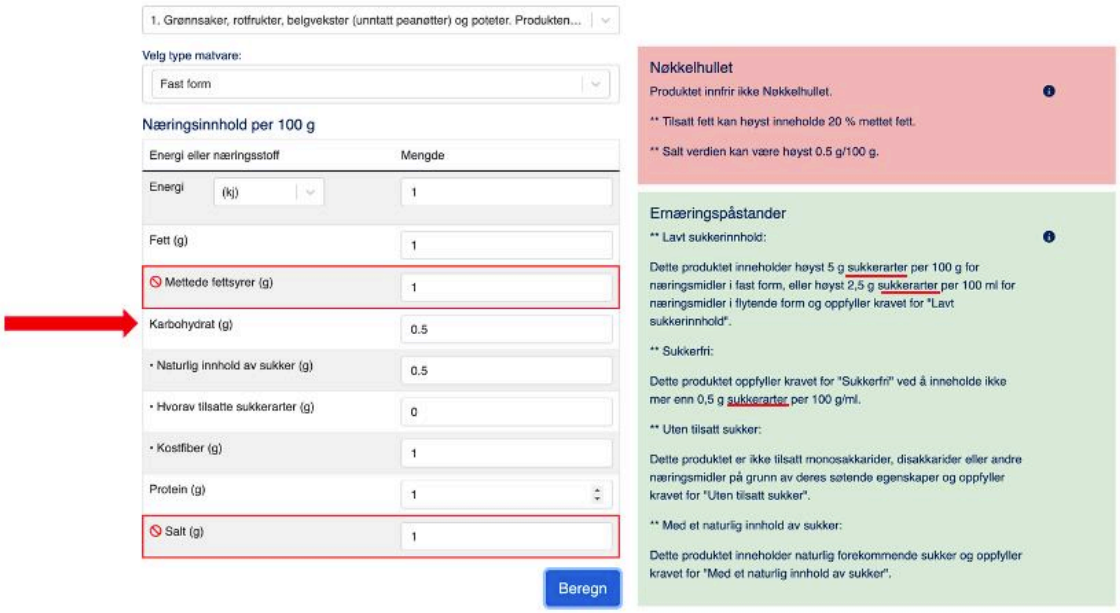


Figure 4- 36. A screenshot of the web calculator UI, where are underlined the terms "Sukkerarter" within the Ernæringspåstander results container as well as the "Karbohydrater" input field row.

Although the existing messages in the Ernæringspåstander results container are correct, as "sukkerarter" are a type of "Karbohydrater", it seems to confuse users.

To better understand the problem and seek advice on the appropriate solution, a meeting was held with the project supervisor and academic members at OsloMet. During the meeting, the need for a clearer distinction between "Karbohydrater" and "sukkerarter" was acknowledged.

Some discussed solutions to this problem involved maintaining the existing messages in the Ernæringspåstander results container about "Lavt sukkerinnhold" and "Sukkerfri" claims, but with additional information to clarify the difference between "Karbohydrater" and "sukkerarter". For example, the new updated message for "Lavt sukkerinnhold" instead of "Dette produktet inneholder høyst 5 g sukkerarter per 100 g for næringsmidler i fast form, eller høyst 2,5 g sukkerarter per 100 ml for næringsmidler i flytende form.", could incorporate the phrase "sukkerarter, en del av karbohydrater", to indicate that the sugar content is part of carbohydrates. Other suggestions discussed were about changing the terminology from "sukkerarter" to "Karbohydrater" in the Ernæringspåstander results container. Another proposal involved adding an input field for the nutritional content of

"sukkerarter", allowing the web calculator to refer directly to "sukkerarter" when addressing the compliance of "Lavt sukkerinnhold" and "Sukkerfri" claims.

Nevertheless, any proposed changes would need to be approved by a food and nutrition expert to ensure they are both technically correct and compliant with the legal regulations. However, due to the limited timeline of this thesis project, consultation with an expert was not possible on this issue. Consequently, discussions about these potential changes are ongoing, pending further feedback from the project supervisor and academic members at OsloMet. Solving this issue has been noted as future work, and the lack of a solution within this thesis is recognized as a limitation of the current research.

4.5.2.2.8 Suggestions on implementing a new nutrient field for "Naturlige søtstoffer" (Natural sweeteners)

The participants suggested adding a new input field for the amount of "Naturlige søtstoffer" (Natural sweeteners) in food products' nutritional calculations. In this case, the participants seem to have the misconception that these types of sweeteners should be differentiated from the category of "tilsatte sukkerarter" (added sugars), which is already present in the web calculator.

However, according to the EFSA claims, the "Naturlige søtstoffer" are considered part of "tilsatte sukkerarter" (European Commission, n.d.). Therefore, creating a separate input field for "Naturlige søtstoffer" could complicate the UX, potentially leading to confusion and mistakes during the data entry process.

In the existing version of the web calculator, users are already asked to input the amount of "tilsatte sukkerarter", which, by definition, includes "Naturlige søtstoffer". This approach maintains simplicity while assessing the adherence of food products to the EFSA claims.

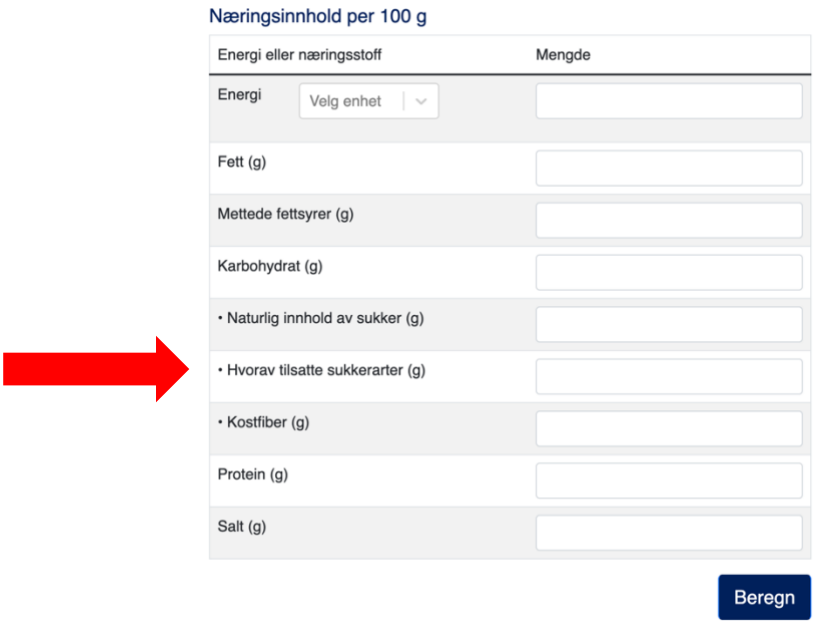


Figure 4- 37. A screenshot of the existing UI for the nutrient input fields, highlighting the input field for "Hvorav tilsatte sukkerarter" (Of which added sugars).

