Application of Food Recommender Systems to Reduce the Animal-Based Product Consumption on Young Adults

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Abstract

The livestock sector has grown into being the main Climate Change driver of the century and therefor the world's main target according to organizations such as the United Nations. This is caused by the unsustainable amount of natural resources required for farming and agriculture such as global water consumption, massive land use, and final greenhouse gas emissions. Growing technologies such as food recommender systems are being developed in the pursuit of sustainable product consumption, and are seen as an efficient tool for raising awareness on topics like health. These food recommender systems have proven to generate a positive impact on consumers, especially young consumers, by adapting to their context and preferences. This study will explore how a food recommender system can help young adults reduce their consumption of animal-based products and make them sustainably aware of the environmental impacts of their consumption. A problem definition and user study will be carried out using Design Thinking tools such as questionnaires and interviews with both consumers and experts to gain a deep understanding of the problem. Finally, the proposed prototype will be tested according to its structure, look & feel, and implementation and will be tested for the concept, usability, and final A/B testing to prove theory and functionality. As a result of this study, the first foundations are laid to achieve a data-driven application that will help users to make purchasing decisions that benefit both themselves and the environment as they continue on their way to reducing their consumption of animal products.

Keywords: Livestock sector; Food Recommender System; Animal-based products; Awareness; Supermarkets; Flexitarian Diet.

1. Introduction

What is the problem?

The livestock sector has become the main accelerator of climate change in the 21st century. Due to the continued need for natural resources such as land, water, and energy fuel, we are causing the emission of harmful greenhouse gasses (GHGs), the destruction of our rainforest for agriculture and crops, and the pollution of clear water for animals and irrigation. (Djekic, 2015).

The demand for livestock supply has tripled in the last 50 years (OECD and Food and Agriculture Organization of the United Nations, 2021) thanks to the evolution of production technologies, the effect of population growth, and a rise in the western social economy (Sanchez-Sabate & Sabaté, 2019). In countries such as the United States, Australia, and Argentina, animal-based products (ABPs) consumption is increasing every year by 100 kg of meat consumed per person (The World Counts, 2021). To satisfy this demand, the production makes use of about 80% of the Earth's terrestrial fields for agriculture and cultivation, and up to 70% of the world's clear waters, according to Our World in Data (Ritchie, 2017). The continued growth of these practices has led to deforestation, a threat to biodiversity, induced a global monetary impact (Springmann, 2018), and crucially, emissions of 14.5% of all human-generated GHGs (United Nations Food and Agriculture, 2018) making the livestock sector the leading cause of global climate change in the 21st century according to the UN Environment Programme (2018).

What is being done about this?

In the last decade, governmental agreements such as the *Paris Climate Agreement* (PCA) of 2015 were conceived by the United Nations to fight climate change (DeConto et al, 2021). However, despite the increasing implementation of strategies and technologies by the livestock sector, such as the provision of fat additives to ruminants to reduce methane (CH^4) or the conversion of abandoned land into forests (afforestation) to achieve zero CO^2 targets (Ridoutt, 2021), it is not yet known whether these new technologies alone can mitigate these GHGs emissions in the future (Hedenus, 2014).

As one of Europe's leading exporters of animal products, the Netherlands is experiencing a climate change crisis due to high levels of nitrogen (N) from its livestock

farms (OECD Economic Surveys: Netherlands, 2021). These alterations in the environment, together with concerns in public health such as the prevention of cancer, have been the principal causes of food consumption changes in the country (Weinrich, 2019). Different studies have proven that the Dutch community has begun to consume more meat substitutes as opposed to other eastern European countries (Weinrich, 2019; Kemper & White, 2021). However, Weinrich (2019) also concluded that information on food alternatives remains an obstacle to encouraging certain consumers. For these reasons, the Netherlands will be the focus of this study.

Who does this affect?

The consumption of ABPs has both biophysical and biocultural factors that alter the way we consume and the choices we make around it (van Vliet et al, 2020). Some theorists are trying to emphasize not only the importance of the biophysical well-being of humans but also of the environment in order to achieve a natural balance (Dietz, 2003). They defend the need for new systems to approach and manifest the importance of environmental well-being to subsequently make better individual decisions (Dietz, 2003).

These decisions are not limited to a certain demographic. To date, several studies have examined the links between ABPs consumption and personas. For instance, a German study investigated the correlations between ABPs consumers and their personality traits and found that ABPs consumption is particularly related to older, politically conservative male participants with lower education as opposed to younger, higher educated females (Pfeiler & Egloff, 2019). According to the study, even though sex was the least correlated variable, age and ideology seemed to play a bigger role in the way participants took care of their health and the environment. That is why this study will focus on young adults' consumption habits due to their continuous transformation and adaptation.

How can a Food Recommender System help?

Given the significance of human consumption habits in the livestock supply chain, recent technological advances in food production and consumption provide consumers with new perspectives on ABPs. For example, the use of three-dimensional printing (3DP) allows the creation of personalized foods both vegetables and fake meat. This favors bespoke nutrition by avoiding the use of animal flesh, reducing the carbon footprint, and provides a potential future solution for world hunger (Dick, Bhandari, Prakash, 2019). In spite of this

existing technology's limitations with production or direct-to-consumer accessibility, advancements like these validate the relevancy of exploring new means for people to consume ABP.

There is an opportunity to use an RS to help provide users with a new perspective on the way they consume food product and ABP. Since its development in the 1990s, recommender systems (RSs) have facilitated users' online access to products from clothes to cars in an ordered and individualized way (Joseph Konstan, John Riedl, 2012). RSs predict the probability of a product being selected by a certain consumer (Zhang et al., 2019, Ricci et al., 2011). In the case of food, users make decisions about it on a daily and contextual basis (Elsweiler, Hauptmann, & Trattner, 2012), giving RS great power to influence these decisions (Viniski et al, 2021). Food Recommender Systems (FRSs) have proven to be a key solution for healthy choices by raising health awareness among users favoring certain products' consumption over others (Elsweiler & Trattner, 2017; Freyne, Berkovsky & Smith, 2011). Thanks to implementations such as content-based filtering (CBF) or context-aware filtering (CA) (Elahi et al, 2015), recommendations can be even more personalized by better identification of the user's likes, product ratings, and/or the link to health-conscious statistics (Elsweiler & Trattner, 2017).

