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Universal Design of ICT

Know your plant-based food product

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OSLOMET

Preface

I would like to thank my Supervisor Way Kiat Bong for his endless guidance, support, and assistance throughout my thesis. I would also want to thank my Co-supervisor Weiqin Chen for her expert opinion and feedback. I also want to thank Oslo Metropolitan University and the Department of Computer Science Faculty of Technology, Art and Design for granted me a chance to get higher studies.

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Abstract

Plant-based food products are becoming popular throughout the world. There are several reasons, such as sustainable products, environment friendly, help to control obesity, rich with nutrients and minerals, help to sustain health management system, boost the immune system, give strength to stand against fatal diseases like CKD (chronic kidney disease). Production and consumption of these products can also help to achieve several United Nations Sustainability Goals, like responsible consumption and production, climate action, good health, and well-being.

To achieve all of these benefits, and goals it is required to attract and strict the public by giving them the correct pieces of information of market available plant-based food products in terms of a web-based application. Several studies show web-based applications are the most effective and convenient way to promote health literacy and the importance of plant-based food products. Different studies also reveal public want to get this information through web-based applications. Accessibility is one of the major concerns with these web-based applications depending on the huge number of internet users, ageing, different kinds of disabilities, impairments, and the digital divide.

In this short thesis, a proposed web-based application developed by the interdisciplinary project team, Health effects and consumer aspects of meat substitutes at OsloMet – Oslo Metropolitan University analyzed by using the WAVE (Web Accessibility Evaluation Tool) to find out the potential error and alert messages. These errors and alert messages may become a barrier for different kinds of assistive technology users and low vision people. There were 47 errors and 16 alert messages. These errors and alert messages remove by using the WCAG and conformance success criteria levels.

The importance of accessibility is also highlighted in different international and national laws. United Nation CRPD (Convention on the Rights of Persons with Disabilities) directs states to make ICT devices and applications according to the Universal Design principles. Norwegian national law Regulation for universal design of information and communication technology (ICT) solutions also emphasizes the importance of accessibility of web-based applications regardless of the individual capabilities and expertise. The accessibility and performance of the proposed web-based application can be enhanced by doing user testing and analyzing working against different assistive technologies.

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1 Introduction

Plant-based food products are getting popular in the last few years. This trend is global, especially in terms of sustainable food, healthy diet, environment friendly, and a wide range of business opportunities (Aschemann-Witzel et al., 2020). People are mostly inclined towards plant-based products due to several reasons. It helps to improve our immune system because water-soluble vacuolar pigments like anthocyanins help to keep the cells healthy and also keep the balance in our body so we can stand against different diseases. Plant-based food products are rich in nutrients, help to control obesity, diabetes, improve visual function, enhancement of retinal blood flow in the eyes, and improve the functionality of the brain, etc. (Tsuda, 2012). In the same way, plant-based diets also use as a treatment in many fatal diseases, such as CKD (chronic kidney disease) (Banerjee et al., 2016). In the current ongoing Covid-19 pandemic, people are now more concerned about their health and focus on plant-based diets to improve their immune system.

Getting and production of plant-based diets also helps us to keep the environment healthy especially due to a lower level of greenhouse gas emission comparing to the animals for human consumptions (Wickramasinghe et al., 2016). In the same way, meat and other animal-based products require more life cycle input per kilogram (kg) than plant-based diets (Carlsson-Kanyama et al., 2003), consequently the usage of water, energy, land is comparatively high than the plant-based food products.

These concepts of the well-being of the environment and be healthy are also tending with several United Nation's sustainable development goals, such as Health and Well-being (goal 3), responsible consumption and production (goal 12), and climate action (goal 13). Usage of plant-based diets provides the possibility to achieve these goals. To achieve these goals and all of the advantages of the plant-based diet, it can be helpful to make the information accessible to consumers by giving the correct pieces of information about the nutrients and the market available plant-based food products. Consumers need to know about what kind of nutrients and calories are including in the plant-based food products that are currently available in the market.

To address this challenge, a web-based application is proposed and developed by an interdisciplinary project team, Health effects and consumer aspects of meat substitutes at OsloMet – Oslo Metropolitan University. In this short thesis, we aim to ensure the web application is accessible to as many users as possible. As we know, in a digital solution like in the form of a web application, there are several challenges in terms of language, content, navigation among the pages of the web application, usage of the different kinds of assistive technologies, and the digital divide. By using the Universal Design principles and WCAG (web content accessibility guidelines) of the web application, it becomes possible to overcome the accessibility and digital divide issues.

2. Literature Review:

2.1 Health literacy with regards to knowing about nutrition

To be healthier and strong to cope with the health diseases it is necessary to be familiar with and understand the importance of health literacy. Health Literacy is a term coined in 1974 which describes *“the degree to which individual can obtain, process, and understand basic health information and services needed to make appropriate health decision”* (Simonds 1974). In 2004, The US Department of Health and Human Services with the collaboration of the Institute of Medicine brought the importance of this issue Infront of the public attention with the report title *“Health Literacy: A Prescription to End Confusion”* (Nielsen-Bohlman, 2004). The report stated that without knowing Health Literacy it is difficult for people to carry out disease management, healthier environment, and in the meanwhile, people will have less knowledge to tackle the prevention services. This report also formulates 4 general relationships between health care and reduced health literacy. These are less knowledge of disease management, increase rate of hospitalization, decreased usage of health care services and, increased cost of health care.

Health Literacy in terms of nutrition also has a very important impact on our health and disease management, many researchers believe that nutrition is very important against chronic medical conditions such as obesity and cardiovascular diseases (Peña-Romero et al., 2018). The World Health Organization (WHO) defined nutrition in 1948 as *“a set of processes by which living beings incorporate, modify and remove substances from outside”*(cited in (Sadeghirad et al., 2016)). After that nutrition comes into the view of people in the second half of the 18th century when a French Chemist Lavoisier established the scientific bases of modern nutrition (Prentice, 1995). Poor Health Literacy has very drastic outcomes, some researcher believes if this issue is not solved properly then people will not be able to respond adequately and use the prevention measurements against the fatal diseases like obesity, heart diseases, diabetes, and cancer (Carmona, 2006).

2.2 Access to information about food product’s nutrition digitally

Internet is a very common and easy way to diffuse health-related and nutrition information among people by public health care institutions, but the internet also hosts a very large number of websites that diffuse such information without any authenticity and trustworthiness (Nabarette et al., 2009). Studies show that less than half of internet

information seekers consult with a health care professional, but it also reveals that prior knowledge is good for healthy discussion with health care professionals but it's good to always discuss with your physicians before acting on any online information (Seçkin, 2014). This same phenomenon is happening with Wikipedia, as most users get nutrition and health-related useful and credible information from Wikipedia (Rutsaert et al., 2014) but studies show Wikipedia mostly cites news articles rather than more authentic and trustworthy sources (Sinha et al., 2018).

Internet and its applications have become the primary and main source for getting nutrition information about food products from the last decade. (Baker et al., 2003) Search engines like google, yahoo, Microsoft Bing, are very common among people for accessing nutrition and food safety information (Fassier et al., 2016). Studies also show people mostly search on the search engine after viewing the advertisement on TV and the poster (Schiro et al., 2020). There is a socio-demographic difference as well, studies also reveal that people with higher socio-economic value are mostly used the internet for health-related information (Renahy et al., 2010). More than 70% of European and American citizens regularly use the internet for getting health-related information (Nölke et al., 2015). It includes nutrient information, calorie intake, prevention against diseases.

Apart from search engines, smartphones and web-based applications are also becoming popular among young people and children for getting nutrition and food safety information (Franco et al., 2016). These applications have multiple functions, like helping users with calorie intake, weight control suggestions, nutrition advice, and meal plan (Johnson et al., 2016). These applications have a positive impact on school-going children, but there required a comprehensive evaluation of how far these applications are useful for young people (Young et al., 2019)?

There are thousands of health care applications are available in play and app store for a patient to monitor their plenty of health care issues ranging from chronic illness management, sleep management, blood sugar level, physical activities, training and exercise videos, and calorie intake. For example, 240 android applications and 600 iPhone applications are available for diabetes in their respective application stores (Eng & Lee, 2013). Additionally, a recent market report also reveals the number of users of fitness and health-related mobile application is higher in the last few years as Americans are eager to use these apps to monitor their health and workout routines (Borison, 2014). In the same way a new term "*Serious*

Games,” is introduced that describes the usage of digital games for educational and training purposes (Annetta, 2010). Some researchers argue that serious gaming is a valuable tool for promoting health-related information, because of its easiness, enjoyable, attractive, and intrinsically motivational nature not only for children and adolescents but it can be used to help people to recover from serious surgeries (Ingadottir et al., 2017).

Social media is also one of the most common ways to express and diffuse information. The main purpose of the organization using social media to expand communication with people. When a message is delivered of any organization through common friends, the message gains more impact (Goh et al., 2013). Studies also show, by using hashtags in social media the engagement of the users is higher as compared to that information without using hashtags(Schiro et al., 2020). For the sake of food safety and nutrition information, health care organizations use social media by using hashtags, and is also the responsibility of people to deliver such useful information to their friends and family members. In this way, we can assist to overcome authenticity and trustworthiness issues.

2.3 Digital tools/web application about the nutrition of food products

Promote Health Literacy and Nutrition among people is quite a challenging task. Traditionally, people used different types of ordinary media channels resulting in the public was not able to receive information adequately, it was quite difficult to communicate and adequately inform the information (Rutsaert et al., 2014), and also it was not possible to engage and educate people with those approaches(Wall & Chen, 2018). But due to the interaction and adoption of information technology and its applications like smartphones, search engines, social media, in our everyday life from the last decade, it becomes easy to communicate with each other and with organizations. Now everyone can interact and communicate online by search engines and social media. Due to these advancements and progressions in information technology people usually use a search engine like Google for getting information related to food safety and nutrition (Fassier et al., 2016).

In the same way, for the sake of the promotion of Health Literacy and nutrition among children and young people, the US Department of Agriculture introduced two online games such as “MyPlate picks”, and “Track and Field Fuel-Up”(Ruggiero et al., 2020; Schiro et al., 2020). A game with the title of “Alien Health Game” is a nutrition instruction game that is used for improving the short-term nutrition knowledge among primary school-going children

(Hermans et al., 2018). On the other hand, there are some other tools, applications, and games through the target audience that are not restricted to children and young people. Like “JustFoodFun”¹ is a smartphone quiz-based game on food literacy. Nutrition based application has to gain popularity among users because it has multi functionalities like the French application “Yuka” enables users to just scan the barcode of the product and will give the friendly interpretation of the information i.e. (nutrition quality, manufacturing methods and alerts of having any harmful additives) in a particular product (Soutjis, 2020). Some nutrition applications assisting their users with weight control, calorie intake, nutrition advice, crowdsourcing, and interpretation of food labels (Dunford et al., 2014).

While using these applications there are some limitations in terms of effective design, users engaging experiences, the effectiveness of these applications in behaviors changes among users (Hingle & Patrick, 2016). In the area of health and well-being studies shows 59% of game's effect is positive and 41% is neutral and mixed (Johnson et al., 2016). Studies also reveal that users required a more user-friendly interface for better and engaging experiences, it requires more interactive features like two-way communications and an open database that allows users to communicate with other participants and friends while sharing their views and add nutrition and health literacy-based information's (Soutjis, 2020). From the perspective of children and young adolescents, they express interest in acquiring nutritional information based on games especially quiz-based (Holzmann et al., 2019). A small study also suggests that children and young adolescents, want to gain nutrition information based on customized Avatar-based games like “Move2play” (Bielik et al., 2012).

2.4 Type of Users

Using the internet and digital tools for health-related information is dependent on socio-demographic characteristics mainly in the USA than in Europe and last in Asia (Fassier et al., 2016). It also depends on the age factor as mostly the young generation are using mobile apps. A recent survey from the Pew Research Center suggested that 62% of smartphone owners use mobile and eHealth applications for acquiring health-related information (Smith & Anderson, 2015). In the same way, different kinds of online games have proven successful to promote food safety and health-related information to children compared to traditional learning

¹ <https://appadvice.com/app/just-food-fun/1244205659>

methods (Young et al., 2019). Due to the flexibility and usage easiness, the target audience of smartphone applications is not restricted to young people and children.