In light of the above, a meeting with the project supervisor and academic members at OsloMet was held. During the meeting, it was acknowledged that many food producers may not be able to access detailed information about the amount of different types of sugars in their products. Therefore, implementing a separate field for "Naturlige søtstoffer" and asking for such specific data could impede the usability of the web calculator.

Given these considerations, the decision was made to maintain the current design of the web calculator, where "Naturlige søtstoffer" are considered part of "tilsatte sukkerarter". This decision prioritizes usability and the accessibility of getting the necessary information for users, ensuring the web calculator stays user-friendly and straightforward. However, the suggestion of implementing more detailed sugar category input fields, such as "Naturlige søtstoffer" in this case, has been identified as a potential improvement in the future development of the web calculator.

4.6 Heuristic evaluation (HE)

This section contains the results from the Heuristic Evaluation (HE). The evaluation specifically followed the five-step procedure detailed in the Website Accessibility Conformance Evaluation Methodology (WCAG-EM) 1.0 (see 2.5.1.1 WCAG-EM procedure), while the Web Content Accessibility Guidelines (WCAG) 2.1 was used as heuristics (W3C, 2014, 2018c).

4.6.1 Step 1 Define the evaluation scope

The scope of this heuristic evaluation was limited because of the project's development phase. Therefore, random sampling was considered unnecessary when considering web page samples for the conformance evaluation. Instead, the focus of the evaluation was to cover the whole website, or in other saying, it included only the only functional web pages of the "Fremtidsmat" web calculator, the homepage and its web calculator page.
These webpages evaluated can be found at the following URLs:

- Homepage: https://nokkelhulet.vercel.app/
- Calculator page: https://nokkelhulet.vercel.app/calculator

The Web Content Accessibility Guidelines (WCAG) Version 2.1 guided this evaluation, aiming for a conformance target at Level AA, considering legal requirements to the Norwegian *"Forskrift om universell utforming av informasjons- og kommunikasjonsteknologiske (IKT)-løsninger"* (Regulation on universal design of information and communication technology (ICT) solutions) (DEPARTMENT OF FOREIGN AFFAIRS, 2017; Lovdata, 2019; United Nations, n.d.-a, n.d.-b).

The baseline for accessibility support focused on the website's compatibility with a popular browser such as Google Chrome, on Apple devices, specifically a MacBook Pro 13 and an iPhone 13. This choice was based on the availability of these devices, and limitations in budget and time for testing on other devices or browsers.

Given the regulations in Norway, the "Lov om behandling av personopplysninger (personopplysningsloven)" (Act on the Processing of Personal Data (Personal Data Act)) set by the EU General Data Protection Regulation (GDPR), and the short timeframe of this thesis, collecting data about the potential users' disabilities was restrictive (Datatilsynet, 2021, 2022; GDPR.EU, 2018; Lovdata, 2022). Therefore, not having this information about the food producers forced adjusting the evaluation strategy and focus on a broad user base instead of specific disability types. Consequently, disability-oriented testing and AT evaluations, including screen readers like JAWS, NVDA, or VoiceOver, was not conducted.

4.6.2 Stage 2 Explore the target website

During this stage, the "Fremtidsmat" website was thoroughly explored to learn its core functionality and purpose. In terms of the website's layout, a structured design was noticed

throughout the website. Yet, the homepage's main functionality was the button "GÅ til webkalkulatoren" (go to the web calculator) that guides users to the nutrition calculator page. On the other hand, the nutrition calculator page had a layered layout including interactive elements like dropdown menus, an "info" pop-up icon, and action buttons for calculating, saving, sharing, and adding new products. There were also external links to "lovdata.no". Certain sections, especially Nøkkelhullet, Ernæringspåstander, and Helsepåstander containers, displayed feedback based on user inputs and actions.

Several functionalities of the Fremtidsmat website were:

1. Navigate to the calculator page for food products.
2. Choose the relevant food group.
3. Choose the specific food category (additional actions: choose sub-category/sub-sub-category) within the selected food group.
4. Select the state of the food product (solid/liquid).
5. Choose an energy unit (kj/kcal).
6. Input nutrient values for the food product.
7. Calculate based on input values.
8. Display compliance to:
    - Nøkkelhullet (The Keyhole Label)
    - Ernæringspåstander (Nutrition Claims)
    - Helsepåstander (Health Claims)
9. Access detailed information regarding food and nutrition regulations and guidelines.
10. Save details of the food product.
11. Options to save product details in formats like PDF, image, cloud storage, and user profile are under development.
12. Share details of the food product.
13. Options to share product details via email, collaboration platforms, or a direct link are under development.
14. Add a new food product to the database.

4.6.3 Stage 3 Select a representative sample and Stage 4 Audit the selected sample

In this thesis, the Accessibility Conformance Evaluation Methodology (WCAG-EM) was conducted, where WCAG 2.1 Level AA was used as heuristics (See 2.2.2.1.2 Guidelines,

success criteria, and conformance). This means that of the total 78 WCAG 2.1 Success Criteria (SC), the evaluation used only the 30 Level A SC and the 20 Level AA SC. The remaining 28 Level AAA SCs were not included in this evaluation. Using the WCAG-EM Report Tool findings were documented as well as a checklist was made for the same purpose (See Appendix W and Appendix X (W3C, n.d.-f)).

Although the WCAG-EM guidelines recommend evaluators should ideally have significant expertise in web accessibility, for this master's thesis project, the evaluation was conducted by a single student, relying on personal knowledge and skills with guidance from the project supervisor.

4.6.4 Step 5 Report the findings

The Fremtidsmat web calculator was evaluated using the WCAG 2.1 Level AA Success Criteria (SC). Of the 50 SC (30 Level A and 20 Level AA), 34 were applicable and evaluated. Sixteen SCs were not evaluated because they did not apply to the web calculator's features. Specifically, ten Level A criteria related to audiovisual content and interactive control were not present, such as "1.2.1 Audio-only and Video-only (Prerecorded)", "1.2.2 Captions (Prerecorded)", "1.2.3 Audio Description or Media Alternative (Prerecorded), "1.4.2 Audio Control", "2.1.4 Character Key Shortcuts", "2.2.1 Timing Adjustable", "2.2.2 Pause, Stop, Hide", "2.3.1 Three Flashes or Below Threshold", "2.4.1 Bypass Blocks", and "2.5.4 Motion Actuation". Additionally, 6 Level AA SC were also not applicable, including "1.2.4 Captions (Live)", "1.2.5 Audio Description (Prerecorded)", "1.3.5 Identify Input Purpose", "1.4.5 Images of Text", "3.1.2 Language of Parts", and "3.3.4 Error Prevention (Legal, Financial, Data)", as the web calculator does not provide live media content or legal and financial transactions. Therefore, the evaluation used the remaining SCs relevant to the web calculator's functionality and content.