The prototype developed following this research ultimately aims to mitigate the environmental impact of the livestock sector by recommending sustainable alternatives on users' shopping lists that will lead them to reduce their ABPs consumption. Therefore, this study seeks to answer the following question: *How can a Food Recommender System help young adults in the Netherlands reduce their ABPs consumption by making them more aware of the environmental impacts of ABP production?*

2. Theoretical Framework

2.1 Livestock industry: environmental effects and consequences.

To survive a climate change wave 2.5 million years ago, our bodies evolved to be capable of eating meat, and we adopted it as part of our diet, culture, or religion (Bassett, 2020). Prior to

the Industrial Revolution in the late 18th century, , farming technology was little more than manpower, and food production was small-scale and inefficient. With an exponentially growing world population and a global demand for meat exceeding more than three times in the last 50 years, rapid agricultural industrialization has bequeathed industry malpractices such as deforestration, overexploitain of grassland, species extinction, and multiple other biodiversity threats which continue to exist today. (Chiles & Fitzgerald, 2016) (Ritchie & Roser, 2019). The increasing global demand for meat In fact, due to the rapid growth of the population, the livestock sector, together with organizations such as the *Organization for Economic Co-operation and Development* (OECD) and the *Food and Agriculture Organization* (FAO) of the United Nations, is implementing new and faster ways of production focused on the improvement of breeding and feed formulas to increase animals' natural growth rhythm. It is expected that 374 Mt of meat will be produced by 2030 (OECD and Food and Agriculture Organization of the United Nations, 2021), resulting in an even greater demand for natural resources.

This increased exploitation of natural resources by the livestock sector negatively impacts our water quality and supply, land usage, and air quality via the emissions of GHGs. The inefficient process of transforming natural resources into meat products has positioned the meat industry as the primary driver of climate change (Ilija Djekic, 2015). The GHGs emissions associated with livestock are mainly carbon dioxide (CO^2), methane (CH^4), and nitrous oxide (NO^2), and are emitted throughout the three different stages of the agricultural process (Petrovic et al, 2015). These are the pre-farm production and goods transportation, the on-farm process where GHGs are primarily produced by the animals themselves, and post-farm processes, including the slaughtering, refrigeration, and distribution of products (Petrovic et al, 2015). Approximately 7.1 gigatons of CO^2 are emitted per year (FAO, 2017).

Today, 50% of land globally is used for agriculture, of which 80% is used to keep livestock even though it represents less than 20% of the total world's supply of calories (Ritchie & Roser, 2019). Regarding the production of beef, the Brazilian National Institute of Space Research (INPE), announced that 8.2 million hectares of the Amazon rainforest have been cleared for cattle since 2009, with more than 70% of the deforestation in this area being due to crop production for farms (Brice et al, 2022). Additionally, an estimated 4.387Km^3 of water is required to produce livestock feed (Heinke et al, 2020), meaning that to produce 500 grams of beef, approximately 8.000 liters of water are needed (Foodprint, 2020). Finally, the

emission of GHGs increased by 10-12% in agriculture with meat production accounting for three-quarters of the total (Thornton, 2019).

Despite studies showing evidence of climate change since the 19th century (Smith & Balmford, 2020), the solutions proposed by the European Union are relatively recent (Hovia, Sundrumb & Thamsborg, 2003). In the PCA of 2015 to 2020, 196 countries agreed, planned, and created their climate change plans intending to reduce up to 40-50% of their GHGs emissions by 2030 (UNFCCC, 2022). Nevertheless, food experts such as Bruce Friedrich, executive director of The Good Food Institute, confessed during an interview that climate change strategies, such as the PCA, will not be possible unless there is a significant reduction in global consumption of ABP and proposes a shift to a plant-based diet as our ultimate solution in the fight against climate change (Giliver, 2021).

2.2 Animal-based product consumption: What influences young adults' consumption?

The world needs a shift in its food consumption habits in order to achieve the goal of an 80-95% reduction in GHGs emissions set by the PCA (Spangenberg & Lorek, 2019). When we talk about animal foods, as van Vliet et al (2020) describe them, we justify their intake with their nutritional benefits, taste, and cultural value. Alternatives to animal-based foods are becoming increasingly popular among consumers, with their aim to provide the market with healthy, affordable, and even meat-mimic alternatives (van Vliet, Kronberg & Provenza, 2020). However, some studies show that there is also a 65-90% failure rate among these alternative foods (Weinrich, 2019). According to Weinrich (2019), the reasons for failure vary from a lack of understanding among users, lack of market orientation and research, or food neophobia among consumers.

The reduction of animal-based foods can generate positive impacts on the environment and even on health, thus leading more people, especially young adults, to opt for new diets (Kemper & White, 2021). Of these new diets, the best known are *vegetarianism*: intake of plant-based products (PBP) as well as dairy and cheese, and *veganism*: not consuming or purchasing anything that comes from an animal. But there are also others such as *pescetarianism*, which involves not eating meat but only fish and plant-based products, *reducetarianism*, where a person decides to reduce their intake of animal products but not

eliminate them, and finally, *flexitarianism*, where a person mostly follows a vegetarian diet but occasionally allows themselves to eat animal products (Kemper & White, 2021). After their research on young adults' consumption, Kemper and White (2021) concluded that this target group is more likely to shift to a flexitarian diet both due to individual concerns (health, price, or discomfort) as well as altruistic motives such as environmental or ethical issues. However, these are not the only determining factors. Neufeld et al (2022) define any decision that connects the consumer with food as the *food environment*. Here, consumers make decisions about their purchase, preparation, and intake. In the case of young adults, these touchpoints are followed by contextual questions such as, “Is there stock?”, “Can I afford it?”, “Do I really want it?” or, “Is it good for me?”. On a bigger scale, these questions will be also altered by the social environment (family, friends), physical environment (individual), and macro systems (i.e social media, cultural rules) (Neufeld et al, 2022).

The literature shows that the factors involved in young adults’ consumption are wide-ranging. However, some of these studies have just emphasized the assignment of plant-based diets among omnivores, and others have failed to find the right motivations to achieve ABPs reductions (Dakin et al, 2021). Finally, almost none of the other studies have looked at the sustainability awareness perspective but only at health-aware proposals as a major factor in reducing meat consumption (Kemper & White, 2021; Sanchez-Sabate & Sabaté, 2019). This sustainability awareness is the understanding of the word "*sustainability*" for a subsequent knowledge of *how* to apply sustainability in our daily lives (Garbie, 2015). According to Garbie (2015), this understanding can reach the public and be made possible through knowledge and data, and in conclusion, awareness.