Due to the tremendous involvement and adoption from young people and children, it is quite a good opportunity to promote health literacy and nutrition information through smartphone applications (Mackert et al., 2009). But some researchers argue, if we did not overcome the accessibility and user-friendly interface issues in these applications then it will be difficult to promote health literacy (Bickmore & Paasche-Orlow, 2012).

According to the World Bank report more than 1 billion, 15% of the world population is facing a different kind of disabilities. This trend is higher in developing countries but the numbers in developed countries are also not impressive. On the other hand, by World Health Organization (WHO) research 285 million people are visually impaired, of which 39 million people are blind and 246 million people have a low vision problem.

Therefore, it is essential to ensure accessibility of web applications for all, it means it must be operable, accessible, and understandable to the extent of individual abilities, in a different situation, and under various circumstances, like in a noisy environment or using any ICT application or devices in an older version of the operating systems.

2.5 Methodology in designing and/or evaluating these digital tools

Due to the ongoing sedentary lifestyle both in developed and developing countries, the number of children and adolescents with obesity and lack of nutrition information has increased in most parts of the world from 1975 to 2016 (Abarca-Gómez et al., 2017). This ongoing trend requires special prevention and treatment for both adolescents and children. At the moment, there is a growing interest in exploring the potential of new information and communication technologies (ICTs), such as mobile apps, to combat the obesity epidemic. These novel tools are low-cost, widely available, and nearly infinitely scalable. Several studies have shown that young people prefer health information delivered via ICTs rather than printed materials (Long & Stevens, 2004). To tackle these obesity and health-related problems a game “Myplate Picks” is designed to facilitate children and youth by providing the movement, physical activities, courage to change behavior related to healthy eating information (Ruggiero et al., 2020).

As we know, promoting health-related and nutrition information through games and digital applications among young children and adolescences is a growing market trend, therefore there are not any obvious design aspects, preference motives, and needs that follow for designing these applications(Lu & Kharrazi, 2018). Moreover, collaboration with the health care professionals and targeted groups at the early stages of the development of such an application may help to rectifying the health-related information and enhancing the usability of the application (Peykari et al., 2011). Several studies also show how we can gain the positive impact of serious games in terms of health and nutrition information, dietary behavior, physical activities, and body mass (DeSmet et al., 2014). In the same way, a randomized controlled trial on the 10-12 years old children who played serious games resulted in significantly increased information about fruits and vegetable consumption (Bellcross et al., 2011). A systematic review showed that most studies in the favor of using digital applications for promoting nutrition and health-related information. The authors believe that video games just not give obesity prevention and health-related information but it also useful for treatment compliance and to promote success (Mack et al., 2017).

Several studies reveal that young children and adolescents want to receive health-related information through digital applications, but studies also reveal how they would like to get these pieces of information? 55% prefer to receive information by playing quiz games and 43% like to get information through solving tasks. Therefore, it is suggested different kinds of quizzes should be included in these applications (Schäfer et al., 2017). To improve the nutritional and health-related information among children, repetitive methods of information should be adopted in these applications (Putnam et al., 2018). On the other hand, studies show children want to get information by using personalized characters, like in the game “Move2Play” where users can contain avatar which can be personalized by users (Bielik et al., 2012). From a recent survey conducted in the southern region of Germany using 43 item questionnaire, those were related to motives, needs, and preference of digital games to children and adolescents, it is interesting to mention most young children and adolescents want to play these games with their friends online, a survey gives the participants number (191/286, 66.8%) and only one-fifth of participants (58/255, 22.8%) prefer to play the game alone (Holzmann et al., 2019).

3. Methodology

3.1 About the website

Overcoming the gap between the users and the nutrition-based plant food products we proposed a Nutrition database for meat and dairy products & plant-based substitute products website. This website is developed by the Oslo Metropolitan University project development team. It is currently in the evaluation and developing process. Norwegian (Bokmal) is the primary language of this website. The website currently has three pages, the first one Produktliste (Product list), Søk produkt (Search product), and the third one is Produktliste (søkeresultat) (Product list, (search result)).

3.1.1 Produktliste (Product list)

It is the main page of the website, with the title of the Produktliste (Product list), where users can find out the product name, type, category along with energy kilojoule, per calories, carbohydrates, fat, saturated fat, sugar, fiber, protein salt information per 100 gram. Users can also find out the producer information by clicking on the provided link of the producer website. This main page also has the navigation button with the title of the Søk produkter (search products), by clicking on this button user navigates to the search page of the website.

Næringsdatabase for kjøtt- og meieriprodukter & plantebaserte erstatningsprodukter

Produktliste

Søk produkter

** Alle næringsstoffene i tabellen er per 100 gram.

Produkt	Produkttype	Produktkategori	Energi (kJ)	Energi (kcal)	Fett (g)	Mettet-fett (g)	Karbohy-drater (g)	Hvorar-sukkerarter (g)	Fiber (g)	Protein (g)	Salt (g)	Produsent
Beyond Burger	Kjættstatninger	Plantebaserte burgere	1107	266	19.0	4.4	5.3	0.0	2.6	18.0	1.1	https://www.beyondmeat.com
Beyond Sausage Bratwurst	Kjættstatninger	Plantepølser	990	238	16.0	7.0	5.0	0.0	3.0	17.0	1.4	https://www.beyondmeat.com
Alpro Havre og mandel	Plantebaserte alternativer til meieriprodukter	Plantedrikke	98	24	1.0	0.1	2.4	1.8	1.5	0.4	0.1	https://web.alpro.com
Coop Vegetardag Burger Bønner og Erte	Kjættstatninger	Plantebaserte burgere	523	125	5.5	0.6	9.2	2.2	6.1	6.7	1.6	https://matlevering.coop.no/
Coop Vegetardag Soppburger	Kjættstatninger	Plantebaserte burgere	471	113	4.9	0.8	6.9	0.4	5.4	7.6	1.8	https://matlevering.coop.no/
Coop Vegetardag Blokk naturell	Plantebaserte alternativer til meieriprodukter	Ost	1176	283	21.0	18.0	23.0	0.0	0.0	0.0	2.0	https://matlevering.coop.no/
Coop Vegetardag Revet Classic	Plantebaserte alternativer til meieriprodukter	Ost	864	206	12.0	11.0	24.0	0.1	0.0	0.5	2.0	https://matlevering.coop.no/
Coop Vegetardag Skivet chili	Plantebaserte alternativer til meieriprodukter	Ost	1197	286	21.0	18.0	24.0	0.2	0.0	0.2	2.0	https://matlevering.coop.no/
Coop Vegetardag Skivet Naturell	Plantebaserte alternativer til meieriprodukter	Ost	1176	283	21.0	18.0	23.0	0.0	0.0	0.0	2.0	https://matlevering.coop.no/
Coop Vegetardag Skivet Rød Jalapeno	Plantebaserte alternativer til meieriprodukter	Ost	866	207	7.0	6.0	35.0	0.0	0.0	0.8	1.9	https://matlevering.coop.no/
Coop Vegetardag Burger Rødbeter og Honning	Kjættstatninger	Plantebaserte burgere	489	116	2.6	0.3	13.0	7.3	5.5	7.1	1.4	https://matlevering.coop.no/
Coop Vegetardag Juicy Burger	Kjættstatninger	Plantebaserte burgere	977	235	14.0	12.0	4.6	1.7	0.0	20.0	0.8	https://matlevering.coop.no/
Folkets Veggi burger	Kjættstatninger	Plantebaserte burgere	412	98	2.7	0.3	10.7	6.5	5.8	4.9	1.1	https://meny.no/

Figure 3-1 Produktliste (Product List)

3.1.2 Søk produkt (Search products)

It is a second page of the website, where users can navigate by clicking on the Søk produkt (search products) button on the main page. On this page, the user can search out the produkttype (product type) along with the Produktkategori (product category). In produkttype (product type) there are there are 4 options kjøtt (meat), kjøtterstatning (meat substitute), alle meieriprodukter (all dairy products), and Alle plantebaserte alternativer til meieriprodukter (All plant-based alternatives to dairy products).

In Produktkategori (product category), there is 23 more option. These are kjøttburger (meat burger), Pølse kjøtt (meat hot dog), kjøttboller (meatballs), Nuggets, Nøkkelhullsmerket kjøtt (Keyhole-marked meat), Plantbaserte burgere (plant based burger), plantepølser (plant hot dogs), Plantbaserte deig (plant-based dough), planteboller (plant balls), Plantbaserte nuggets (plant based nuggets), Andre plantbaserte kjøtterstatning (Other plant-based meat substitutes), Melk (milk), Ost (cheese), Havregurt (oatmeal), yoghurt, Fløte-is (cream ice-cream), Matfløte (whipped cream), Plantedrikke (plant drinks), planteost (plant cheese), soya yoghurt, koghurt, plante-fløte (plant cream).



Figure 3-2 Søk produkt (Search products)

Besides these search options, there is Advansert Søk (advance search) option, through this option users can find out the products with the specific range of energies, calories, Fett, carbo carbohydrate, fiber, protein salt per gram between 0 to 100.

Søk produkt

Produkttype:

Produktkategori:

Energi kj mellom 0 10000

Energy kcal mellom 0 1000

Fett gram mellom 0 1000

Mettetfett gram mellom 0 1000

Karbohydrater gram mellom 0 1000

Hvoravsukkerarter gram mellom 0 100

Fiber gram mellom 0 100

Protein gram mellom 0 100

Salt gram mellom 0 100

Figure 3-3 Søk produkt (Search products) advance options.

3.1.3 Produktliste (søkeresultat) (Product list (search result))

It is a third page of the search result; it appears after pressing the Søk (search) button on the Søk produkt (Search products) page. On this page, the user can mark the favorite food products and add them to the favorite list by clicking on the Legg till favorittliste (Add to favorite list) button. This favorite list functionality will be added in future work. So far, it just an overview of the working of this website. Users can also navigate to the previous Søk produkt page by clicking on the Nytt Søk (new search) button.

Produktliste (søkeresultat)

Nytt søk

** Alle næringsstoffene i tabellen er per 100 gram.

Produkt Sort	Produkttype	Produktkategori	Energj	Energj	Fett	Mettet-	Karbohy-	Hvorav-	Fiber	Protein	Salt	Produsent	
			(kJ) Sort	(kcal) Sort	(g) Sort	fett (g) Sort	drater (g) Sort	sukkerarter (g) Sort	(g) Sort	(g) Sort	(g) Sort		
Beyond Burger	Kjøtterstatninger	Plantebaserte burgere	1107	266	19.0	4.4	5.3	0.0	2.6	18.0	1.1	https://www.beyondmeat.com	Legg til favorittliste
Coop Vegetardag Burger Bønner og Erte	Kjøtterstatninger	Plantebaserte burgere	523	125	5.5	0.6	9.2	2.2	6.1	6.7	1.6	https://matlevering.coop.no/	Legg til favorittliste
Coop Vegetardag Soppburger	Kjøtterstatninger	Plantebaserte burgere	471	113	4.9	0.8	6.9	0.4	5.4	7.6	1.8	https://matlevering.coop.no/	Legg til favorittliste
Coop Vegetardag Burger Rødbeter og Honning	Kjøtterstatninger	Plantebaserte burgere	489	116	2.6	0.3	13.0	7.3	5.5	7.1	1.4	https://matlevering.coop.no/	Legg til favorittliste
Coop Vegetardag Juicy Burger	Kjøtterstatninger	Plantebaserte burgere	977	235	14.0	12.0	4.6	1.7	0.0	20.0	0.8	https://matlevering.coop.no/	Legg til favorittliste
Folkets Veggi burger	Kjøtterstatninger	Plantebaserte burgere	412	98	2.7	0.3	10.7	6.5	5.8	4.9	1.1	https://meny.no/	Legg til favorittliste
Go' vegan burger	Kjøtterstatninger	Plantebaserte burgere	1175	281	20.0	18.0	25.0	0.5	0.0	0.5	1.8	https://meny.no/	Legg til favorittliste
VegMe BBQ-burger	Kjøtterstatninger	Plantebaserte burgere	710	170	9.5	0.6	6.4	1.7	3.5	13.0	1.5	https://www.vegme.no/	Legg til favorittliste
Hålsans kôk Sensational Burger	Kjøtterstatninger	Plantebaserte burgere	764	183	9.2	4.0	5.5	1.1	5.0	17.0	1.0	https://www.halsanskok.no/	Legg til favorittliste

Figure 3-4 Produktliste (søkeresultat) (Product list (search result))

3.2 Automated Evaluation

To promote the accessibility of web content and make it accessible for people who are suffering from disabilities and different kinds of impairments Web Content Accessibility Guidelines (WCAG) from World Wide Web Consortium W3C establish 65 checkpoints and 14 guidelines to overcome the accessibility and feasibility issues in web-based applications (Centeno et al., 2006). Some of these checkpoints and guidelines can be evaluated by humans but it implying a very high cost and time taking process (Centeno et al., 2006). To overcome these constraints automated evaluation of web-based applications against these guidelines and checkpoints takes place. Automated evaluation tools play a very crucial role in identifying the usage of missing attributes in HTML code that assist different assistive technologies, they also help the developer to analyze and collect data of accessibility guidelines and detect non-compliance against different success criteria of contrast errors, and provide the relevant information to overcome or rectify the potential error (Vigo et al., 2013).