Therefore, the evaluation used the remaining SCs relevant to the web calculator's functionality and content. The results show that the web calculator satisfied 16 out of 20 relevant Level A SC (80% compliance), including "1.3.1 Info and Relationships", "1.3.2 Meaningful Sequence", "1.4.1 Use of Color", "2.1.1 Keyboard", "2.1.2 No Keyboard Trap", "2.4.3 Focus Order", "2.4.4 Link Purpose (In Context)", "2.5.1 Pointer Gestures", "2.5.2 Pointer Cancellation", "2.5.3 Label in Name", "3.1.1 Language of Page", "3.2.1 On Focus",

"3.2.2 On Input", 3.3.2 Labels or Instructions", "4.1.1 Parsing", and "4.1.2 Name, Role, Value". In Level AA, 10 out of 14 relevant SC criteria were met (approximately 71.43% compliance), such as "1.4.4 Resize text ", "1.4.11 Non-text Contrast", "1.4.13 Content on Hover or Focus", "2.4.5 Multiple Ways", "2.4.6 Headings and Labels", "2.4.7 Focus Visible", "3.2.3 Consistent Navigation", "3.2.4 Consistent Identification", "3.3.3 Error Suggestion", and "4.1.3 Status Messages".

However, the calculator did not meet 8 SC, with an equal split between Level A and Level AA. Failing to fully confirm Level A and Level AA means that The Fremtidsmat web calculator does not achieve an acceptable level of compliance as the Norwegian regulation on the universal design of ICT solutions requires.

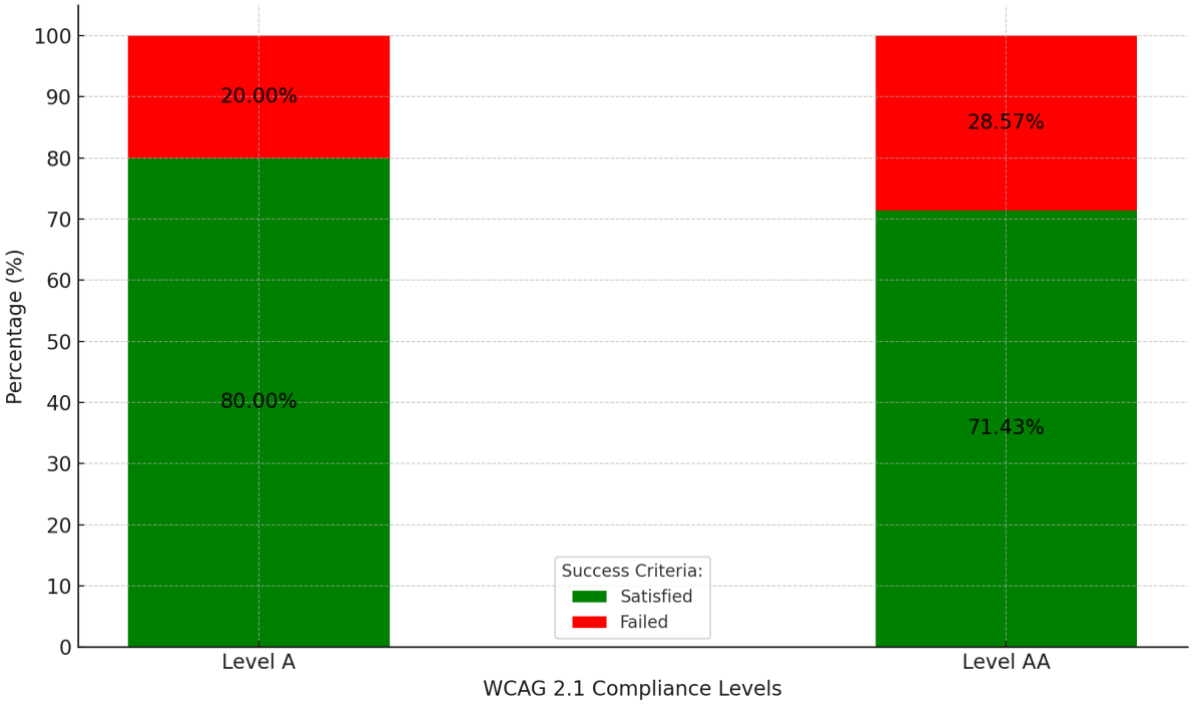


Figure 4- 38. A bar chart illustrating WCAG 2.1 compliance results of the Heuristic Evaluation of the Fremtidsmat web calculator.

In this section, the focus is on the criteria that the Fremtidsmat web calculator failed to meet (See Appendix W and Appendix X). Here are the detailed findings categorised by the four main principles of web accessibility, POUR (Perceivable, Operable, Understandable, Robust) (see 2.3.1.1 Principles):

- **Perceivable Issues:**

    1) **1.1.1: Non-text Content (Level A)**

        Several FontAwesome icons, such as faCircleInfo, faSave, faShare, and faPlus, were implemented without the necessary text alternatives (See Appendix Y). Proper attributes like aria-label or aria-labelledby are needed to ensure accessibility for users who cannot see them, especially screen reader users.

    2) **1.3.3: Sensory Characteristics (Level A)**

        The "info" and "close" actions use FontAwesome icons (faCircleInfo and faXmarkCircle). However, the aria-label attribute is needed here because, for now, the users rely only on visual representations (See Appendix Y).

    3) **1.3.4: Orientation (Level AA)**

        The buttons "Lagre produkt", "Del produkt", and "Legg til et nytt produkt", when viewed on a minimised desktop screen or an iPhone, lose the gap between them, making it difficult or impossible to interact with the page correctly. The "Legg til et nytt produkt" button is almost cut off the screen, making it unable to read its content and interact in small screen size.

        The figures below illustrate these issues:

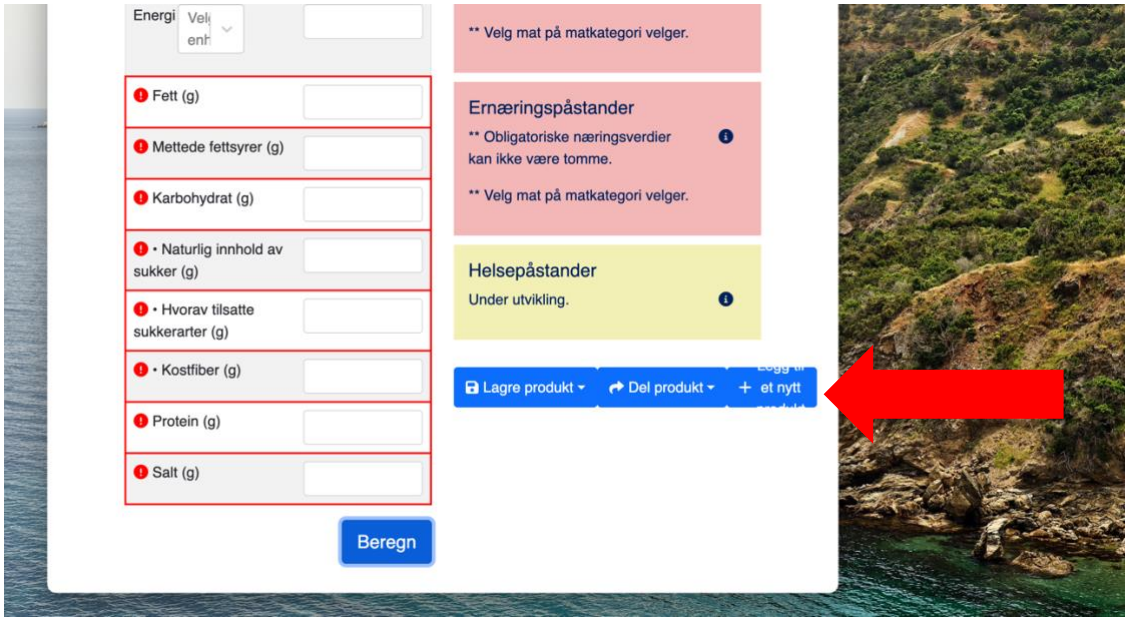


Figure 4- 39. A screenshot of the UI of the Ftremtidsmat web calculator that highlights the "Legg til et nytt produkt" button where part of it is cut off, making the content non-visible on a minimized Mac desktop screen.

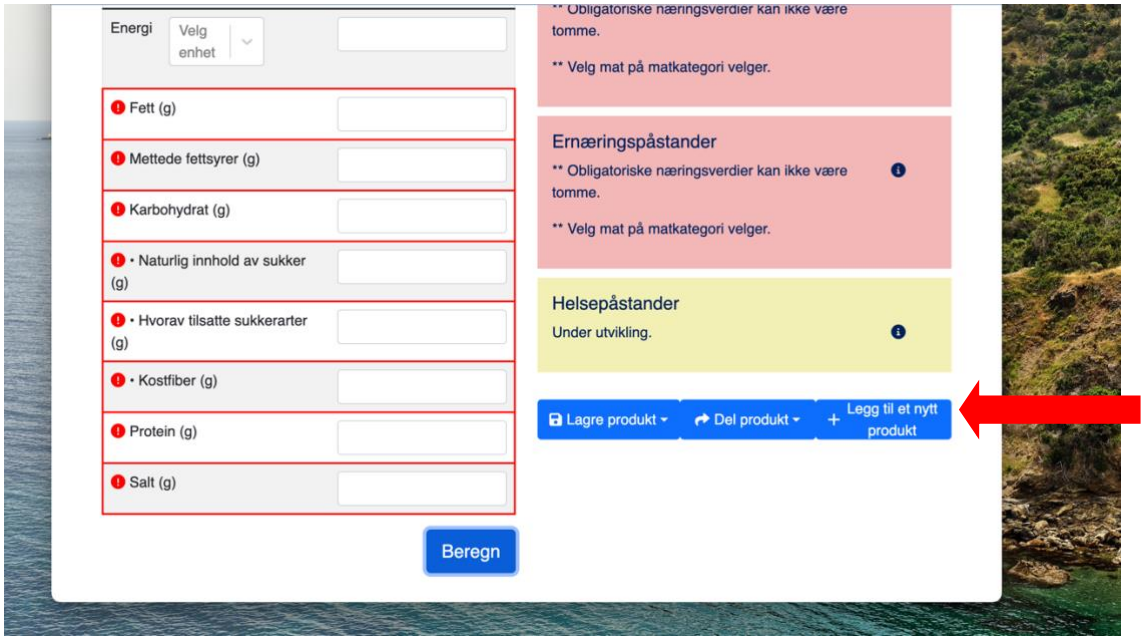


Figure 4- 40. A screenshot of the UI of the web calculator, that displays the "Lagre produkt", "Del produkt", and "Legg til et nytt produkt" buttons where their gap disappears on a minimized Mac desktop screen.

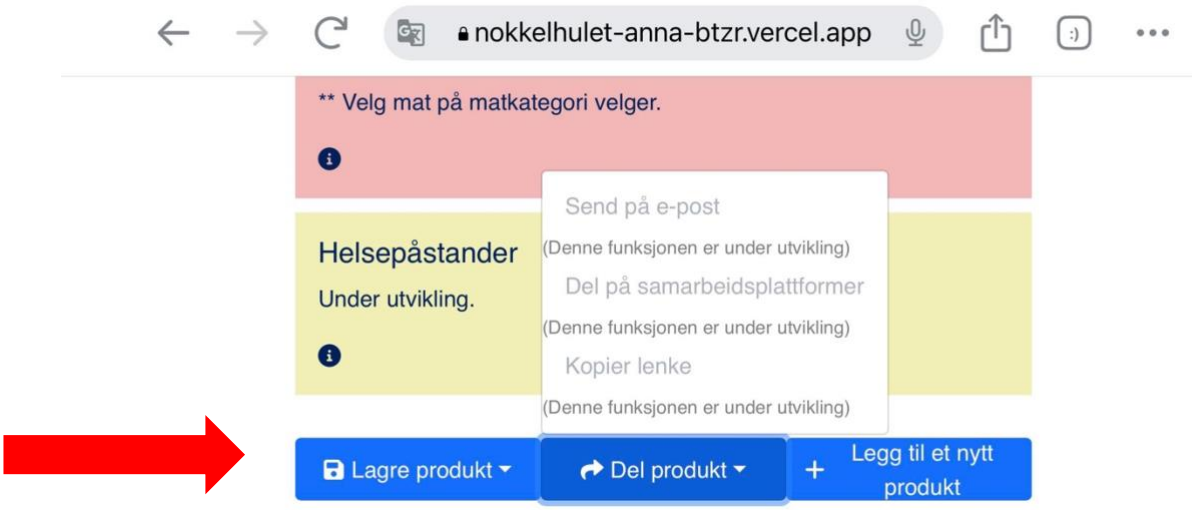


Figure 4- 41. A screenshot of the web calculator's UI on an iPhone with a horizontal orientation, where the gap between the "Lagre produkt", "Del produkt", and "Legg til et nytt produkt" buttons disappears.

Figure 4- 42. A screenshot on an iPhone with a vertical orientation where the "Legg til et nytt produkt" button is partially cut off, making its content non-visible.

The CSS of the position of these buttons should be adjusted.

4) 1.4.3: Contrast (Minimum) (Level AA)

The disabled options on "Lagre produkt" and "Del produkt" buttons have a greyed-out background and description text, such as "Denne funksjonen er under utvikling)" (This feature is under development.). When testing the contrast of the text of these options against its background, it was observed

that this contrast ratio does not comply with the recommended 4.5:1 ratio for normal-sized text.

5) **1.4.10: Reflow (Level AA)**

When viewed on a minimised desktop screen on a Mac or an iPhone 13, buttons "Lagre produkt", "Del produkt", and "Legg til et nytt produkt" lose the gap between them, making it difficult or impossible to interact with the page correctly. While in small screen size, the "Legg til et nytt produkt" button gets almost cut off the screen, making it unable to read its content and interact. The CSS of the position of these buttons should be adjusted to maintain functionality across devices or different screen sizes.