2.3 Food chain and customer awareness.

Focusing on Western countries, ABPs consumption is considered not only an essential part of our diet and human well-being (biophysical theory) but also an economic-political trade in which it is believed to be related to the growth of our cultures and the bonding of our societies over time (biocultural theory) (van Vliet et al, 2020). When we make decisions about the biophysical well-being of humans, we sometimes forget to take into account the

biophysical well-being of the environment (i.e. the well-being of other animals, plants, and ecosystems) and how our consumption decisions affect them in order to achieve a natural balance (Dietz, 2003). However, theorists differ on the level of importance to be given to each. Some prioritize human well-being and individual decisions over anything else unless that affects our well-being (*Anthropocentrism*), and others defend that ethical choices about environmental well-being should carry more weight (*Ecocentrism*). The public receives environmental information from a variety of sources, leading to uncertainty, differing interpretations based on individual biophysical values and leading to rash decisions on the ethical consumption of ABPs. Dietz (2003) again highlights the need to develop systems that consider the sustainable-awareness perspective to make better decisions about our consumption habits. The right decision can be made only if the sustainable-awareness perspective is considered.

Despite the large number of studies highlighting the need for a dietary shift from meat to PBP, surprisingly just a few have attempted to investigate the relationship between food consumption and awareness to make this a reality (Talbot et al, 2020; Beardsworth & Keil, 1991; Wolstenholme, 2020; Pfeiler & Egloff, 2019). The researcher Barbara McDonald (2000) carried out a psychological study to understand how people learn about veganism and how they convert to it. In her study, she explains Mezirow's Transformative Learning Theory, which states that in order to make a change such as eating habits, it is necessary to go through a transformation ranging from learning, analysis, reflection, and action to become critical thinkers and learn how to handle uncertainties with patience (Brinson, 2021). In her study of 12 vegans and/or vegetarians, Barbara wanted to understand the conversion process, highlighting that these participants were unaware of the reality of the meat industry before their "*catalytic experience", i.e. their conversion*. Barbara concluded that participants were more likely to make conscious and sustainable decisions when aware, in this case, of the animal cruelty behind their consumption (McDonald, 2000).

Other studies also highlight the lack of awareness among consumers of the impact meat consumption has on our environment, with some outlining certain biases such as taste when it comes to deciding to reduce meat or not (Hartmann & Siegrist, 2017; Perino & Schwirplies, 2022). Some argue that these reasons go back to the biophysical factor we seemed to have inherited (Schwirplies, 2022), and others add the lack of empathy or disgust toward killing an animal for food amongst omnivores as opposed to vegetarian people

(Rothgerber, 2001). That is why this research will aim to study the effect awareness has on consumers when it comes to reducing their ABPs ingest using a data-driven loop.

2.4 Mezirow's Transformative Learning Theory: Contribution for a possible solution.

People move through transformations. These can change one's life through a change in understanding of oneself or the world (Schnepfleitner & Ferreira, 2021). Or it can happen through the accumulation of gradual knowledge thus changing your view of something (Schnepfleitner & Ferreira, 2021). With his *Transformative Learning Theory* (TLT), Mezirow wanted to question and evaluate how his deep-seated values related to the outside world, as well as awareness (Schnepfleitner & Ferreira, 2021). In his years of study, Mezirow defined 10 steps that a person goes through on his or her way to this transformation. These are "*1. a disorienting dilemma; 2. self-examination; 3. a critical evaluation of assumptions; 4. recognition of a connection between one's discontent and the process of transformation; 5. exploration of options for new roles, relationships, and actions; 6. planning a course of action; 7. Acquisition of knowledge and skills to implement one's plan; 8. Provisional testing of new roles; 9. Building competence and self-confidence in new roles and relationships; 10. Reintegration into one's life based on the conditions dictated by the new perspective"* (Schnepfleitner & Ferreira, 2021).

The conversion that many follow in their crusade towards dietary change varies and is context-dependent, i.e. it differs on personal circumstances, culture, and/or knowledge (Elsweiler & Trattner, 2017). However, in most cases, it seems to have its origins in the emotional, ethical, and moral side of being human (McDonald, 2000). The discovery of both the different practices carried out on animals and the consequences of their consumption (moral and ethical, environmental, health, economic) (Beardsworth & Keil, 1991), led many consumers to change their habits. In any case, this transformation always seemed to follow the foundations of Mezirow's steps, starting with a dilemma, continuing with awareness, followed by attitude, and ending with social or personal motives that contribute to the shift to plant-based diets (Salehi, Carmona, Redondo, 2020). As designers, these attitudinal changes in consumers must be distinguished according to their dietary styles or their methods of adaptation to them (Salehi, Carmona, Redondo, 2020).

2.5 Recommender Systems.

Since their emergence in the 1990s, RSs have taken over the field of commerce and its content by providing personalized recommendations to individual consumers for a wide range of products. (Konstan & Riedl, 2012). The author Shubham Kumar (2021) defines an RS as a subclass of information filtering systems that seeks to predict the rating or the preference a user might give to an item (Kumar, 2021). Simply put, an RS predicts the probability of a product being selected by a certain consumer (Zhang et al., 2019, Ricci et al., 2011). With the creation of the web, the number of consumer platforms increased, complicating the way humans made decisions due to the wide variety of products to choose from (Melville & Sindhwani, 2010). Recommender systems help turn this new opportunity into a profitable asset for any type of online business (Viniski et al, 2021).

There are three main types of RS: collaborative filtering (CF), content-based filtering (CBF), and hybrid filtering (HF) (Melville & Sindhwani, 2010). CF It analyses the data of all users' interactions, purchases, or preferences and compares them with each other, creating a user-to-user relationship and a final recommendation based on the collective opinion. In contrast, we find CBF, in which recommendations to users are not strictly based on the collective's interactions but on the comparison of item characteristics (item-to-item) to match user preferences (Melville & Sindhwani, 2010). The algorithm analyzes the product characteristics such as location, profiles, or descriptions to make recommendations. HF combines elements of both CF and CBF. The decision as to which type of RS is most appropriate will be determined by the data available and the format of the data (Viniski et al, 2021).