Because of the variability of the Web functions, automatic tools are produced to objectively measure compliance with established standards/guidelines. There are currently several automated resources available to assist with fast and impartial web usability evaluations. The tools capable of quickly providing evaluation results are easy to use and are highly user-friendly (Luján-Mora et al., 2014). Although automated tools are incredibly useful for

objectively evaluating web usability, some of the findings recorded involve human judgment or manual web inspection (Peters & Bradbard, 2010).

For the sake of accessibility evaluation of our proposed web application, we will use WAVE (Web Accessibility Evaluation Tool). It has been used in several studies including in e-government research like West, 2008 and Youngblood & Mackiewicz, 2012. It is a powerful tool which uses for evaluating the accessibility features of a website, it is powered by WebAIM (web accessibility in mind) under the center for persons with disabilities of Utah State University, Logan. It provides visual feedback about the accessibility of the web pages. It analyses the alerts, errors, contrast errors, features, structure elements, and wai aria. It is also helpful to identify the potential accessibility issues for screen readers and keyboard users.

3.2.1 Working of WAVE (Web Accessibility Evaluation Tool)

There are two ways for using this tool, one by visiting the website with a URL (<https://wave.webaim.org/>) and put the website address in the search bar. Second to add the extension of this tool in your web browser and run the extension of the page you want to evaluate. As per our evaluation concerns, we will adopt the second way, because our website is running on localhost, so the evaluation will be done by adding the extension in the web browser and run the tool on the web application page.

After running the web browser extension of WAVE, it highlights the information which is important for an accessibility evaluation with inline icons. It also shows the summary of the evolution in a sidebar on the left of the window. There are four other panels within the sidebar which are Details, Reference, Structure, and Contrast. WAVE findings are organized into six categories.

1. Errors:
Not fulfilling some WCAG and will impact problems for certain users.
2. Contrast Errors:
Web text does not meet the WCAG contrast requirements.
3. Alerts:
Some elements that may cause issues to certain groups of people.
4. Feature:
Some elements improve accessibility after implemented correctly.
5. ARIA:
Give the number of usage WAI-ARIA tags on the web page.

6. Structural element:

Describes the whole structure in terms of the number of usages of different structural elements of the specific web page.

4 Results

4.1 Performing evaluation using WAVE

This section is designated for the overall accessibility analysis results of WAVE (Web Accessibility Evaluation Tool) on the proposed web-based application pages.

Table 4-1 describes the result's summary of WAVE analysis on the proposed web-based application. It shows the number of errors, alert messages, features, structural elements, contrast errors, and ARIA attributes. Errors, alerts, and contrast errors will be discussing more in detail structural elements and ARIA attributes will not be discussed in the later sections of the results because these two have not to impact on the accessibility compliance of the proposed web-based application. Contrast errors and Errors will be discuses together as both are categorizing in the errors section.

Table 4-1 Summary of the WAVE analysis result.

Name of page	Errors	Alerts	Features	Structural Elements	Contrast Errors	ARIA
Product List	1	1	0	17	2	0
Search product	37	14	3	3	3	0
Product list (Search result)	2	1	0	17	2	0
Total	40	16	0	37	7	0

4.1.1 Produktlist (Product List)

Figure 4-1 provides the summary of the analysis of WAVE on the first page of the web-based application Produktlist (product list). Here, in summary, there are 1 error, 2 color contrast errors, 1 alerts message. The WAI-ARIA (web accessibility initiative-accessibility-rich internet application) is 0, which means there is not any violation of ARIA attributes in the HTML code of this page. There are 17 structural elements, which means the whole structure of this web page is consists of 17 elements.

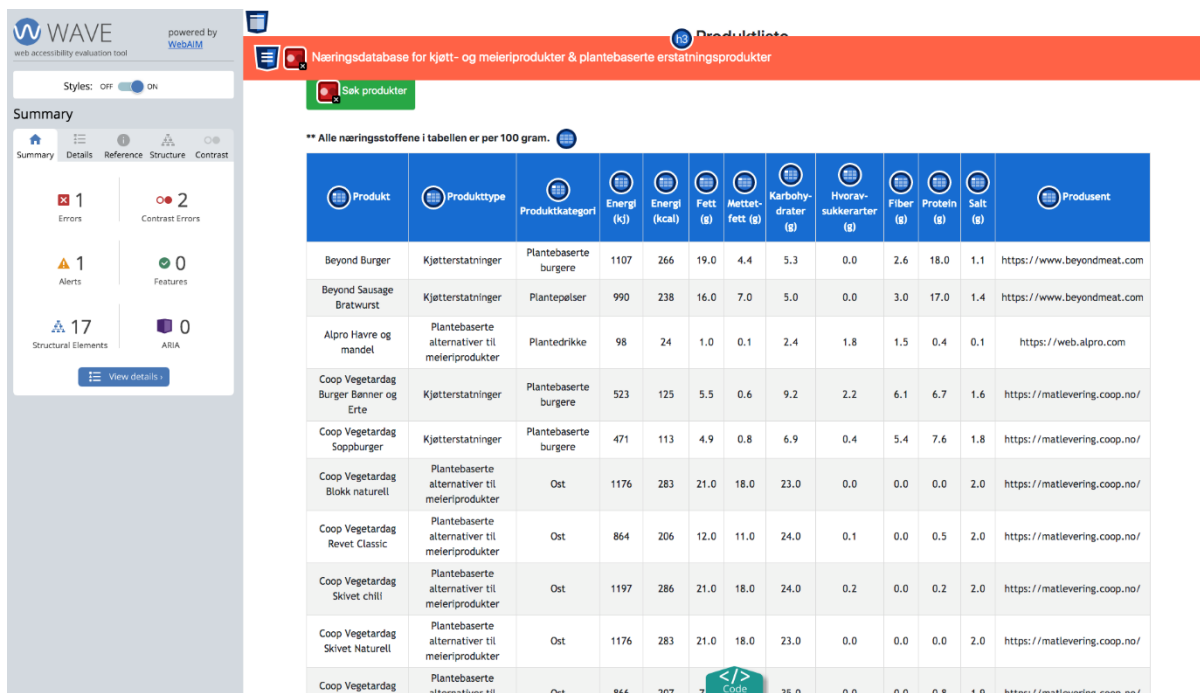


Figure 4-1 Wave Analysis on Produktlist

4.1.1.1 Error Details

As shown in figure 4-2, this error is related to the language attribute <html lang>. It seems like there is not lang attribute initiated on this page. <html lang> attribute is very important for the screen reader to identify the language of the web pages and also it is necessary to translate the content of the web pages into another language. Not using the <html lang> attribute on the web pages is also a violation of (Level A) success criteria.

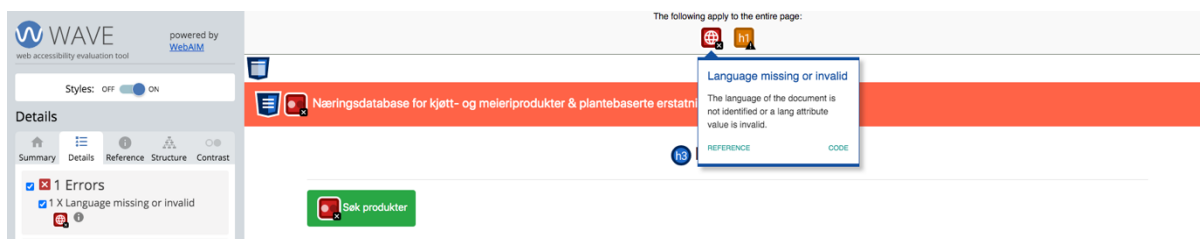


Figure 4-2 Produktlist error detail

The product-list.jsp (java server page) figure 4-3 shows, there is not initiating the <html lang> attribute on the server-side script.

```

<?@ page language="java" contentType="text/html; charset=ISO-8859-1"
pageEncoding="ISO-8859-1"%>
<?@ taglib uri="http://java.sun.com/jsp/jstl/core" prefix="c"%>
<!DOCTYPE html>

<html>
<head>
<style>
div.my_container {
width:100%;padding-right:100px;padding-left:100px;margin-right:auto;margin-left:auto;
}

#products {

```

Figure 4-4 Produt-list.jsp code

There are 2 contrast errors on the Produktlist page. Figure 4-4 provides one of the contrast information. This error is on the header of the page. It is obvious from the WAVE contrast analyzer header is failing to fulfil the AA and AAA success criteria. Adequate color contrast is necessary for all end-users, especially for those who have low vision.

The screenshot shows the WAVE accessibility tool interface on the left, displaying a contrast error. The error message reads: "Very low contrast. Very low contrast between text and background colors." The contrast ratio is shown as 2.94:1. The page content on the right includes a search bar and a table of products with nutritional information.

Produkt	Produkttype	Produktkategori	Energi (kJ)	Energi (kcal)	Fett (g)	Mettet-fett (g)	Karbohy-drater (g)	Hvorav-sukkerarter (g)	Fiber (g)	Protein (g)	Salt (g)	Produsent
Beyond Burger	Kjætterstatninger	Plantebaserte burgere	1107	266	19.0	4.4	5.3	0.0	2.6	18.0	1.1	https://www.beyondmeat.com
Beyond Sausage Bratwurst	Kjætterstatninger	Plantepølser	990	238	16.0	7.0	5.0	0.0	3.0	17.0	1.4	https://www.beyondmeat.com
Alpro Havre og mandel	Plantebaserte alternativer til meieriprodukter	Plantedrikke	98	24	1.0	0.1	2.4	1.8	1.5	0.4	0.1	https://web.alpro.com
Coop Vegetardag Burger Bønner og Erte	Kjætterstatninger	Plantebaserte burgere	523	125	5.5	0.6	9.2	2.2	6.1	6.7	1.6	https://matlevering.coop.no/
Coop Vanarøfås		Plantebaserte										

Figure 4-5 Contrast Error detail of the header

Figure 4-5 shows the contrast error details of the Søk Produkt (search product) button, which is the 2-contrast error of the Produktlist page. Here, we can see large texts fulfil the success criteria Level AA, but the normal text is missing to fulfil any success criteria.