6) **1.4.12: Text Spacing (Level AA)**

For the body text, no specific line-height is mentioned. Additionally, the CSS does not have a defined spacing set after paragraphs. In the CSS, letter spacing and word spacing are not explicitly defined (See Appendix Y). To correct this, the line height for body text should be adjusted to at least 1.5 times the font size. A minimum spacing of 2 times the font size should be set after each paragraph. The text should have a letter spacing of at least 0.12 times the font size. Moreover, a minimum word spacing of 0.16 times the font size should be ensured.

- **Operable issues:**

2.4.2: Page Titled (Level A)

Based on the code, there is no indication of an <title> element or any dynamic mechanism in place to set or change the page title (see Appendix Y). The <title> element should be added.

- **Understandable issues:**

3.3.1: Error Identification (Level A)

Error identification mechanisms are missing for some of the elements, such as the energy unit selector (jk/kcal) and the "Velg type matvare" (Choose food type) selector when the user does not select any options.

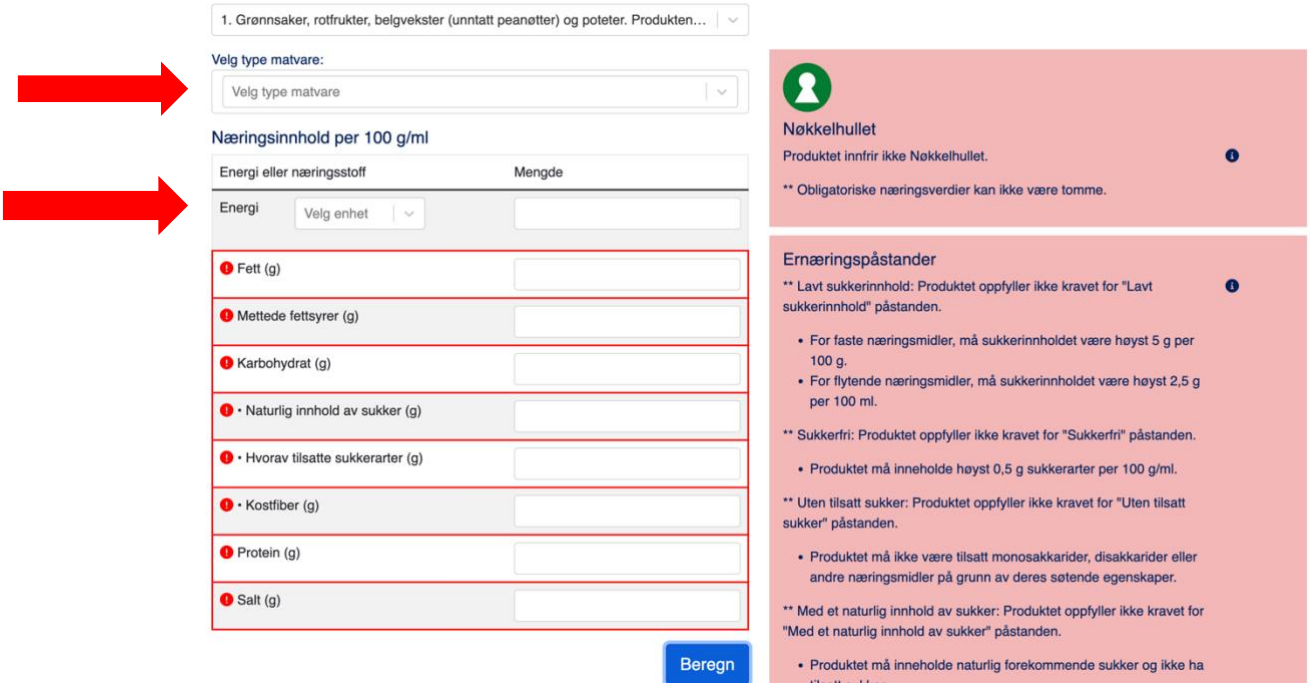


Figure 4- 43. A screenshot of the web calculator's UI illustrating the lack of error prompts on the energy unit selector (jk/kcal) and the "Velg type matvare" (Choose food type) selector when left unselected.

Error identification must be implemented to these elements by adding validation checks to notify users of input errors.

- **Robust issues:**

  No robust issues were identified.

While the findings from the HE provides insight into potential improvements to the Fremtidsmat web calculator, due to the time constraints of this thesis project timeline, the recommendations could not be directly integrated into further development of the Fremtidsmat web calculator. These findings are strongly recommended to guide future improvements to the tool.

Chapter 5: Discussion

This chapter includes a discussion of results, user-centered design (UCD) methodology and methods, and evaluation techniques. This chapter also includes a discussion of the contribution of this study, limitations, and topics for future work based on this research are also presented.

5.1 Fremtidsmat web calculator prototype development process

Since the main aim of this thesis project is to develop an accessible web calculator that addresses diverse food producers' needs in confirming the alignment of their products with Norwegian and European labelling regulations, the research integrated usability and accessibility into the User-Centered Design (UCD) process. Particularly, the development of the Fremtidsmat web calculator aligned with both the activities mentioned in the ISO 9241-210 standards and the UCD principles proposed by Gould and Lewis (Gould & Lewis, 1985; ISO, 2010b). The approach ensured the tool was developed according to its end users' specific needs and tasks, emphasising the importance of user involvement and iterative processes in software development.

5.1.1 Implementation of Ernæringspåstander (nutrition claims)

This thesis project was based on the recent work of Ahmed Faisal, a former master's student, who initially developed the Fremtidsmat web calculator, explicitly based on the Nøkkelhullet (The Keyhole label) food categorization (Ahmed, 2022; Lovdata, 2015). While Ahmed laid the foundation for this web calculator, this study further developed the tool, focusing on implementing Ernæringspåstander (Nutrition Claims) (European Commission, n.d.; Lovdata, 2017). Specifically, the sugar-related Ernæringspåstander such as "Lavt sukkerinnhold" (low sugars), "Sukkerfri" (sugars-free) and "Uten tilsatt sukker" (with no added sugars), and the "Med et naturlig innhold av sukker" (contains naturally occurring sugars) claim.

The focus on integrating sugar-related Ernæringspåstander into a web-based calculator for food producers is a unique element of this research. As per our knowledge, there is no previous study dedicated to sugar-related nutrition claims within an accessible web-based tool. For instance, Faisal's foundational work on the Nøkkelhullet categorization system set an example for such tools in the food industry. However, it did not extend to the inclusion of any Ernæringspåstander in its design. The last updated version of the Fremtidsmat

prototype integrates the sugar-related Ernæringspåstande, presenting a more targeted approach, which offers considerable assistance for food producers in adhering products to food labelling regulations. This functionality is essential for producers to avoid false or misleading labelling and reduce the risk of legal penalties, damage to reputation, mistrust, and confusion among consumers.

The decision to focus only on sugar-related claims was due to the short timeframe of this thesis. Nevertheless, this specific implementation still contributes to the field of food labelling and regulation compliance tools, addressing a gap in the technology available to food producers.