These algorithms have the function of improving the user experience (UX) of online services, avoiding information overload, and personalizing the content provided (Shin, 2020). Yet, some researchers also raise the issue of the accuracy of recommendations for maintaining UX over time (Lawrence et al, 2001; Jorge et al., 2016). Donghee (2020) argues that customer preferences are not static and may evolve, therefore he asserts that RSs should be aware of these changes, detect them and be able to adapt to users accordingly. Another problem we may encounter when implementing RS would be the rapid and continuous addition of product data, which makes it difficult for the algorithm to quickly examine the

new product and compare it to other items or changes in user preferences (Lawrence et al, 2001). Despite these algorithm constraints, RSs have proven in multiple case studies (Rohani et al, 2020; Alsalemi et al, 2019; Rajani Shankar Sadasivam, 2016) to be an effective tool when combined with awareness and personal transformation objectives thanks to the motivational push they generate in users on their journey toward mental health improvements, use of energy sustainable practices, or the tailoring of health behavior changes respectively.

2.6 Food recommender systems. Application of content-based and context-aware filtering on FRSs.

The applications RSs have nowadays are as broad as the e-commerce market (Viniski et al, 2021). However, when it comes to recommendations on food, the game changes. The frequency with which users make food-based decisions are daily and vary based on the situation of the user (context-dependent) (Elsweiler, Hauptmann & Trattner, 2012). A study conducted by Elsweiler and Trattner (2017) had the purpose to set the first foundations on how FRSs can contribute to healthier lifestyles, in this case, by promoting cooking inspiration. These health-aware FRSs are a growing concept for which different researchers have tried to establish a basis due to the lack of research on FRSs and the number of variables needed in their algorithms (Toledo, Alzahrani & Martínez, 2019). In their research, Elsweiler and Trattner detected some challenges when developing FRSs that are context-dependent on the user such as individual health, culture, religion, dietary lifestyle, or the individual mood at that moment.

The main type of RS utilized for FRSs is CBF to tailor to the individual user’s needs (Elsweiler & Trattner, 2017). For instance, Freyne & Berkovsky (2010) made recipe recommendations based on the ingredients the user had rated positively. That is, if the user likes tomatoes, the RS predicts the user will like recipes containing tomatoes. An advantage of implementing CBF, is that the recommendation will be based on the individual user's likes and preferences instead of the community as with CF, assuring a personalized, health-aware recommendation (Toledo, Alzahrani & Martínez, 2019). Following the exploration of CBF to address the limitations of FRSs, researchers propose a shift toward context-aware filtering (CA) (Elahi et al, 2015). CA allows for additional variables to be introduced into the

algorithm, such as those mentioned above, to better identify user likes, product ratings, and the link to health-conscious statistics (Elsweiler & Trattner, 2017).

The deployment of RS used for FRSs continues with knowledge-based recommender systems (Thi Ngoc Trang Tran et al, 2015), sequential recommender systems (Hyun et al, 2020), group-based methods (Elsweiler & Trattner, 2017; Thi Ngoc Trang Tran et al, 2015), or Interest Sustainability Prediction (Hyun et al, 2020). In summary, these other tools are variants or extensions of the main RS types and their use differs according to the database variables, products recommended, or context needs. For this research, we will focus on CBF and CA to define the variables of the users' context and develop a prototype that can be adjusted to the corresponding awareness of that context.

4. Methodology

Introduction

This study aims to better understand the current situation in the livestock sector concerning its environmental consequences and then develop a user-friendly, data-driven solution to help young adults on their way to reducing their ABPs consumption. This mobile-based prototype ultimately aims to mitigate the environmental impacts by recommending sustainable-aware alternatives to users. In order to design and develop a user-friendly solution, we will follow the Design Thinking (DT) process, a methodology implemented in the late 2000s that consists of a human-centered approach to innovation (Tim Brown & Jocelyn Wyatt, 2010). This methodology follows the project phases of research, empathy, ideation, and implementation to develop an optimal solution for the defined problem statement.

1. RESEARCH

Data collection users

The data collection includes the sourcing of and quantitative data from a user survey, and preliminary user and expert interviews. Users were chosen according to the selected demographic (young adults located in the Netherlands) while experts within the relevant project fields of nutrition, farming, and supermarket commerce. (nutrition, supermarkets, and farming). The data collected from these interviews will be strictly qualitative and will be represented in the form of graphics, or as highlighted quotes on the results page. The survey will consist of 12 multiple-choice questions representing the quantitative data, and 6 short questions for qualitative data from 22 participants (Appendix B, survey 1). This method was selected due to the quick and efficient way of reaching multiple users in a shorter time and therefore, obtaining a good number of responses to validate the research question (RQ). The data collection tool used is *Google Forms*. *Jupyter Notebook* will then be used to clean and analyze the data by turning the quantitative data into visual graphics (Appendix D).

Data Collection Python Prototype

The data collected for the RS prototype consisted of the product scraping from Albert Heijn (AH) website. Using the *Beautiful Soup Library* for web data collection on Python, the code developed will scrape the links from the desired website (in this case, www.ah.nl), go through the data on the website, and finally collect the data needed to turn it into a CSV file that will later function as database (Thomas & Mathur, 2019). One of the advantages of this approach is the possibility to collect data from multiple pages at the same time, to collect different data from the same page simultaneously, or to compare different sources automatically (Mitchell, 2018). Web scraping has been chosen primarily because of the lack of an Application Programming Interface or API, a software that allows instantaneous connection and exchange of data (IBM Cloud Education, 2020), to obtain the desired products' data. These products have been selected by 'keyword' (type of food) with the intention of obtaining a wide selection of products by search word. The keywords are: *meat, fish, chicken, nuts, vegetables, fruit, legumes, dairy, cold meat, salad, pastries, cheese, pasta*. Together with its variables: *name, description, summary, ingredients, quantity, price, keyword*, and finally the preferred *diet*.

Data collection management

The General Data Protection Regulation (GDPR) defends the protection of individuals' data regarding its collection, usage, and possible further trade (European Parliament and Council, 2016). In order to guarantee the security and protection of the participants, all participants were given a *Consent Form* (Appendix A) beforehand with the reasons for their data being collected and with the promise of being anonymous throughout the research. Participants were asked to complete the form prior to proceeding with the next steps.