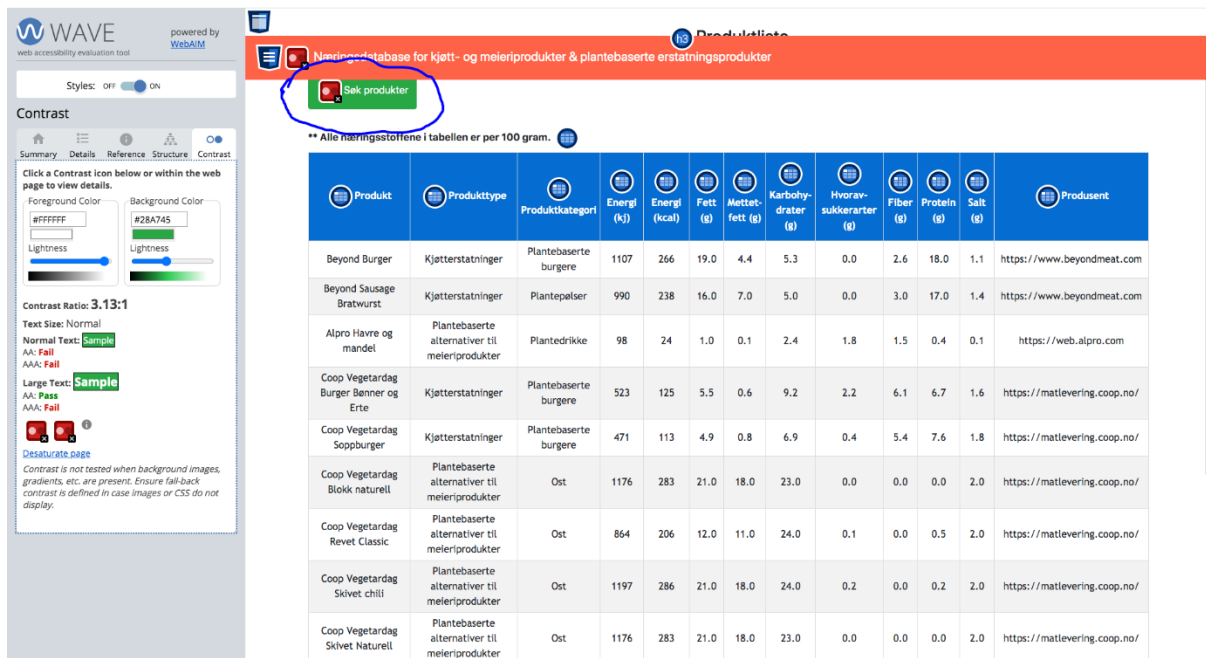


Figure 4-6 Contrast Error detail of the Søk Produkter button

4.1.1.2 Alert Message Detail

Figure 4-6 provides the missing first-level heading information on the Produktlist page. Proper usage of heading on web pages facilitates page navigation to the assistive technology's users. It also provides the semantic, structure, and visual meaning to the document. The first-level heading considers the most important heading and that's why it also assumes to be present on nearly all pages.

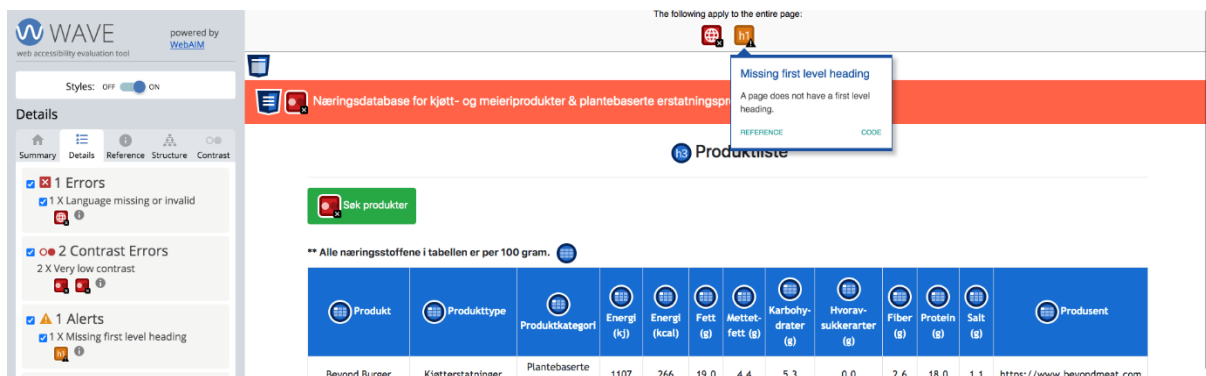


Figure 4-7 Produktlist Alert Message Detail

Figure 4-7 is the Produktlist.jsp file, which shows not usage the h1 attribute in the java server page script.


```

<div>
  <h3 class="text-center">Produktliste</h3>
  <hr>
</div>

```

Figure 4-8 Produktlist.jsp file.

4.1.2 Søk Produkt (Search Product)

Figure 4-8 WAVE analysis on the search product page provides the summary of the errors, contrast errors, and alert messages information. There are 37 errors, 3 contrast errors, and 14 alert messages. There are 3 structural elements used on this page, heading level 2, Header, and navigation. There is not any WAI-ARIA attributes violation on this page. Feature 0 gives the information i.e. there is not an element that can improve accessibility if we implement that correctly.

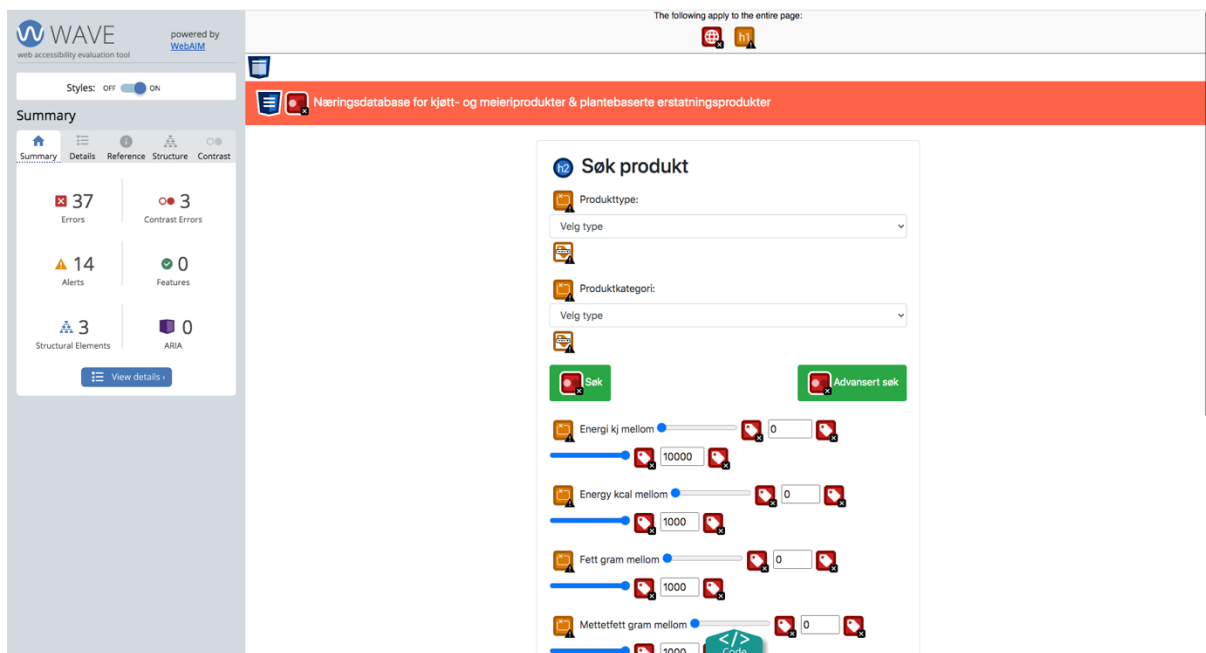


Figure 4-9 WAVE analysis on the search product page.

4.1.2.1 Error Details

Figure 4-9 indicates the detail of the errors. There is a total of 37 errors but those are from 2 groups. One is missing form label and the second is a language missing or invalid. Missing form label has a frequency of 36 and language missing, or invalid error frequency is just 1.

The language attribute is essential for the screen readers to identify the language of the page and its contents. It also helps to automatically translate the content of the web pages. In the

same way, missing the corresponding label for a form control also creates problems for screen readers to identify the purpose of that specific form control.

These errors can be resolve by adding specific attributes. Like in the case of language missing or invalid, this error resolve by adding the <html lang> attribute in the server-side script of this page. In the same way, the missing form label can be resolve by adding the <label> attribute with its corresponding form control.

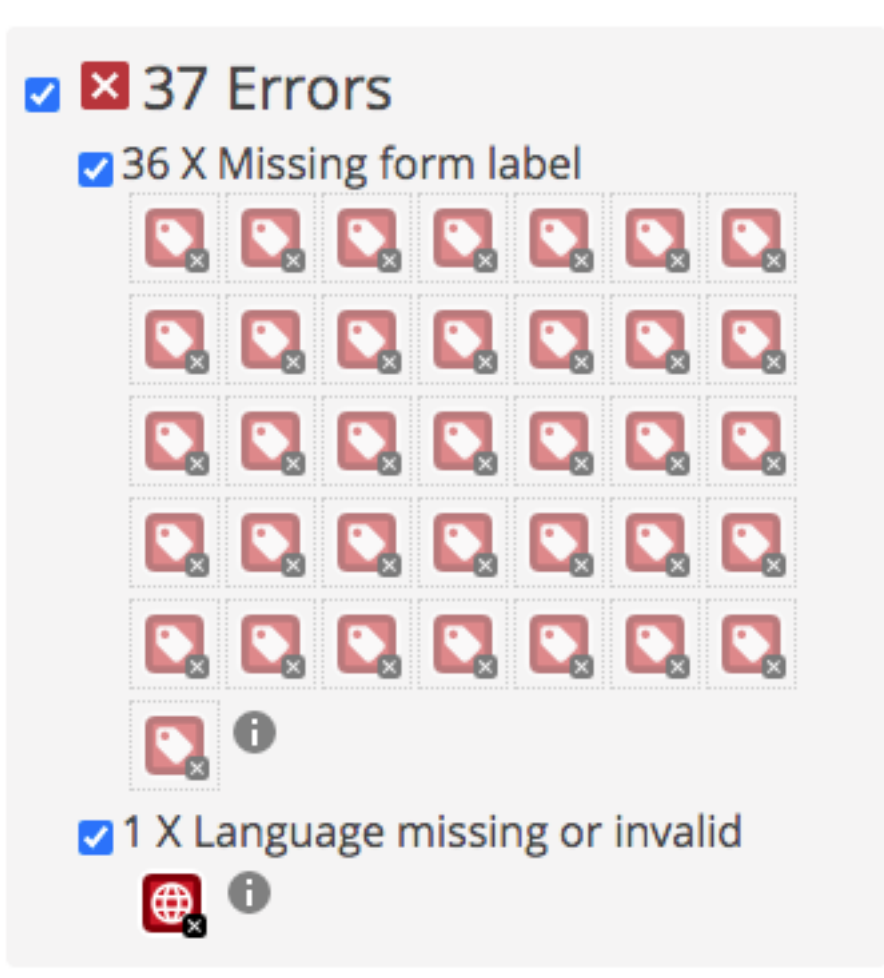


Figure 4-10 Errors detail of search product page

Figure 4-10 shows the java server page code, which describes the missing usage of form label control.

```
</fieldset>
<fieldset class="form-group">
  <label>Energy kcal mellom</label>
  <input type="range" name="amountRangeMINEnergyKcal" id="amountRangeMINEnergyKcal" min="0" max="1000" value="0" oninput="this.form.amountInputMINEnergyKcal.value=this.value" />
  <input type="number" name="amountInputMINEnergyKcal" id="amountInputMINEnergyKcal" min="0" max="1000" value="0" oninput="this.form.amountRangeMINEnergyKcal.value=this.value" />
  <input type="range" name="amountRangeMAXEnergyKcal" id="amountRangeMAXEnergyKcal" min="0" max="1000" value="1000" oninput="this.form.amountInputMAXEnergyKcal.value=this.value" />
  <input type="number" name="amountInputMAXEnergyKcal" id="amountInputMAXEnergyKcal" min="0" max="1000" value="1000" oninput="this.form.amountRangeMAXEnergyKcal.value=this.value" />
</fieldset>
```

Figure 4-11 Missing form label control

Figure 4-11 shows the java server page code of product-search, which describes not the usage of the language attribute in the source file.

```
<@ page language="java" contentType="text/html; charset=ISO-8859-1"
pageEncoding="ISO-8859-1"%>
<@ taglib uri="http://java.sun.com/jsp/jstl/core" prefix="c"%>
<!DOCTYPE html>
<html>
<head>
<meta charset="ISO-8859-1">
</style>
```

Figure 4-12 Missing language attribute.

There are 3 contrast errors on the search product page as shown in figure 4-12. One is on the header of the page, the second is with Søk (search) button, and the third with Advansert Søk (advance search button).

Contrast errors are very crucial for all kinds of users, especially for low vision. These errors are also violating the WCAG (web content accessibility guidelines) and success criteria AA.

These errors can be eliminated by adding the specific contrast between the background and foreground colors.