5.1.2 Evaluation of usability and accessibility

The development of the Fremtidmat web calculator prototype consisted of five iterations. This iterative approach was critical in addressing usability issues, improving functionality and conformance to web accessibility standards such as the Web Content Accessibility Guidelines (WCAG) and The Web Accessibility Initiative - Accessible Rich Internet Applications (WAI-ARIA) (W3C, 2018c, 2023g). Evaluations regarding the usability and accessibility of the prototype were conducted with different methods, such as user-based testing and an inspection-based evaluation.

The user-based testing conducted by Hammar Lars played a vital role in improving the Fremtidsmat web calculator (Hammer, 2023). Qualitative data were collected via user-based testing sessions on each iteration that included tasks, questionnaires, and interviews, offering feedback on the usability and functionality of the web calculator. The feedback from the user-based testing ensured the tool remained user-friendly. An example would be the implementation of the "Lagre produkt" (Save Product), "Del produkt" (Share Product), and "Legg til et nytt produkt" (Add New Product) buttons and their esthetic and functionality improvement based on user suggestions.

Following the final iteration, the Heuristic Evaluation (HE) of the Fremtidsmat web calculator was conducted considering legal requirements to the Norwegian *"Forskrift om universell utforming av informasjons- og kommunikasjonsteknologiske (IKT)-løsninger"* (Regulation on universal design of information and communication technology (ICT) solutions), therefore it aimed conformance to WCAG 2.1 and targeted explicitly for conformance at Level AA (Lovdata, 2019). In other words, of the total 78 WCAG 2.1 Success Criteria (SC), the evaluation used only the 30 Level A SC and the 20 Level AA SC, while the remaining 28 Level

AAA SCs were not included in this evaluation. However, 34 SC were applicable and evaluated during the testing since 16 SCs were not evaluated because they did not apply to the web calculator's features. The HE revealed that the web calculator satisfied 16 out of 20 relevant Level A SC (80% compliance) and 10 out of 14 relevant Level AA SC criteria (approximately 71.43% compliance), revealing major underlying accessibility issues of the functional prototype of the web calculator and non-compliance with the Norwegian web accessibility regulations. Although there is room to improve web accessibility and ensure full compliance with WCAG 2.1 Level A and Level AA, these results show a strong commitment to accessibility.

5.2 Contributions

The main contribution of this research is further developing the Fremtidsmat web calculator and integrating the Ernæringspåstander, representing notable progress in web development, accessibility, and UCD, particularly within the context of food labelling regulations in Norway. It demonstrates how technical web-based tools can be developed to address special industry needs and challenges while complying with usability and accessibility standards. This research fulfils an urgent industry need and sets an example for future web developments in creating accessible, user-friendly tools in fields where regulatory compliance is required.

In terms of UCD, the iterative development process followed in this project, guided by the application of UCD activities and principles, ensured that the final prototype of the web calculator was not only technically correct but also met end users' needs and preferences, making it easier to use and perform complex tasks no matter the expertise on the food labelling regulations.

In terms of web accessibility, special attention was paid to integrating accessibility standards such as WCAG and WAI-ARIA throughout all the development stages. The commitment to these standards made sure the prototype was not only easy to use for a broad range of users but also met the legal requirements for such a tool, such as the Norwegian *"Forskrift om universell utforming av informasjons- og kommunikasjonsteknologiske (IKT)-løsninger*", which is crucial not only to enhance the user experience but also to reduce the risks of potential lawsuits and fines related to potential discrimination against users with disabilities.

Lastly, by integrating Ernæringspåstander into the Fremtidsmat web calculator, this research builds a basis to bridge the gap between strict and complex food labelling laws and the need for an accessible web-based tool that a broad range of users can use, from experts to beginners in the food industry. This contribution is especially noteworthy as a foundation for future research into integrating other Ernæringspåstander. It also opens the possibilities for expanding the tool's applicability to include other types of food labelling regulations, such as Helsepåstander (health claims), or to see if the tool can work in different countries with different food labelling laws (Lovdata, 2017).

5.3 Limitations of the thesis

It is acknowledged that this thesis has multiple limitations, reflecting the challenges faced during development and evaluation.

The limited timeframe of this thesis and scheduling difficulties impacted the user-based testing. The testing was conducted with a small number of participants, only 5. Even though Norman says that "Five users are enough", this research was divided into four rounds of user-based testing (Nielsen Jakob, 2000). Distributing those 5 participants across these iterations led to a small number of participants in each iteration. This number needs to be closer to what is required by Nielsen to find enough usability issues. Since the Fremtidsmat web calculator is a newly developed tool, having a large user group at all expertise levels is critical too (Sauer et al., 2010).

Additionally, the HE evaluation of the web calculator was conducted by a single master student, which means the entire interface inspection relied on a single novice evaluator without the involvement of a team of accessibility experts. Relying on the results of just one individual is not recommended (Nielsen Jakob, 1994). This approach can miss finding accessibility issues, presenting potential ethical challenges, especially when the Fremtidsmat web calculator could face legal implications, including fines if it fails to comply with WCAG 2.1 Level AA.

The findings from the HE showed that the web calculator failed to fully confirm Level A and Level AA of WCAG 2.1, complying 80% with Level A criteria and approximately 71.43% with Level AA. These results indicate that the Fremtidsmat web calculator does not achieve an acceptable level of compliance as the Norwegian regulation on the universal design of ICT solutions requires. While many components of the web calculator comply with WCAG 2.1

Level A and Level AA, specific areas need improvement to ensure full compliance. Addressing these will not only align the website with the guidelines and standards of web accessibility but also make sure it meets national and international web accessibility regulations. However, this thesis's limited timeline made it impossible to address the identified accessibility issues. This limitation highlights the need for future development and improvement of the tool to fully meet WCAG 2.1 Level AA and enhance its accessibility.

Another limitation in the HE of the web calculator was the restrictive testing environment due to budget and time, with the evaluation conducted only using Google Chrome and Apple devices, specifically a MacBook Pro 13 and an iPhone 13. Conducting the HE solely on Apple devices and Google Chrome may not provide a complete understanding of the web calculator's accessibility across different platforms and browsers. Even though the tool has been developed using the Bootstrap front-end toolkit and designed to be responsive across various browsers, be it on mobile devices or desktop browsers, there is always a possibility that some of those browsers and devices exhibit potential accessibility issues (Bootstrap, n.d.-a). For example, issues such as the orientation and reflow of the "Lagre produkt", "Del produkt", and "Legg til et nytt produkt" buttons were pointed out based on HE even though the tool was designed to be responsive on Google Chrome and Apple devices. Future work could expand the testing scope to include a broader range of devices and browsers, ensuring a more thorough evaluation of the web calculators' accessibility across different user environments.