2. EMPATHY

Interviews

The interviews conducted will be divided into *user interviews* and *expert interviews* depending on the interviewee profiles. The data collected through these interviews will be necessary for two reasons: first, to understand the position of the target group in this ecosystem and understand their worries, needs, wants, and the corresponding jobs-to-be-done (Ulwick, 2017). Secondly, the expert interviews will provide professional

input on our research question by digging deeper into the topic and assuring the feasibility of the solution proposed.

User interviews: The focus group consisted of young adults between 18 and 30 years old located in the Netherlands. Participants of the study were required to at least have a legal residence permit to reside in the country. This group has been selected for two reasons: firstly, because of the rising awareness and exposure of younger generations to new ABPs' ways of consumption according to our biophysical and biocultural factors. And secondly, the continuous transformation interviewees experience allows us to initiate a debate on ABPs consumption. These participants collaborated voluntarily and were mostly reached out through the immediate circle of the researcher through HU University and student accommodation centres. . There was an active initiative from the researcher to diversify the sample of participants by sourcing volunteers of different genders, cultural backgrounds, religions, and ethnicity. The common characteristic of the participants is their relationship with ABPs and the aforementioned plant-based movements in the theoretical framework, their concern about climate change, and their exposure to technological solutions. The chosen language of communication between the researcher and interviewees was English.

In the first interviews, five consumers were interviewed. In this case, the type of interview followed is what Wilson (2013) calls a *semi-structured Interview*. These interviews follow a script of questions around a topic but allow both the interviewee and the interviewer to generate conversation, comment on different topics, and thus, obtain diverse points of view (Appendix C, Interview 1). The questions focused on the level of knowledge of the interviewees regarding ABPs consumption and the environment, the relevance of the topic for them, solutions they might encounter, or their journey toward sustainable consumption.

Expert Interviews: Three different fields of expertise were considered to validate the feasibility of the idea, therefore expert interviewes were held witha nutritionist, supermarket manager , and farmer. These experts were also located in the Netherlands and were contacted both via the LinkedIn platform and through personal contacts. In this case, the type of interview was a *Structured Interview* due to the planning and management of the script and the time required beforehand (Appendix C, Interviews 2,3 & 4).

3. IDEATION

Prototype

RQ: *How can a Food Recommender System help young adults reduce their animal-based product consumption and make them more aware of the environmental impacts of ABPs production?*

Food Recommender systems have proven to be good allies in the quest to raise consumer awareness, for instance, on health and environmental issues, especially through applications (Elsweiler & Trattner, 2017; Freyne & Berkovsky, 2010). This final prototype will consist of a mobile application that connects users with local supermarkets and generates recommendations based on 1) the user's diet preferences (CA), 2) the interaction of the user with the different products and 3) the characteristics of the products (i.e ingredients, summary, description, and price). The user will continue to be able to do their grocery shopping but with the support of a FRS that will turn their product selection into sustainable alternatives according to their diet preferences *i.e Flexitarian, Pescetarian, Vegetarian, Vegan* (Salehi et al, 2020).

Following Mezirow's TLT, this prototype will aim to increase the public's awareness of the environmental impact of the meat industry, and their motivation to ultimately reduce their ABPs consumption by providing information and resources regarding the different diets and the different impacts of the products. This theory will see its impact on our assumptions and ideologies underpinned by the biophysical and biocultural factors (Brinson, 2021).

The user interface (UI) will be designed and prototyped using the tool *Figma*. This will facilitate designing with efficiency, effectiveness, precision, and freedom. Another advantage of *Figma* is the creation of an interactive prototype that will be used as well during the user testings and lately adapted to the iteration phases. The functional RS will be developed using *Python* and *Jupyter Notebook* to scrape the products from the chosen supermarket (in Dutch), clean the data, and build the CA and CBF systems. This prototype will be also developed in English hence, the scraped data will be explained to the users during the user testing if required.

User Testing and Iterations

Sometimes normal situations end up failing in the request to design for people with different backgrounds, needs, worries, and wants (Brown, 2006). The vision of DT is to follow a human-centered strategy emphasizing the necessity to involve stakeholders (i.e, users) in the project phases to avoid wrong assumptions and therefore, potential failure (Carlgren, Rauth & Elmquist, 2016). During the phase of ideation, both the *Figma* prototype and the RS prototype were tested with consumers from the focus group (both in person and online). This was an opportunity to receive feedback from potential users of the product and validate whether or not the product was fulfilling its predetermined objectives.

This phase of the project consisted of four iterations in which the project and goals were presented to the users following a series of methodologies such as *concept testing*, *usability testing*, and *A/B testing* to guarantee results. For each of these methodologies, assistance was solicited from 5 users (Bowman, 2017) who previously volunteered with the user research. These users met the defined target profile of young students aged 18-30 years old, living in the Netherlands, and with a concern or desire to reduce their meat consumption. Each of them had a different background, age, sex, and culture to further diveresify the results. These iterations were conducted both in person and online and used English as the common language.

Iteration 1: Concept Testing.

Objectives: The purpose of Concept Testing is to test the principal idea of a project, raise the problem with the users through the interview, and present them with a simple middle-fidelity prototype through which the idea is expressed (Bowman, 2017). By applying this framework to the project, the objective was to discover the feasibility of a recommendation system used to raise users' awareness of their personal consumption of ABPs and its impact on sustainable living. This would be tested by presenting research participants with a digital prototype of the proposed solution.

Prototype: The *role prototype* (Houde & Hill, 1997) created for the project was based on four simple middle-fidelity screens designed using *Figma*. Each screen presented the core features and functionalities of the proposed solution, such as the mobile application’s home page, the user flow for selecting a diet preference, a search functionality

enabling users to search for a supermarket, and the flow for browsing food product alternatives.

Procedure: To obtain the necessary results from the testing session, the first step was to contextualize the situation with the user. A script was created explaining the objectives of the interview, and the purpose of the prototype. Rather than recording the interviews, the principal researcher manually took notes to collect insights. The user was guided through the first steps of the prototype (i.e. choosing a diet or searching for products) but was given full freedom to comment on the steps taken, why they were taken, their thoughts, their needs, or their future expectations regarding the final prototype. This concept testing took approximately 45 minutes with each of the involved participants.

Expert Interviews: Expert interviews were conducted in parallel to the aforementioned user testing sessions. Three experts were invited to discuss and share their insights on relevant project topics such as nutrition, product consumption, sustainability, and ABPs and PBPs consumption. These interviews were both by telephone or online according to the interviewee's preferences. Similar to the user testing sessions, these expert interviews took approximately 45 minutes and were completed in English.