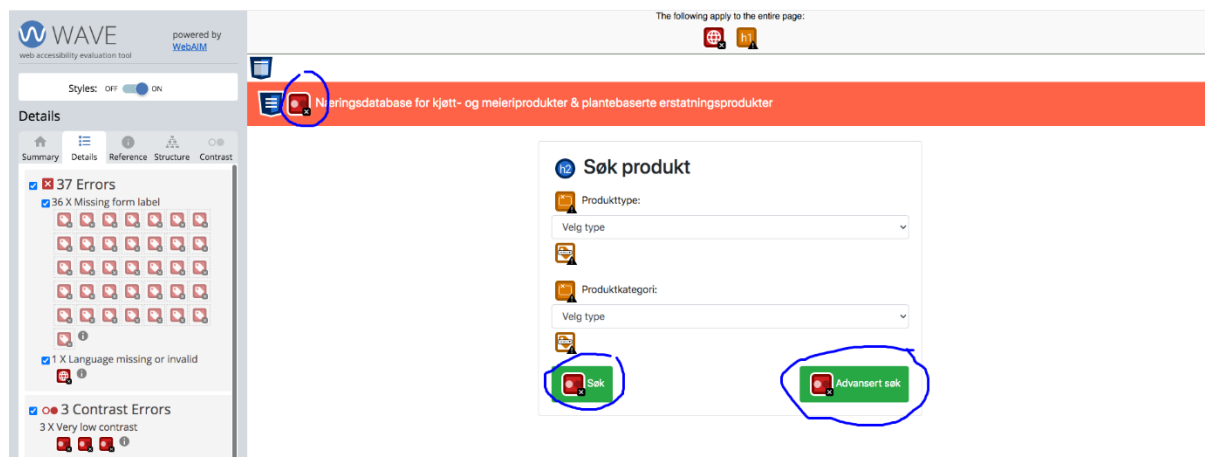


Figure 4-13 Contrast error detail of Search Product page.

4.1.2.2 Alert Messages Detail

Figure 4-13 shows the alert messages details. There are 14 alert messages, but they are from 3 different groups. 2 alert messages from the select missing label, 11 are from Fieldset missing legend, and 1 from missing first-level heading.

<select> elements provide the descriptive information about their function. This is done via associated label text. If we do not use this then the default, select option will provide such information that sometimes not accessible. In the same way, fieldset legends describe the form elements within a fieldset and it is useful for the screen reader. On the other side, not

having the heading level will become a problem for many assistive technology users to navigate the page.

These issues can be resolved by adding their specific attribute in the HTML code. As for removing heading alert message <h1> heading level 1 attribute is used. For resolving the select missing label, the corresponding label will be used with their <select> attribute in the HTML code. In the end, for resolving the fieldset missing legend alert message, <legend> attribute is used to facilitate the screen reader and to enhance the accessibility of the web pages.

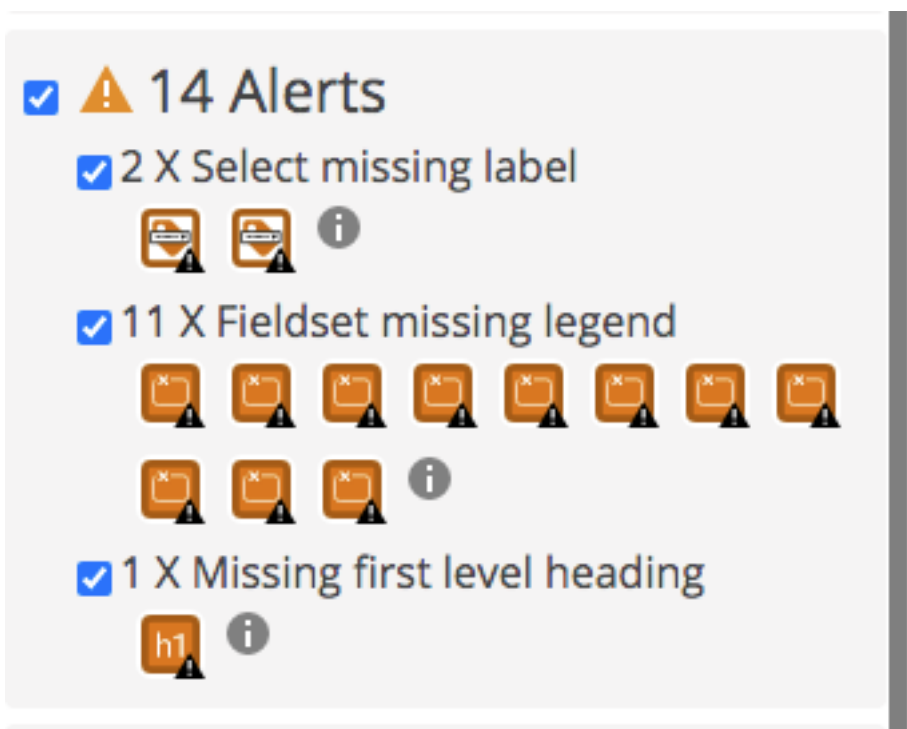


Figure 4-14 Alert Messages Detail

Figure 4-14 describes the source code where the select label and fieldset legends are missing.

```

</div>
<fieldset class="form-group">
  <label>Produkttype:</label>
  <select type="text" value="<c:out value='${product.producttype}' />" class="form-control" name="producttype" id="producttype">
    <option selected="selected">Velg type</option>
  </select>
</fieldset>
<fieldset class="form-group">
  <label>Produktkategori:</label>
  <!-- select name="subtype" id="subtype" -->
  <select type="text" value="<c:out value='${product.subtype}' />" class="form-control" name="subtype" id="subtype">
    <option selected="selected">Velg type</option>
  </select>
</fieldset>
<button type="submit" class="btn btn-success">Søk</button>
<button title="Filtrere søk basert på næringsstoffer" type="button" class="btn btn-success" style="float: right" onclick="loadDoc()">A
</button>
</div>
<div id="bottom" style="display:none">
<br>
<!--

```

Figure 4-15 Missing select label and fieldset legend

Figure 4-15 shows the source code file where the first level heading is missing.

```

<%@ page language="java" contentType="text/html; charset=ISO-8859-1"
  pageEncoding="ISO-8859-1"%>
  <%@ taglib uri="http://java.sun.com/jsp/jstl/core" prefix="c"%>
<!DOCTYPE html>
<html>
<head>
<meta charset="ISO-8859-1">
<style>

</style>
<script>

```

Figure 4-16 Missing first-level heading

4.1.3 Produktlist (Søkeresultat) (Product List (Search Result))

Figure 4-16 WAVE analysis on the product list (search result), describes the summary of the errors, alerts, contrast errors, and structural elements information. Features and ARIA have not any violation and need improvements. There are 2 errors, 13 contrast errors, 1 alert message, and 17 structural elements on this page. In 17 structural elements, there are 13 table header cells, 1 heading level 3, 1 header, and 1 navigation.

WAVE powered by WebAIM
web accessibility evaluation tool

Styles: OFF ON

Summary

- 2 Errors
- 13 Contrast Errors
- 1 Alerts
- 0 Features
- 17 Structural Elements
- 0 ARIA

View details

Næringsdatabase for kjøtt- og meieriprodukter & plante- og erterstatningsprodukter

Nytt søk

** Alle næringsstoffene i tabellen er per 100 gram.

Produkt	Produkttype	Produktkategori	Energi (kJ)	Energi (kcal)	Fett (g)	Mettet-fett (g)	Karbohy-drater (g)	Hvorav-sukkerarter (g)	Fiber (g)	Protein (g)	Salt (g)	Produsent	
Sort			Sort	Sort	Sort	Sort	Sort	Sort	Sort	Sort	Sort		
Beyond Burger	Kjøtterstatninger	Plantebaserte burgere	1107	266	19.0	4.4	5.3	0.0	2.6	18.0	1.1	https://www.beyondmeat.com	Legg til favorittliste
Coop Vegetardag Burger Bønner og Erte	Kjøtterstatninger	Plantebaserte burgere	523	125	5.5	0.6	9.2	2.2	6.1	6.7	1.6	https://matlevering.coop.no/	Legg til favorittliste
Coop Vegetardag Soppburger	Kjøtterstatninger	Plantebaserte burgere	471	113	4.9	0.8	6.9	0.4	5.4	7.6	1.8	https://matlevering.coop.no/	Legg til favorittliste
Coop Vegetardag Burger Rødbeter og Honning	Kjøtterstatninger	Plantebaserte burgere	489	116	2.6	0.3	13.0	7.3	5.5	7.1	1.4	https://matlevering.coop.no/	Legg til favorittliste
Coop Vegetardag Juicy Burger	Kjøtterstatninger	Plantebaserte burgere	977	235	14.0	12.0		1.7	0.0	20.0	0.8	https://matlevering.coop.no/	Legg til favorittliste

Figure 4-17 WAVE analysis on the product list (search result) page.

4.1.3.1 Errors Detail

Figure 4-17 describes the details of the errors. One is related to a missing language attribute that can be resolved by adding the `<html lang>` attribute. It causes a problem for the screen reader to identify the language of the web pages and it also helps to automatically translate the language of the webpage into another language.

The second error is related to the empty table header of the web page. An empty `<th>` attribute may cause to provide incorrect information of the table header because it is associated with the table cells that convey the correct row/column headers. It can be resolved by providing the text within the cells that describes the column or row.

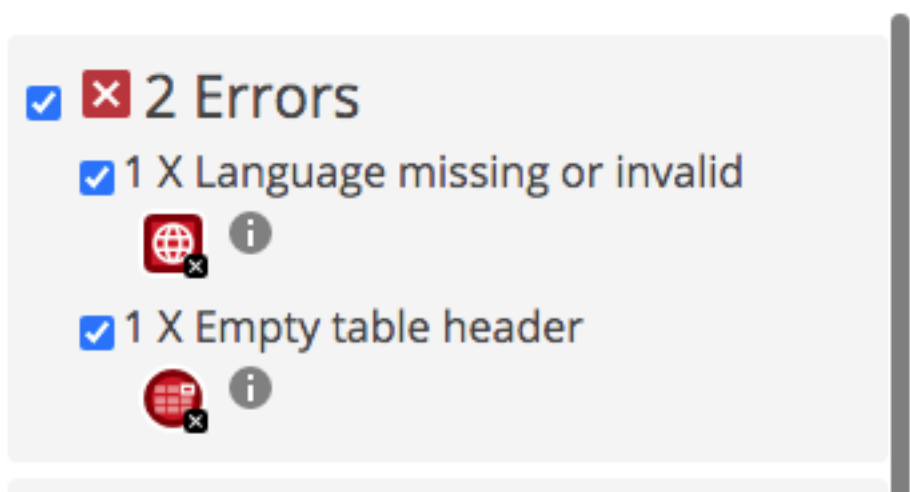


Figure 4-18 Errors Detail

The following figure 4-18, shows the missing usage of the language attribute in the source file.

```
<%@ page language="java" contentType="text/html; charset=ISO-8859-1"
    pageEncoding="ISO-8859-1"%>
<%@ taglib uri="http://java.sun.com/jsp/jstl/core" prefix="c"%>
<!DOCTYPE html>
<html>
<head>
<style>
div.my_container {
width:100%;padding-right:100px;padding-left:100px;margin-right:auto;margin-left:auto;
}

```

Figure 4-19 Missing Language attribute

Figure 4-19 empty table header describes there is nothing in the table header attribute.

```
<a id ="saltgramDES">Høvest</a>
</div>
</div>
</th>
<th>Produsent</th>
<th><br />
<div>
</div></th>
</tr>
</thead>
<tbody id="somedivbody">
```

Figure 4-20 Empty Table Header

There are 4-20 contrast errors on this page. These errors are on the navigation button, Nytt Søk (new search) button, and Legg til favorittliste (add to the favorite list) buttons as shown in figure 24.

The screenshot shows a web accessibility evaluation tool (WAVE) interface on the left and a nutrition database page on the right. The tool interface displays the following error details:

- 2 Errors:**
 - 1 X Language missing or invalid
 - 1 X Empty table header
- 13 Contrast Errors:**
 - 13 X Very low contrast
- 1 Alerts:**
 - 1 X Missing first level heading
- 17 Structural Elements:**
 - 1 X Data table
 - 13 X Table header cell
 - 1 X Heading level 3
 - 1 X Header
 - 1 X Navigation

The main page content is a nutrition database table titled "Næringsdatabase for kjøtt- og meieriprodukter & plantebaserte erstattingsprodukter". The table has columns for Product, Product type, Product category, and various nutrients (Energy, Fat, Saturated fat, Carbohydrates, Fiber, Protein, Salt). The table is currently empty. A "Nytt søk" button is highlighted with a red box. "Legg til favorittliste" buttons are highlighted with red boxes for each row in the table.