The thesis also faced limitations in collecting data about the potential users' disabilities due to compliance to the *"Lov om behandling av personopplysninger (personopplysningsloven)" (Act on the Processing of Personal Data (Personal Data Act))* set by the EU General Data Protection Regulation (GDPR) (GDPR.EU, 2018; Lovdata, 2022). This restriction, in combination with the limited time frame of this thesis, made gathering detailed information about the disabilities of Fremtidsmat employees and business members who might use the Fremtidsmat web calculator impossible. Therefore, disability-oriented testing and evaluations using Assistive Technology (AT) were not conducted, limiting the understanding of the web calculators' accessibility for users with different disabilities and potentially missing issues for this critical user group. The data collection and AT testing limitations emphasise the need for future research and development, particularly in improving the tool's accessibility for users with disabilities.

Another limitation of this thesis was that the development of the web calculator faced several technical and interdisciplinary constraints, particularly in the complexity of implementing different features and Ernæringspåstander while adhering to accessibility and food labelling regulations. The process of implementing Ernæringspåstander required a deep understanding of food labelling regulations such as Nøkkelhullet and Ernæringspåstander, pointing out the need for collaboration with a nutrition and food expert. However, given the thesis scope and the need to prioritize specific aspects over others, consultation with such specialists was not always possible, living out the implementation of some advanced features and functionalities, such as implementing a "warning" symbol to alert users when various Ernæringspåstander and Nøkkelhullet guidelines might not be applicable to every food product, even if technically meeting the criteria; or adding another input field for "sukkerarter" (total sugars) instead of using the input field with the term "Karbohydrater" (Carbohydrates). This limitation impacted the depth to which Ernæringspåstander could have been integrated.

Lastly, collaboration with the academic staff from OsloMet and food and nutrition experts at Fremtidsmat provided essential insights. However, the project turned out to be more complex than expected, which required prioritising specific aspects over others. Combined with the author's background as an Information Technology (IT) and Universal Design (UD) student with limited knowledge of food and nutrition labelling regulation, it led to the decision to overlook the total list of 30 permitted nutrition claims provided by the European Food Safety Authority (EFSA) and integrate into the web calculator only the sugar-related Ernæringspåstander, such as "Lavt sukkerinnhold" (low sugars), "Sukkerfri" (sugar-free), and "Uten tilsatt sukker" (no added sugars), as well as "Med et naturlig innhold av sukker" (contains naturally occurring sugars) (European Commission, n.d.). Future work on this project could benefit from a more multidisciplinary team. Collaboration with food labelling regulation and nutrition specialists could lead to the full integration of the Ernæringspåstander into the web calculator.

5.4 Future work

According to the limitations identified in this research, future work needs to be conducted to enhance the web calculator's functionality, usability, and accessibility.

Of high importance would be addressing the issues found on the HE and ensuring full compliance of the web calculator to WCAG 2.1 Level A and Level AA, meeting the level of compliance the Norwegian regulation on the universal design of ICT solutions requires. Furthermore, observations from user-based testing showed that there is a need to develop more advanced features. This might include the implementation of "warning" symbols to alert users about potential labelling misuse, more transparent differentiation of applicable and non-applicable claims displayed in the Ernæringspåstander results container, implementing additional nutrient input labels, clearer labelling of "Lagre produkt" (Save Product), "Del produkt" (Share Product), and "Legg til et nytt produkt" (Add New Product) buttons, saving food product details in different formats, sharing options via email or collaboration platforms. Collaborating with food and nutrition experts can lead to the correct implementation of these and more advanced functionalities while ensuring that the web calculator remains up-to-date with evolving food labelling regulations and industry best practices.

Given the limitations of user-based testing in this thesis project, future research should conduct a more extensive user-based testing process to gather a broad range of feedback. This means increasing the number of participants and examiners and including participants with a more diverse expertise level in the food and nutrient industries. Future work should involve a team of accessibility experts instead of relying on a single novice evaluator, as in the existing study. User-based testing regarding accessibility needs to be carried out in the future instead of only conducting HE based on WCAG. These accessibility tests should cover testing with people with a broad range of abilities and disabilities, including those using ATs.

In addition, future work should also include automated evaluation as another way of inspection-based evaluation other than HE. These tests should be conducted systematically to gather more data on accessibility issues which might have been overlooked in manual evaluation, and conformance with WCAG. Using tools such as WAVE (Web Accessibility Evaluation Tool), Google Lighthouse, axe DevTools, and many more will enable a broader and more efficient detection of accessibility issues, complementing the insights gained from manual evaluations. Also, the HE should expand to include testing on different browsers and devices instead of only Apple devices and Google Chrome. Extending the examiners and the

testing environment will help better understand the Fremtidsmat web calculator accessibility and conformance with WCAG.

Although this thesis project focused on implementing sugar-related Ernæringspåstander, future work on the web calculator should integrate the rest of the permitted Ernæringspåstander as outlined by EFSA. In the future, researchers can also try integrating Helsepåstander, expanding the tool's applicability to a broader range of food labelling regulations.

Some complex technical and food regulatory issues, brought up by the participants or explored during the technical development of the tool, combined with the fast-paced evolving food labelling regulations, require future development to prioritize a collaborative interdisciplinary approach. A multidisciplinary team is needed, with expertise ranging from food labelling regulations, food production, and nutrition to web accessibility, usability, design, and software development, to refine the tool's functionality and accuracy further.

Additionally, exploring the web calculator's adaptability to different countries' food labelling laws could increase the tool's international relevance and applicability. This could start by providing an English version of the tool.

Chapter 6: Conclusion

6.1 Revisiting the research question

The focus of this research was to find out:

" How can web accessibility recommendations, combined with User-Centered Design (UCD) and Heuristic Evaluation (HE), ensure that the Fremtidsmat web calculator addresses the needs of diverse food producers in confirming the alignment of their products with Norwegian and European food labelling regulations?"

Combining web accessibility recommendations, User-Centered Design (UCD), and Heuristic Evaluation (HE) formed a strong foundation for ensuring the Fremtidsmat web calculator effectively addressed the needs of diverse food producers in conforming the alignment of their products with Norwegian and European food labelling regulations, like Nøkkelhullet (The Keyhole label) and Ernæringspåstander (nutrition claims) (Lovdata, 2015, 2017). This many-sided approach aimed to make a tool that is not only functional and compliant with regulations and recommendations but also accessible to a broad range of users, regardless of their background or level of expertise in the food and nutrition industry.

As summarised by W3C Director and inventor of the World Wide Web, Tim Berners-Lee (W3C, 2022b):

"The power of the Web is in its universality. Access by everyone, regardless of disability, is an essential aspect."

By implementing accessible web design practices, the Web benefits not just people with disabilities but everyone, which is important not only to enhance the user experience (UX) but also to reduce the risks of potential lawsuits and fines related to potential discrimination against users with disabilities, as emphasised by the *"Forskrift om universell utforming av informasjons- og kommunikasjonsteknologiske (IKT)-løsninger"* (Regulation on universal design of information and communication technology (ICT) solutions) (Lovdata, 2019). During the development of the Fremtidsmat web calculator prototype, special attention was paid to Norwegian regulations, like adhering to web accessibility recommendations such as Web Content Accessibility Guidelines (WCAG) 2.1 and aiming for Level AA conformance (W3C, 2018c). However, the results from the Heuristic Evaluation (HE), conducted following the last development iteration, showed that the web calculator failed to fully confirm Level A and Level AA of WCAG 2.1, complying 80% with Level A Success Criteria and approximately

71.43% with Level AA Success Criteria. These results, even though they show that the web calculator does not achieve an acceptable level of compliance as the Norwegian regulation on the universal design of ICT solutions requires, reflect a strong commitment to accessibility.