Iterations 2 & 3: Interaction Prototyping

Objectives: For the second and third iterations, there was a focus on designing the final high-fidelity designs through interaction prototpying. These iterations covered the complete user experience of the proposed solution. Relevant tasks for this phase focused on observing participants using the final versions of the prototype with a complete range of functionalities. Participants were also observed while trying to fulfill certain key flows within the prototype such as account creation, preference selection, product navigation, supermarket selection, food selection, browsing through alternatives, viewing product information. Furthermore, these sessions enabled the researcher to see how users experience sustainability awareness through the prototype. Through this, the main goal was to detect possible errors in the design, identify missing features, or how to improve the protoype’s overall UX/UI experience.

Testing methodology: For both iterations, *Usability Testing* is the methodology selected to ensure that the prototype has been designed for the intended persona, and to test its effectiveness, its efficiency, and whether or not it causes positive results in its users

(Bastien, 2010). At the end of Iteration 3, a brief *A/B testing* will be conducted to help decide the best option for providing and representing sustainability awareness (Kaufmann, Cappé & Garivier, 2014).

Prototype: It will consist of a *Look & Feel prototype*, which means that the UI and UX of the prototype will cosmetically resemble the final solution as much as possible but without considering the backend functions of the product yet (Houde & Hill, 1997). This look & feel will be tested during both iterations among selected users. The goal is to receive feedback and impressions from users about the produt's overall Look & Feel, which would inform the design process for the final high-fidelity prototype design. Users were able to test a close-to-real version of the prototype through the *Figma Mirror* mobile app, which quickly enables users to visualize and interact with designs directly on a smartphone device.

Procedure: Iterations 2 & 3 were designed to test the insights and features applied to the improved prototype. Following the steps of Iteration 1, a script was created to ensure the control of time and tasks to be performed. The script was organized into the following segments: : 1) *Usability and Structure*, i.e., covered questions concerning the UX design, the accessibility to the different functions, and the interface architecture navigation. 2) *Look & Feel*, i.e., focused on whether the design systems (colors, typography, call-to-action buttons, and images) facilitate navigation and accessibility, and achieve user-friendly interactions. Finally, the last five minutes were given to the participant to make comments, suggestions, or share their experiences or uncovered points with the researcher. Once a session was completed, a short survey was sent to each participant with 7 multiple-choice questions and 2 short answers regarding the level of difficulty of the exercise, the level of difficulty of the prototype, or the level of awareness encountered (Appendix B, survey 2). This testing took between 45 and 60 minutes with 5 participants in each iteration, totalling to 10 participants.

Iteration 4. Recommender System Testing.

Objectives: The final iteration was focused on testing the FRS developed using the coding language, *Python* (Duque, 2011), and the *Jupyter Notebook* tool. The aim of this test session is, again, to test the effectiveness and usability of the functional RS prototype, and to detect possible errors in the system.

Testing methodology: As facilitated in Iterations 2 & 3, the testing methodology of this phase will consist of *Usability Testing*. What will be done is an observation of the

participants using the CA RS through trial and error. Afterwards, a survey will be sent to collect the participant's experience using the prototype (Appendix B, Survey 4).

Prototype: This *Implementation Prototype* is developed to address the functional side and how the system will work in the future, regardless of the appearance of the system (Houde & Hill, 1997). Its development was divided in two parts:

1) Building the first program based on a CBF. Using the vector distance, *Cosine Similarity*, between the product's *'Summary'* variable (Sv, 2020). This will compare the '*Summary'* content of products to generate the first recommendations.

2) Proceed with the addition of diets to obtain the CA system. A numerical value will be given to the four main diets:: *Flexitarian* 1, *Pescetarian* 2, *Vegetarian* 3, *Vegan* 4. In addition, group the product's keywords according to the diets manually: *Meat*: 1; *Fish*: 1,2; *Chicken*: 1; *Nuts*: 1,2,3,4; *Vegetables*: 1,2,3,4; *Fruit*: 1,2,3,4; *Legumes*: 1,2,3,4; *Dairy*: 1,2,3,3; *Cold Meat*: 1; *Salad*: 1,2,3; *Pastries*: 1,2,3; *Cheese*: 1,2,3; *Pasta*: 1,2,3. Once the products are classified by diet, these receive a final number from 1-4 calculated with the sum of the diets to which they correspond. For instance, if a product corresponds to Flexitarian (1), Pescetarian (1), Vegetarian (1), and Vegan (0), the final sum will be 3 and therefore, it will be suitable for those first three diets but will not be shown to a consumer who has selected the vegan diet (i.e. eggs or cheese) (Image 1).

Unnamed: 0	Product name	Description	Summary	Price	Ingredients	Quantity	key word	Flexitarian	Pescetarian	Vegetarian	Vegan	diet
0	AH Rundergehakt	RundergehaktVerpakt onder beschermende atmosfeer.	Rundergehakt om eindeloos mee te varieren. Nat...	4.89	500 Gram	500 g	Meat	1	0	0	0	1
1	Vegetarische Slager Ereburger	Veganistische burger op basis van soja en tarw...	De Vegetarische Slager maakt plantaardig vlees...	4.59	2 Stuks. 226 Gram	226 g	Meat	1	0	0	0	1
2	AH Rundergehakt	RundergehaktVerpakt onder beschermende atmosfeer.	Rundergehakt om eindeloos mee te varieren. Nat...	3.49	300 Gram	300 g	Meat	1	0	0	0	1
3	Vegetarische Slager Mc2 burger	Vegetarische burger op basis van soja, verrijk...	Dit is het bewijs dat lecker eten geen hogere ...	2.55	160 Gram	2 stuks	Meat	1	0	0	0	1
4	AH Hamburger	RunderhamburgerVerpakt onder beschermende atmo...	Hamburgers gemaakt van mild gekruid rundvlees ...	3.79	400 Gram	4 stuks	Meat	1	0	0	0	1
...	...	...	...	...	...	...	...	...	...	...	...	...
304	Valle del sole Zwarte bonen	Zwarte bonen	Een natuurlijke bron van voedingsstoffenGoede ...	1.19	350 Gram	350 g	Legumes	1	1	1	1	4
305	Honig Peulvruchten pasta fusilli kikkererwten	DROGE DEEGWAAR met 50% kikkererwtenBron van ei...	Honig fusili kikkererwten is gemaakt van 50% k...	2.69	300 Gram	300 g	Legumes	1	1	1	1	4

Image 1. Final Database.