Figure 4-21 Contrast errors detail.

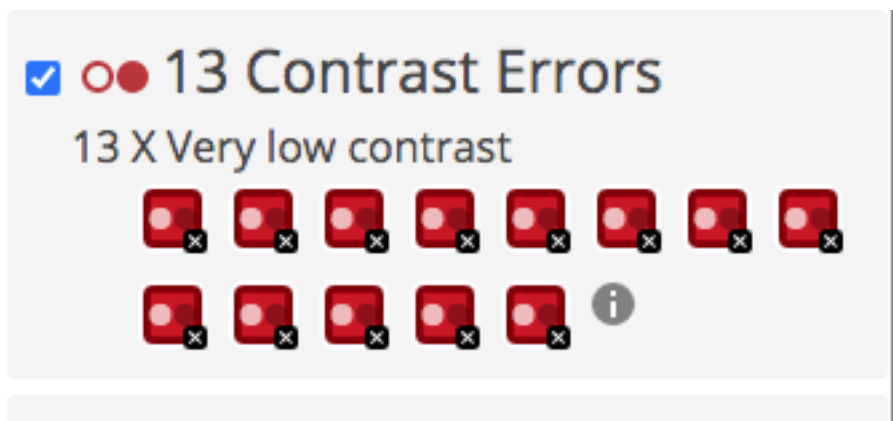


Figure 4-22 Contrast Errors detail

These errors cause problems to all kinds of end-users, especially low vision users. These errors can be resolved by adding the specific contrast between the foreground and background colors. These errors are violating the WCAG (web content accessibility guidelines) and also the success criteria AA.

4.1.3.2 Alert Messages Detail

The alert message is related to the first level heading as shown in figure 4-22. This error causes a problem for assistive technologies users to navigate the web page, this error can be resolved by adding the `<h1>` heading attribute in the code.

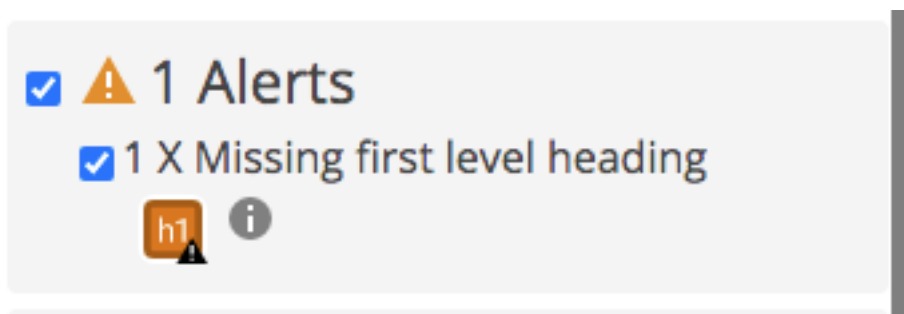


Figure 4-23 Alert Messages Detail

Figure 4-23 describes the source code file, where heading level 3 is used and heading level 1 is missing.

```

<div class="my_container">
  <h3 class="text-center">Produktliste (søkeresultat)</h3>
  <hr>
  <div>

```

Figure 4-24 Missing first-level heading.

4.1.4 WAVE Errors Details

Table 4-2 describes all errors details in the form of concerning meaning, importance and, frequency in all three pages.

Table 4-2 WAVE errors detail.

Error	Meaning	Importance	Frequency
Missing language attribute or invalid	The language attribute of this page is not identified, or it may be invalid.	Correct usage of language attribute provides the screen readers to identify the language of the page, or it also provides the facility to translate the content of web application.	3
Form label is missing	Form control has not the corresponding label.	The features of the form label might not be displayed to the screen-reader if it is not marked properly. It provides extra space for click ability and gives visible details.	36
Empty table header	A table header <th> does not contain text.	Having no text in the table header can give incorrect information to the screen-readers.	1

Very low contrast	Text and background color have very low contrast	It is essential for all users, but it creates problems for low vision users.	7
-------------------	--	--	---

4.1.5 WAVE Alerts Details

Table 4-3 shows the alert messages details in all three web-based application pages.

Table 4- 3 WAVE Alerts details.

Alert	Meaning	Importance	Frequency
The first-level heading is missing	There is not first-level heading on a web page.	Headings provide semantic and visual meaning and structure to the documents, missing or not having first-level heading creates problems for users to navigate through assistive technologies.	3
Missing fieldset legend	A fieldset does not have a legend.	It is useful for a screen-reader to presents a description of the form elements within a fieldset.	11

Missing select label	There is not associated label for select elements.	For providing the descriptive text function of <select> elements, associated label text is necessary.	2
----------------------	--	---	---

4.2 Fixing Errors:

This section is dedicated to the status of error fixing of the web-based application.

4.2.1 Produktliste

Figure 4-24 describes the summary of error fixing of the Produktliste web-based application page. Here, there are not any errors, contrast errors, and alert messages.

Previously there were 1 error, 1 alert message, and 2 contrast errors.

The screenshot shows the Wave accessibility tool interface on the left and the Produktliste web page on the right. The tool's summary panel indicates 0 errors, 0 contrast errors, 0 alerts, 1 feature, and 17 structural elements. The main content area displays a table of products with nutritional information.

Produkt	Produkttype	Produktkategori	Energj (kj)	Energj (kcal)	Fett (g)	Mettet-fett (g)	Karbohy-drater (g)	Hvorav-sukkerarter (g)	Fiber (g)	Protein (g)	Salt (g)	Produsent
Beyond Burger	Kjletterstatninger	Plantebaserte burgere	1107	266	19.0	4.4	5.3	0.0	2.6	18.0	1.1	https://www.beyondmeat.com
Beyond Sausage Bratwurst	Kjletterstatninger	Plantepølser	990	238	16.0	7.0	5.0	0.0	3.0	17.0	1.4	https://www.beyondmeat.com
Alpro Havre og mandel	Plantebaserte alternativer til meleriprodukter	Plantedrikke	98	24	1.0	0.1	2.4	1.8	1.5	0.4	0.1	https://web.alpro.com
Coop Vegetardag Burger Bønner og Erte	Kjletterstatninger	Plantebaserte burgere	523	125	5.5	0.6	9.2	2.2	6.1	6.7	1.6	https://matlevering.coop.no/
Coop Vegetardag Soppburger	Kjletterstatninger	Plantebaserte burgere	471	113	4.9	0.8	6.9	0.4	5.4	7.6	1.8	https://matlevering.coop.no/
Coop Vegetardag Blokk naturell	Plantebaserte alternativer til meleriprodukter	Ost	1176	283	21.0	18.0	23.0	0.0	0.0	0.0	2.0	https://matlevering.coop.no/
Coop Vegetardag Revet Classic	Plantebaserte alternativer til meleriprodukter	Ost	864	206	12.0	11.0	24.0	0.1	0.0	0.5	2.0	https://matlevering.coop.no/
Coop Vegetardag	Plantebaserte alternativer til	Ost	1197	286	21.0	18.0	24.0	0.2	0.0	0.2	2.0	https://matlevering.coop.no/

Figure 4-25 Produktliste page error status

Figure 4-25 shows the usage of the lang= “nb” attribute in the <html> tag to fix the missing language attribute error in the Produktliste web-based application.


```

<div>
  <h1 class="text-center">Produktliste</h1>
  <hr>
</div>

```

Figure 4-30 Fixing h1 alert message.

Figure 4-30 shows the status of fulfilling the contrast standards of AA, and AAA against both normal text and large text.

The screenshot shows the WAVE accessibility tool interface. On the left, the 'Contrast' panel is active, displaying a contrast ratio of 8.59:1. It indicates that 'Normal Text' and 'Large Text' both 'Pass' the AA and AAA standards. The main content area shows a 'Produktliste' table with the following data:

Produkt	Produkttype	Produktkategori	Energi (kJ)	Energi (kcal)	Fett (g)	Mettet-fett (g)	Karbohy-drater (g)	Hvorav-sukkararter (g)	Fiber (g)	Protein (g)	Salt (g)	Produsent
Beyond Burger	Kjættetstninger	Plantebaserte burgere	1107	266	19.0	4.4	5.3	0.0	2.6	18.0	1.1	https://www.beyondmeat.com
Beyond Sausage Bratwurst	Kjættetstninger	Plantepølser	990	238	16.0	7.0	5.0	0.0	3.0	17.0	1.4	https://www.beyondmeat.com
Alpro Havre og mandel	Plantebaserte alternativer til meieriprodukter	Plantedrikke	98	24	1.0	0.1	2.4	1.8	1.5	0.4	0.1	https://web.alpro.com
Coop Vegetardag Burger Bønner og Erte	Kjættetstninger	Plantebaserte burgere	523	125	5.5	0.6	9.2	2.2	6.1	6.7	1.6	https://matlevering.coop.no/
Coop Vegetardag Soppburger	Kjættetstninger	Plantebaserte burgere	471	113	4.9	0.8	6.9	0.4	5.4	7.6	1.8	https://matlevering.coop.no/
Coop Vegetardag Blokk naturel	Plantebaserte alternativer til meieriprodukter	Ost	1176	283	21.0	18.0	23.0	0.0	0.0	0.0	2.0	https://matlevering.coop.no/
Coop Vegetardag Revet Classic	Plantebaserte alternativer til meieriprodukter	Ost	864	206	12.0	11.0	24.0	0.1	0.0	0.5	2.0	https://matlevering.coop.no/
Coop Vegetardag	Plantebaserte alternativer til	Ost	1197	286	21.0	18.0	24.0	0.2	0.0	0.2	2.0	https://matlevering.coop.no/

Figure 4-31 Fulfilling the contrast errors standards

4.2.2 Søk Produkt

Figure 4-31 describes the error fixing status of the Søk Produkt web-based application page. There were previously, 37 errors, 14 alert messages, and 3 contrast errors. Now all the error alerts messages, and contrast errors are fixed.

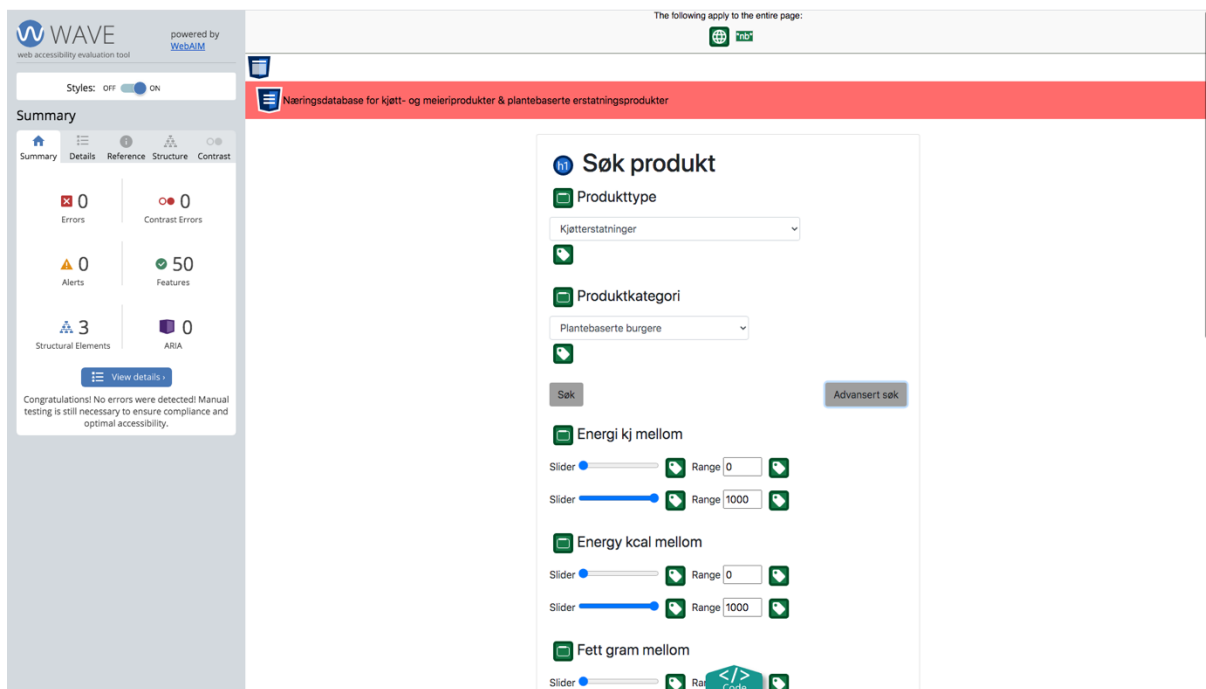


Figure 4-32 Error fixing the status of Søk produkt page

Figure 4-32 shows the usage of the language attribute in the <html> tag to overcome the missing language attribute error in the Søk Produkt web-based application.

```

<?@ page language="java" contentType="text/html; charset=ISO-8859-1"
pageEncoding="ISO-8859-1"%>
  <?@ taglib uri="http://java.sun.com/jsp/jstl/core" prefix="c"%>
  <!DOCTYPE html>
  <html lang ="nb">
  <head>
    <meta charset="ISO-8859-1">
  <style>

```

Figure 4-33 Fixing missing language error attribute

There were 36 missing form label errors and 11 alert messages of missing usage of the fieldset legend attribute in the Søk Produkt web-based application page.