Additionally, aligned with WCAG, the HE highlighted accessibility issues of the tool's User Interface (UI) not visible by user-based testing. Pointing out these accessibility issues is the first and most crucial step in improving the web calculator's accessibility. While time limitations meant these issues could not be addressed, the HE gave the development team a better understanding of the tool's accessibility challenges, helping them prioritise these issues for future enhancements. Without the HE, some of these accessibility issues might have remained unnoticed and, consequently, unresolved in future development work, leading to a less inclusive tool.

The application of User-Centered Design (UCD) methodology played a vital role in the development of the Fremtidsmat web calculator. UCD, as guided by the activities mentioned in the ISO 9241-210 standards and the UCD principles proposed by Gould and Lewis, made sure that the final version of the web calculator prototype was not only technically correct regarding the implementation of the Nøkkelhullet, sugar-related Ernæringspåstander, but also that its functionality met the needs and preferences of the food producers who would use it (ISO, 2010b; Gould & Lewis, 1985). This approach involved iterative user-based testing and feedback incorporation from end-users such as Fremtidsmat employees and business members. By centring the development of the web calculator's UI around the end-user's requirements and experiences, the tool was enhanced to be more user-friendly, assisting food producers with different levels of expertise regarding the proper use of food labelling regulations.

Overall, this thesis project contributes to efforts in the field of web development and accessibility within the food and nutrition industry. The combination of web accessibility recommendations, UCD, and HE established a strong base for further development of the Fremtidsmat web calculator. While the tool may not have achieved perfect accessibility at the end of the final development phase, the process highlighted critical issues, setting a path for future improvement.

6.2 Concluding the research

The aim of this thesis project was the further development of the Fremtidsmat web calculator prototype, contributing to efforts in assisting diverse food producers in confirming the adherence of their food products with complex food labelling regulations, such as Nøkkelhullet and Ernæringspåstander (Lovdata, 2015, 2017). Specifically, the thesis focused on the implementation of the sugar-related Ernæringspåstander such as "Lavt sukkerinnhold" (low sugars), "Sukkerfri" (sugars-free) and "Uten tilsatt sukker" (with no added sugars), and the "Med et naturlig innhold av sukker" (contains naturally occurring sugars) claim.

By employing a many-sided approach in creating the tool, the research integrated User-Centered Design (UCD), Heuristic Evaluation (HE), and web accessibility recommendations, as detailed in "Section 6.1". The development of the tool adopted an iterative process, continuously incorporating user feedback, addressing usability issues, and conforming to web accessibility standards such as WCAG 2.1 Level AA (W3C, 2018c). A Heuristic Evaluation (HE) was conducted on the final version of the Fremtidsmat web calculator prototype, using the Website Accessibility Conformance Evaluation Methodology (WCAG-EM), adhering to WCAG 2.1 Level AA as guiding heuristics, for compliance with Norway's *"Forskrift om universell utforming av informasjons- og kommunikasjonsteknologiske (IKT)-løsninger" (*Regulation on universal design of information and communication technology (ICT) solutions) (Lovdata, 2019; W3C, 2014). The HE results showed that the web calculator failed to fully confirm WCAG 2.1, complying 80% with Level A Success Criteria and approximately 71.43% with Level AA Success Criteria. Despite not complying with the Norwegian web accessibility regulations, these results reflect a strong commitment to accessibility. Moreover, the HE revealed major underlying accessibility issues of the functional prototype of the web calculator that were not visible by user-based testing. While time limitations meant these issues could not be addressed, the HE gave the development team a better understanding of the tool's accessibility challenges, helping them prioritise these issues for future enhancements.

In addition to the HE, accessibility recommendations and UCD, this thesis project was also based on a strong commitment to ethical considerations, as reflected on the insights of "Section 1.2". Paramount among these was the responsible handling of personal data and the protection of participants' privacy as required by the "Lov om behandling av personopplysninger (personopplysningsloven)" (Act on the Processing of Personal Data

(Personal Data Act)) set by the EU General Data Protection Regulation (GDPR) (GDPR.EU, 2018; Lovdata, 2022). The responsibility for ethically processing data and privacy was particularly critical as participants were involved in the development process via the UCD approach. For this reason, SIKT's (Norwegian Agency for Shared Services in Education and Research) approval was obtained by Hammer, making sure that all ethical requirements related to participant involvement, data collection, and confidentiality were kept throughout the user-based testing process (Hammer, 2023). This commitment to ethical considerations and functionality brings into light areas where future development is necessary, as discussed in "Chapter 5".

While the current version of the Fremtidsmat web calculator is an important step forward, there is space for further improvements, as outlined in "Chapter 5". The decision to prioritize integrating a select group of claims into the Fremtidsmat web calculator, specifically the sugar-related Ernæringspåstander, instead of the total list of 30 permitted nutrition claims provided by the European Food Safety Authority (EFSA), was a notable constrain influenced by the author's Information Technology (IT) background with limited knowledge in food labelling regulations. (European Commission, n.d.). Future work on this project could benefit from a more multidisciplinary team, ensuring full integration of the Ernæringspåstander into the web calculator, as well as expanding the tool's applicability to include other types of food labelling regulations, such as Helsepåstander (Health Claims) (Lovdata, 2017).

In addition, creating a team of web accessibility experts, instead of relying on a single novice evaluator, as in the existing study, would improve the thoroughness and accuracy of the accessibility assessments, both user-based testing and an inspection-based evaluation. Such collaboration is critical in ensuring full compliance with WCAG 2.1 Level AA, which is important not only in meeting the needs of all end-users, regardless of their background, needs or level of expertise in the food industry, but also in reducing the risks of potential lawsuits and fines related to possible discrimination against users with disabilities.

Lastly, future research should expand the number of participants in the user-based testing, ensuring a more diverse representation of familiarity and expertise levels with food labelling regulations. This will help notice more of the end-users' needs and preferences, thereby enhancing the tool's usability and effectiveness. Similarly, user-based testing regarding accessibility needs to be carried out in the future instead of only conducting HE

based on WCAG. These accessibility tests should cover testing with a diverse range of participants, particularly those who rely on Assistive Technologies (AT). Engaging with individuals who use screen readers, alternative keyboards, or other AT will provide valuable insights into the real-life accessibility of the Fremtidsmat web calculator and may help identify and address any barriers they face, further improving the inclusivity and functionality of the tool.

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Appendices

See Batzeri_Anna_366244_ACIT5900_Appx.pdf.