This future prototype aims to collect the preferences of its users and compare them with the products of selected supermarkets to finally create an individual database for each user. This

database will be the key to generating recommendations. The user will receive the recommendations and, by interacting with them, the user will adapt their preferences, thus creating the feedback loop that can be seen below (image 2).

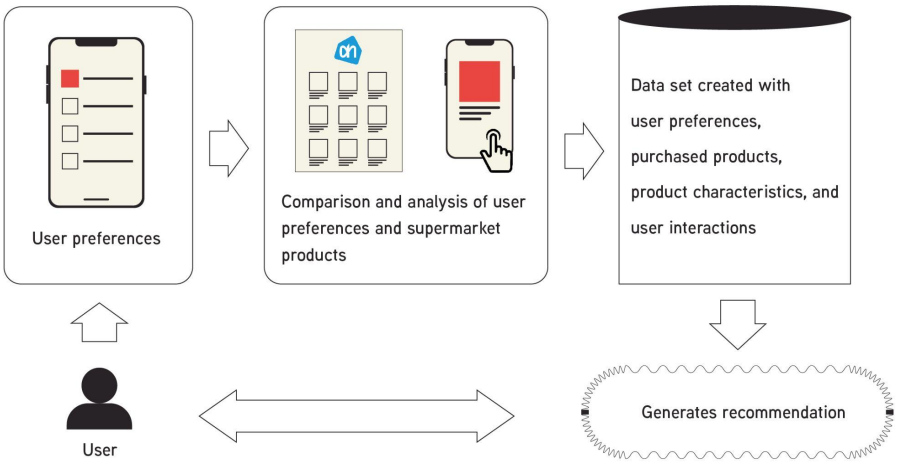

Image 2. Representation of feedback loop.

Procedure: This iteration was tested in the same method as Iteration 2. A script was developed in which the context of the project was explained, users were asked to use the system to achieve their recommendations and to comment on the steps they took and why.

4. Results

Introduction

Following the DT methodology and after the insights and feedback received from the interviews, questionnaires, and user testing is collected, the implementation phase begins. Throughout the implementation phase, Mezirow's TLT will be reflected starting with the user's own dilemma, followed by awareness provided by the app, attitude building, and end with individual action (Salehi, Carmona, Redondo, 2020). The main objective to be observed in these results is the balance between the right level of awareness to generate an impact on the user in order not to lose the essence of an application that contributes to their daily groceries shopping.

Proof of concept

Participants' results: The first questionnaire lays the foundations for our target persona (Blomkvist, 2002). With a total of 22 responses (N=22), this persona is on average 23 years old, shops for themselves, and chooses AH as their main supermarket because of home distance and the quality of the product. On the other hand, our persona defines themselves as an omnivore and consumes ABPs more than twice a week due to taste and their trust in health benefits (i.e., nutrients and protein). Finally, they have considered reducing their ABPs consumption for environmental and ethical reasons, but have not succeeded due to the same reasons mentioned before. (Appendix D)

Both in the questionnaire and the interviews, a short explanation was shared about the latest environmental and livestock data collected to date, to which one of the interviewees commented: *"It worries me. Knowing this makes me think that eating meat is not good for the environment. It is very difficult because, as far as I know, I need animal products. It would be nice to know what substitutes there are to get the same nutrients and generate a smaller impact"*. This type of uncertainty was repeated both in the questionnaire and in the interviews. Feedback from the research shows that participants acknowledge there is a problem to which they would like to put a solution, but they do not know where to begin: *"We should educate people on more food choices so that they start buying more organic/ethical products. So, not only less or no meat but also not only soi or avocados"*.

Expert Interview: The leading Dutch supermarket AH *"is developing new initiatives such as offering plant-based products more affordable to encourage their consumption"*, says one of the product and environment team leaders. AH's aim to raise awareness is seen from a marketing point of view, *"as a commercial strategy. We run 'Meat-free Week', 'Awareness Week', or even a premium account that offers discounts on plant-based products"*. This is due to changes detected in the type of consumption that *"young people in their 20s and 30s"* are developing. *"It is obvious that there is a new trend attracted by social networks that makes young people aware of the environment, ethical values, but also what is fashionable. Therefore, we have to adapt to it"*, adds the expert. From her point of view, an RS that takes into account consumption in supermarkets would be beneficial not only as a first step towards raising awareness but could also be external support for supermarkets as they have to maintain a more neutral and general stance. *"In the coming years, the meat industry in the Netherlands will be affected which will affect us as well. AH will have to adapt to the new wave but will still be dependent on distributors, regulations, and consumers"*.

Iterations 2 & 3. Awareness.

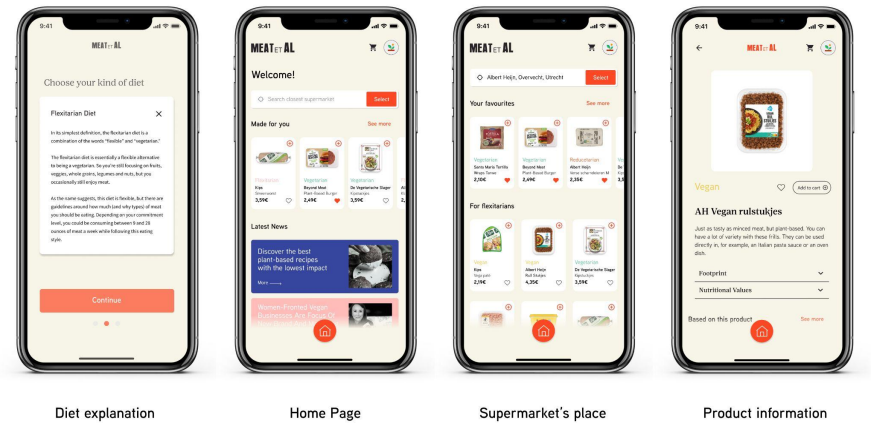

Image 3. Second Mid-Fi prototype created on Figma.