Figure 4-33 shows, the modification in the code to overcome the missing form labels, by using the specific label against each form

```

<label for= "amountRangeMINEnergyKcal"> Slider
  <input type="range" name="amountRangeMINEnergyKcal" id="amountRangeMINEnergyKcal" min="0" max="1000" value="0" oninput="this.form.amountInputMINEnergyKcal.value=ti
  </label> <label for= "amountInputMINEnergyKcal">
    Range
    <input type="number" name="amountInputMINEnergyKcal" id="amountInputMINEnergyKcal" min="0" max="1000" value="0" oninput="this.form.amountRangeMINEnergyKcal.value=i
    </label>
    <label for= "amountRangeMAXEnergyKcal">
      Slider
      <input type="range" name="amountRangeMAXEnergyKcal" id="amountRangeMAXEnergyKcal" min="0" max="1000" value="1000" oninput="this.form.amountInputMAXEnergyKcal.valu
      </label>
      <label for= "amountInputMAXEnergyKcal">
        Range
        <input type="number" name="amountInputMAXEnergyKcal" id="amountInputMAXEnergyKcal" min="0" max="1000" value="1000" oninput="this.form.amountRangeMAXEnergyKcal.val
        </label>
      </label>
    </fieldset>

```

Figure 4-34 Fixing missing form label errors.

Figure 4-34 shows the usage of the <legend> attribute to overcome the alert messages of 11 missing legend attributes.

```

<fieldset class="form-group">
  <legend>Produkttype </legend>

  <label for = producttype>
    <select title = "Produkttype" type="text" value="<:out value='${product.producttype}' />" class="form-control" name="producttype" id="producttype" title= "Produkttype">
      <option selected="selected">Vejl type</option>
    </select>
  </label>
</fieldset>

<fieldset class="form-group">
  <legend>Produktkategori </legend>

  <label for = subtype>

  <!-- select name="subtype" id="subtype" -->
  <select title= "producktkategori" type="text" value="<:out value='${product.subtype}' />" class="form-control" name="subtype" id="subtype">
    <option selected="selected">Vejl type</option>
  </select>
</label>
</fieldset>

```

Figure 4-35 Code modification for Fixing fieldset missing legend

Figure 4-35 shows the code modification to fix the missing first-level heading attribute in the Søk Produkt web-based application.

```

<h1>
  <c:if test="${product == null}">
    Søk produkt
  </c:if>
</h1>

```

Figure 4-36 Fixing missing the first level heading alert message

Figure 4-36 shows the usage of the aria-labeledby attribute to overcome the missing select label alert messages in the Søk Produkt web-based application page.

```

<label for = producttype>
<select title = "Produkttype" type="text" value="<:out value='${product.producttype}' />" class="form-control" name="producttype" id="producttype" title= "Produkttype">
<option selected="selected">Vejl type</option>
</select>
</label>

```

Figure 4-37 Fixing the missing select label alert messages

Figure 4-37 describes the code modification to overcome the contrast errors in the Søk and Advansert Søk buttons by using the style attributes with the specific color contrast values of the Søk Produkt web-based application.

```
ie="submit" class="btn btn-success-V2" style="background-color:#9E9E9E" >Søk</button>
:le="Filtrere søk basert på næringsstoffer" type="button" class="btn btn-success-V2" style="background-color:#9E9E9E; float:right";... onclick="loadDoc()">Advansert søk
```

Figure 4-38 Fixing contrast errors.

Figure 4-38 shows the code modification to overcome the contrast errors in the navigation <nav> and anchor <a> tags.

```
<nav class="navbar navbar-expand-md navbar-dark" style="background-color:#FF6868">
  <div>
    <a href="request.getContextPath()>/list" style="color:#000000" font-size="30px"> Næringsdatabase for kjøtt- og meieriprodukter & plantebaserte erstatningsprodukter </a>
  </div>
</nav>
```

Figure 4-39 Fixing contrast errors.

Figure 4-39 shows the WAVE analysis for fulfilling the contrast AA, AAA standards of the Søk Produkt web-based application.

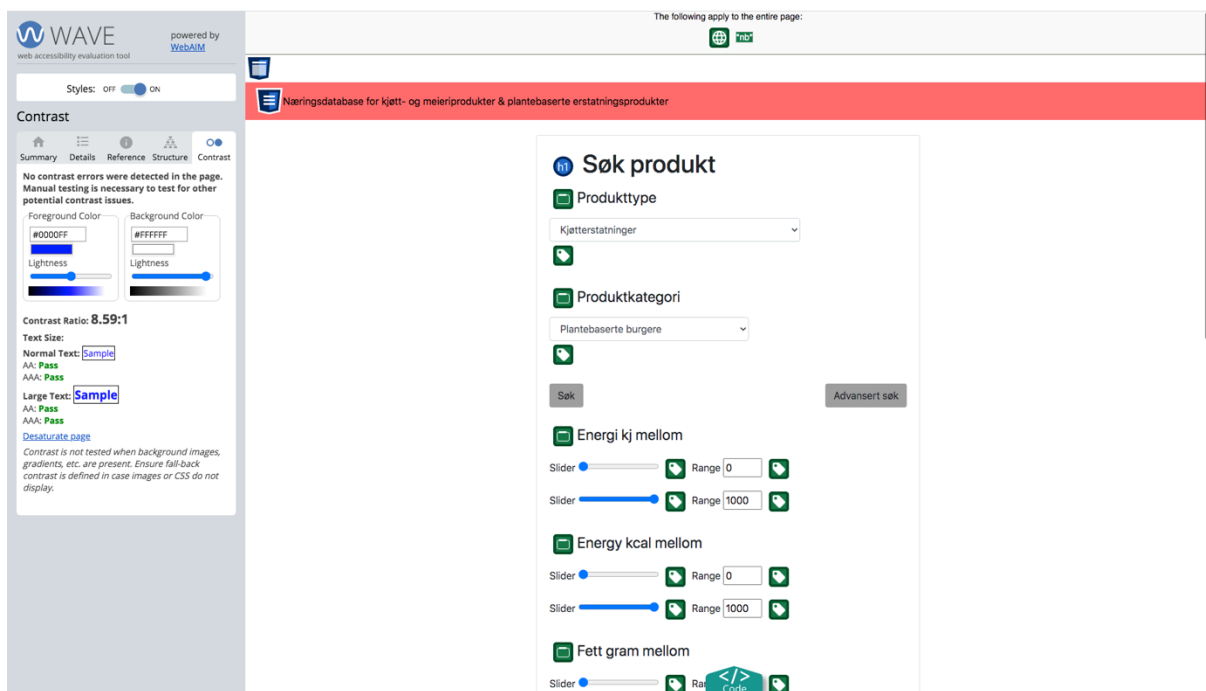


Figure 4-40 Fulfilling the contrast errors standards

4.2.3 Produktliste (søkeresultat)

Figure 4-40 describing the overall error fixing the status of the Produktliste (søkeresultat) web-based application page. There were 2 errors, 1 alert message and 2 contrast errors previously. Now, there is 0 errors, contrast errors and alert message.

The screenshot shows the WAVE web accessibility evaluation tool interface. On the left, the Summary panel indicates 0 errors, 0 alerts, 18 structural elements, and 0 ARIA errors. The main content area displays a search results page titled 'Produktliste (søkeresultat)'. A table lists products with columns for 'Produkt', 'Produkttype', 'Produktkategori', and various nutritional values (Energi, Fett, Mettet-fett, Karbohydrater, Hvorav-sukkerarter, Fiber, Protein, Salt). The 'Produkt' column includes product names like 'Coop Vegetardag Burger Bønner og Erte' and 'Folkets Veggl burger'. The 'Produktkategori' column lists 'Plantebaserte burgere'. The 'Produkt' column also includes a 'Legg til favorittliste' button for each product. The tool highlights several errors, including missing language attributes and table header errors.

Figure 4-41 Error fixing the status of Produktliste (søkeresultat) page.

Figure 4-41 shows the usage of language attribute lang= "nb" for fixing the missing language attribute error in Produktliste (søkeresultat) web-based application page.

```
<?@ page language="java" contentType="text/html; charset=ISO-8859-1"
pageEncoding="ISO-8859-1" %>
<?@ taglib uri="http://java.sun.com/jsp/jstl/core" prefix="c" %>
<!DOCTYPE html>
<html lang ="nb">
<head>
<style>
```

Figure 4-42 Fixing language attribute error.

Figure 4-42 shows the usage of table header "Legg til favorittliste" to overcome the missing table header error previously in Produktliste (søkeresultat) web-based application page.

```
</div>
</div>
</th>
<th>Produsent</th>
<th>Legg til favorittliste<br />
<div>
</div></th>
</tr>

</thead>
<tbody id="somedivbody">
```

Figure 4-43 Fixing table header error.

Figure 4-43 shows the usage of <h1> heading level 1 attribute for fixing the missing first-level heading previously in Produktliste (søkeresultat) web-based application page.

```
id= "test" class="row">

div class="my_container">
  <h1 class="text-center">Produktliste (søkeresultat)</h1>
  <hr>
  <div>
    <a href="<%=request.getContextPath()%>/search" class="btn btn-success">Søk</a>
  </div>
  <br>
  <b>Alle næringsstoffene i tabellen er per 100 gram.</b>
```

Figure 4-44 Fixing missing first-level heading.

Figure 4-44 shows the code changes to remove the contrast errors on the navigation and anchor tags of the Produktliste (søkeresultat) web-based application page.

```
<nav class="navbar navbar-expand-md navbar-dark" style="background-color:#FF6868">
  <div>
    <a href="<%=request.getContextPath()%>/list" style="color:#000000" font-size="30px">Næringsdatabase for kjøtt- og meieriprodukter & plantebaserte erstatningsprodukter.</a>
  </div>
</nav>
```

Figure 4-45 Fixing contrast errors on the navigation bar.

Following figure 4-49 shows the fixing of contrast errors on the “Nytt Søk” button of the Produktliste (søkeresultat) web-based application page. These errors were removed by adding the specific background color by using the style attribute.

```
<div>
  <a href="<%=request.getContextPath()%>/search" class="btn btn-success-v2" style="background-color:#9E9E9E">Nytt søk</a>
</div>
<br>
<b>Alle næringsstoffene i tabellen er per 100 gram.</b>
```

Figure 4-46 fixing contrast errors on Nytt søk buttons

Figure 4-46 shows the code changes in the style attribute of the “Legg til favorittliste” button of the Produktliste (søkeresultat) web-based application page.

```
class='btn btn-success-v2' style="background-color:#9E9E9E">Legg til favorittliste</button>').appendTo('#somedivbody');
```

Figure 4-47 Fixing contrast errors on Legg till favorittliste button

Figure 4-47 shows the fulfilling the contrast standards AA and AAA for normal and large texts in the Produktliste (søkeresultat) web-based application page.

The screenshot shows the WAVE web accessibility evaluation tool interface. On the left, the 'Contrast' panel is active, displaying a contrast ratio of 8.59:1. Below this, it shows 'Normal Text: Sample' and 'Large Text: Sample', both with 'Pass' status for AA and AAA standards. The main content area displays a search result page titled 'Produktliste (søkeresultat)'. A table lists products with their nutritional values per 100g. The table has columns for Product, Product type, Product category, Energy (kJ), Energy (kcal), Fat (g), Saturated fat (g), Carbohydrates (g), Fiber (g), Protein (g), Salt (g), and Producer. Each row includes a 'Legg til favorittliste' button.

Produkt	Produkttype	Produktkategori	Energi (kJ)	Energi (kcal)	Fett (g)	Mettet-fett (g)	Karbohy-drater (g)	Hvorav-sukkerarter (g)	Fiber (g)	Protein (g)	Salt (g)	Produsent	Legg til favorittliste
Coop Vegetardag Burger Bønner og Erte	Kjøttstatninger	Plantebaserte burgere	523	125	5.5	0.6	9.2	2.2	6.1	6.7	1.6	https://matlevering.coop.no/	Legg til favorittliste
Coop Vegetardag Soppburger	Kjøttstatninger	Plantebaserte burgere	471	113	4.9	0.8	6.9	0.4	5.4	7.6	1.8	https://matlevering.coop.no/	Legg til favorittliste
Coop Vegetardag Burger Rødbeter og Honning	Kjøttstatninger	Plantebaserte burgere	489	116	2.6	0.3	13.0	7.3	5.5	7.1	1.4	https://matlevering.coop.no/	Legg til favorittliste
Coop Vegetardag Juicy Burger	Kjøttstatninger	Plantebaserte burgere	977	235	14.0	12.0	4.6	1.7	0.0	20.0	0.8	https://matlevering.coop.no/	Legg til favorittliste
Folkets Veggi burger	Kjøttstatninger	Plantebaserte burgere	412	98	2.7	0.3	10.7	6.5	5.8	4.9	1.1	https://meny.no/	Legg til favorittliste

Figure 4-48 Fulfilling the contrast errors standards.

5 Discussion:

In the second part of the result section (4.2), WAVE did not highlight any kind of errors and alert messages in the proposed web-based application. It means an application may comply with all the WCAG (web content accessibility guidelines) but it does not mean it is truly accessible. WAVE is just to find out the possible WCAG errors and figure out how we can overcome those errors. Truly accessible means the proposed web-based application has not any accessible errors and issues, it can only be possible and predict after carefully automated and human evaluation because in web accessibility evaluation there are two aspects technical such as fulfill conformance levels and guidelines and non-technical like testing against user's abilities and expertise in different situations. (Abou-Zahra, 2008). WAVE is just providing the optimal accessibility and possibility to fulfill the missing conformance success criteria levels and to overcome highlighted WCAG errors. It also highlights the potential effect of those errors on different kinds of assistive technology users. There were different errors, but most of them related to the same group of errors. 36 out of 47 errors were related to the missing form label and in the alert messages section 11 out of 16 related to missing fieldset legend. The second most common type of errors was related to contrast errors 7 out of 47.

These errors and alert messages are removed by using the appropriate and specific form label concerning their legend attributes with specific color contrast. By not using these attributes, contrast and form labels it may cause difficulties for a different kind of assistive technologies and low vision users, as researcher believe if we do not overcome the accessibility and user-friendly interface issues in web-based applications then it will be difficult to promote health literacy and nutrition information among the users (Bickmore & Paasche-Orlow, 2012). Secondly according to WHO (World Health Organization) research data 285 million people are visually impaired. Out of this 285 million people, 39 million are blind and 246 million people have a low vision problem. In the same way, WHO also mentioned more than 1 billion, 15% of the world population is facing different kinds of disabilities. This trend is prevailing both in developed and underdeveloped countries. Ageing is also one of the alarming aspects in the accessibility point of view. According to the (UN) **United Nations World Population Ageing 2019** report 1 out of 11 people in the world is over age 65 and it will be 1 out of 6 in 2050. Now there are 703 million people are over age 65 and this number will be projected to double 1.5 billion in 2050.

This huge amount of population cannot be ignored in terms of accessibility of the ICT environment because older and disabled people can be benefited by making accessible and user friendly-interface devices in their real life.

5.1 Universal Design

Web-based applications are useful to interact and diffuse health literacy and any other kind of useful information among people. Therefore, it is essential to ensure the accessibility of these applications. So that it can be useful to as many people as possible regardless of individual abilities and disabilities under different scenarios and situations. To tackle this problem and make web-based applications accessible to the individual, organizations and governments internationally W3C (World Wide Web Consortium) developed the WCAG (Web Content Accessibility Guidelines) with the cooperation of experts and organizations. The purpose of these guidelines to lay out the standards of the Web content to overcome the accessibility issues for different kinds of disabled and impaired persons. These are technical guidelines for web developers, designers authoring tools, and evaluation tool developer. These guidelines help out different organizations set out technical standards for web accessibility.

These guidelines also lay down the foundations to meet the “Universal Design” approach. The term *“Universal Design”* is defined as *“the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design”* by the Center for Universal Design at North Carolina State University (Connell et al., 1997). There are further 7 principles of Universal Design.

- 1) Equitable Use
- 2) Flexibility in Use
- 3) Simple and intuitive Use
- 4) Perceptible Information
- 5) Tolerance for Errors
- 6) Low Physical Effort
- 7) Size and Space for Approach and Use

The principles expressed the author's conviction that basic universal design principles extend to any area of design, including built environments, products, and communications, and also

help the consumers and designers to understand the characteristics of useful design solutions (Case, 2008). As per the proposed web-based application concern, we try to meet the Universal Design approach by using the WCAG and conformance success criteria levels and try to solve different accessibility issues found through WAVE analysis. Most of the errors and issues were related to the contrast and usage of different attributes that facilitate the users of assistive technologies.

5.2 Rules and Regulations

To emphasize the usage of the Universal Design approach and its principles, there are several regulations declares by different organizations and governments to overcome the accessibility issues. United Nation CRPD (Convention on the Rights of Persons with Disabilities) Article 2 “Definition” defined the usage of Universal Design in all aspects of products, environments, programs, and services, it also enforces the usage of assistive technologies for particular groups of people to overcome the accessibility and disabilities issues. In CRPD Article 9 “Accessibility” addresses the states parties and directs them to take the appropriate measures to ensure persons with disabilities have the same rights as normal persons in terms of the physical environment, transportation, information communication including communication technologies and systems (Márton et al., 2013).

There are some other articles of CRPD which are relevant to the Universal Design of ICT.

- 1) Article 9 Highlights the importance of independent living and be a part of the community regardless of disability and impairments
- 2) Article 21 Emphasize the freedom of expression and opinion and also highlights the importance of accessing the information.

These two articles are directly related to web-based applications, like article 9 stated being independent and be a part of your community regardless of disabilities and impairments. We complete most of our daily life routine work by using web-based applications, like online shopping, buying tickets, exploring google maps to find out the restaurants, social society clubs, etc. If these web-based applications are not accessible for disabled persons, then it will be difficult for them to complete their everyday tasks. Article 21 also highlights the importance of being independent and participate in the community by directly emphasizing the importance of accessing the information, and today most of the information is delivered

through web-based applications. That's why it is important to consider the accessibility in designing and developing web-based applications.

In the same way, In Europe, the Act with the name of **European Accessibility (2015)** enforces intending to *"improve the functioning of the internal market for accessible products and services by removing barriers created by divergent legislation"* (Easton, 2013).

In America, there is a law with the name of **US Rehabilitation act section 508**, which states that federal agencies will make sure that all their electronic and information technology (EIT) will be accessible, usable, reachable, and operable for all kind of end-user despite their disabilities and any kind of impairments (Olalere & Lazar, 2011).

In Norway, there is a rule with the title of **Regulation for universal design of information and communication technology (ICT) solutions**. Article 1 defined the purpose of the regulation by make ensure the usage of Universal Design in terms of information and communication technology. In article 4 regulation defined the requirements for the design of ICT solutions by stating the minimum requirements and compliance of the net-based solution(Decree, 2013).

"Net-based solutions must as a minimum be designed in compliance with standard Web Content Accessibility Guidelines 2.0 (WCAG 2.0) NS/ISO/IEC 40500:2012 at the A and AA level, with the exception of guidelines 1.2.3, 1.2.4 and 1.2.5, or with corresponding standards"

Article 11 of this regulation stated the enforcement date 1st July 2013. It also makes sure the enterprises must make new ICT solutions according to the Universal Design at the latest 12 months after the enforcement of this regulation. Existing ICT solutions must be converted to the Universal Design approach till 1st January 2021(Decree, 2013).

Through all these rules and regulations one thing is clear that the new and existing ICT applications fulfill the accessibility requirements for their long-term existence and compete in the international markets by using the WCAG and conformance success levels criteria. Therefore, our proposed web-based application is fulfilling the requirements of WCAG and conformance success levels criteria as well.

5.3 Checking Accessibility of Web-based Application

Despite physical disability or other limitations, accessibility is one aspect of web quality that ensures the site is efficient and easy to navigate and its structure is understood (Accessibility, 2006). The accessibility does not apply to people with physical disabilities who choose to use the internet, but also to people with a wide range of experiences, interests, and needs.

Individuals with unstable Internet connections, temporary or age-related problems, and various technical expertise (browser style, screen sizes, etc.) are also included (De Andrés et al., 2010). In other words, website accessibility issues go beyond the needs of people with disabilities. In addition to the increased browsing experience, an accessible website also allows companies to upgrade their website effectively (Hofstader, 2004), provides better web visibility, and increases traffic on their site account their individual needs and the context in which they find themselves (Russell & Rulzion, 2005). To check the compliance of the web-based application with the WCAG (web content Accessibility Guidelines) and conformance levels of A (lowest), AA (mid average), AAA (highest), there are several automated accessibility analysis tools. Although there is a possibility for manually checking the WCAG and conformance levels of A, AA, AAA it is a very costly and time taking process (Centeno et al., 2006).

In this short thesis, the proposed web-based application analyzed by using the WAVE (Web Accessibility Evaluation Tool), although there were several other evaluation tools as well. The choice of the evaluation tools depends on the required criteria such as conformance guidelines and conformance level required (Al Mourad & Kamoun, 2013). The reason for selecting WAVE as an accessibility checker, it can be used by adding the extension in google chrome and it is free to use. While other accessibility tools required to add the URL of the website in their proposed online checker search bar. As per the proposed web-based application concern, it is not deployed, and it is run on the localhost. Secondly, WAVE analyzes the accessibility with WCAG 1.0, 2.0 and conformance level of AA, AAA, which are requirements to fulfill the national and international rules and legislations.

6 Conclusion

Accessibility is one of the core aspects of a web-based application. It can be enhanced by adopting and utilizing the Universal Design principles and WCAG (web content accessibility guidelines). To promote nutritional information and plant-based food products among the public, a web-based application can play a vital role.

In this short thesis, to enhance the accessibility of the proposed web-based application an automated analysis of the web-based application is conducted to find out the potential WCAG (Web Content Accessibility Guidelines) errors and alert messages. This analysis is conducted by using WAVE (Web Accessibility Evaluation Tool), the reason for using this tool, first it is free and can be used as a Google Chrome extension for localhost applications as well while other automated tools required to put the URL of the website in their specific search bar for conducting analysis. As far proposed web-based application concern it is not deployed, and WAVE can run on it. Secondly, it analyzes by using the WCAG 2.1 success criteria guidelines which are also the requirements to meet the international and national rules and regulations. There were 47 errors and 16 alert messages. Those were related to the contrast errors and missing essential attributes that may become problems for different assistive technology users and low vision people. In the second part of this analysis, these errors and alert messages are removed by using the specific attributes and contrast to fulfill the WCAG and conformance success criteria levels.

Overcome these errors and alert messages in the proposed web-based application help to diffuse nutritional, health-literacy, and plant-based food products among people. It can also be used in the digital marketing and also provides the platform to share the correct pieces of information of market available plant-based food products.

The quality and the accessibility of the proposed web-based application can be enhanced further by taking the user testing. So far, this web-based application is not testing against individual capabilities, expertise, and different assistive technologies. By testing the web-based application with different age group users and considering the different assistive technologies the accessibility of the application will be enhanced and it also provides the chance to compare the performance of the automated online website accessibility checker tools with the user testing.

Reference:

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