Usability testing: The objective of Iterations 2 & 3, was to improve the level of awareness that users received from the proposed product through the features of the prototype (Image 3). Participants were able to use most of the actions of the prototype and comment on *what they see, what they do, how they do it,* and *why.* Following Mezirow's theory, users analyzed the relationship of the products to each diet, the titles of the items, and the carbon

footprint information of the products. The results of these sessions revealed that there was a long reaction time between users landing on the supermarket's page and moving on to the product information that reflects later on in the ratings (Table 1). Although they comment on the sustainable-awareness moments in the rest of the application, it was clear that the environmental data provided on the product was hidden therefore inaccessible, which causes the interruption of the experience the prototype desires to create. On the other hand, it was revealed that participants find the selection of diets and their respective information helpful as a first step to awareness (learning). However, participants also mention a lack of continuity throughout the other pages. According to one user, *"I don't know how I can go back to my type of diet, how I can change it, what it means beyond the products I can or cannot eat, and what impact am I making with it".*

	Difficulty of use	Most complex screen	Customer awareness	Awareness encounter	Sustainability-awareness helpfulness
Iteration 1 (Observation)	The navigation was not clear	Alternatives section	-	5/10	-
Iteration 2 (Survey)	4,2	Product information	7,8	7	6,5
Iteration 3 (Survey)	2,6	Product information	6	8,5	8,4

Table 1. Summary of participants' results after iterations 1, 2, and 3.

In a final positive response, all participants shared their surprise at an everyday application that supports them to better understand their consumption. *"A lot of times you hear the news in the media but if you want to get informed on the topic, you have to do a lot of research to come to a conclusion. It ends up not being worth it".* An insight from the A/B test revealed that participants would find the proposal more valuable if more environmental information was clearer or more tangible (Appendix B, survey 3). This concept resulted in considerable improvements to the prototype's features, such as the development of a recipe library or the inclusion of diet categories to ensure the contuinuity of the user's journey in food product discovery.

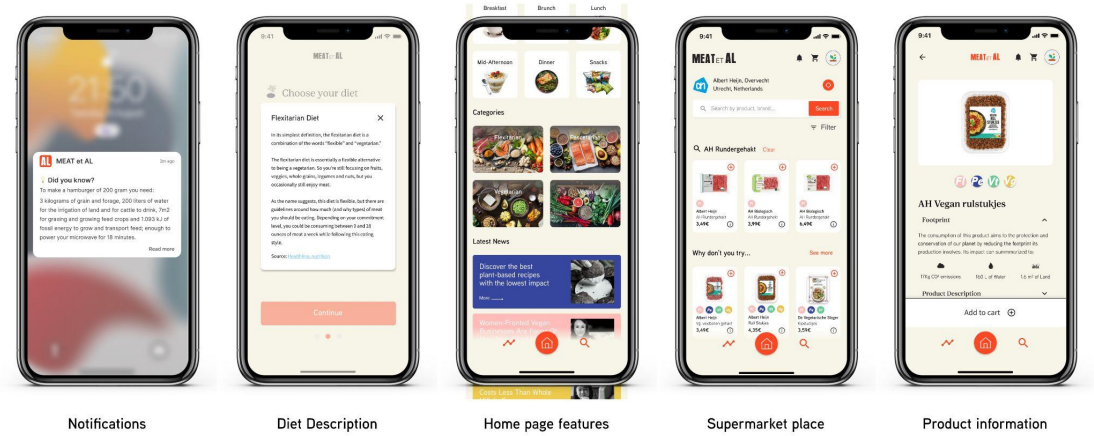

Image 4. Final Hi-Fi screens designed in Figma.

Expert interview: The designed prototype for this particular research session focuses on consumers' diet preferences therefore, an interview was conducted with a nutritionist focused on nutritional education. When asked what was most important to know about ABPs and PBP from a professional point of view, her response was *"A good, structured, plant-based diet low in ABPs can be beneficial in all cycles of life, from childhood to adulthood. However,* she added, *"without proper monitoring, vegetarian or vegan diets can lead to a deficit of nutrients such as vitamins B-12, calcium, vitamin D, or zinc"*. When the prototype was presented, there were both positive and negative responses. *"I reckon it is a brilliant idea that can bring these diets closer to all of us [...] Luckily, it will create more conscious minds"*. However, as the theory mentions, when a technology is applied to food, there are always extra variables to take into account such as health or lifestyles that differ among consumers. That is the main concern for the expert: *"Big companies always have marketing strategies to persuade customers to still believe meat is an essential food in their diets [...] sadly, health appeals to everyone and it is very easy to spread myths about it. My advice will always be to trust health professionals"*.

Iteration 4. Functionality.

```
get_content_recommendations()
```

```
Please choose your diet
Press 1: Flexitarian
Press 2: Pescetarian
Press 3: Vegetarian
Press 4: Vegan
2
Please enter a keyword to find a product: Fish
Plese choose your item based on keyword search!
press 0 for Fish Tales Gerookte Sockeye zalm 100g
press 1 for Fish Tales Ansjovis filets in olijfolie msc
press 2 for Fish Tales Skipjack tonijn in water
press 3 for Iglo Fishcuisine Bretagne
press 4 for Fish Tales Gerookte zalmsalade
press 5 for Fish Tales Tonijnsalade
3
Choosen item is:  Iglo Fishcuisine Bretagne .
```

	Product name	Description	Summary	Price	Ingredients	Quantity	key word	Flexitarian	Pescetarian	Vegetarian	Vegan	diet
148	Iglo Vissticks	6 porties gepaneerde Alaska koolvisfilet, voor...	De vertrouwde Iglo kwaliteit, maar met een nog...	7.79	30 Stuks. 840 Gram	840 g	Fish	1	1	1	1	4

Image 5. Python Prototype Result..

This implementation prototype (image 5) was tested with 5 participants to confirm its usability both in terms of its actual functioning and its usability for a potential future mobile app. The testing involved three people who defined themselves as omnivores, one person defined as a meat-eater, and one flexitarian all between the ages of 20 and 30. According to these five participants, this prototype had a difficulty level of 3.4 in the steps to follow, and 5 in usability, leaving them feeling *happy* but *surprised* and confused at the same time (image 6). They argue that these results are due to the fact that it is not a final prototype but that, for this testing, it fulfilled its function of providing recommendations about their chosen diet. Nevertheless, the display of the information received felt confusing (image 7). However, among the five, they say it could be a good tool for better sustainable consumption (82%), and how likely they will start following a diet low in ABPs is 78%. Finally, when asked what other preferences they would expect, the answers were surprisingly unanimous naming issues such as health (naming allergies), sport (mentioning following specific diets), money (being a student), and one last person would like to be able to restrict the foods they do not like.

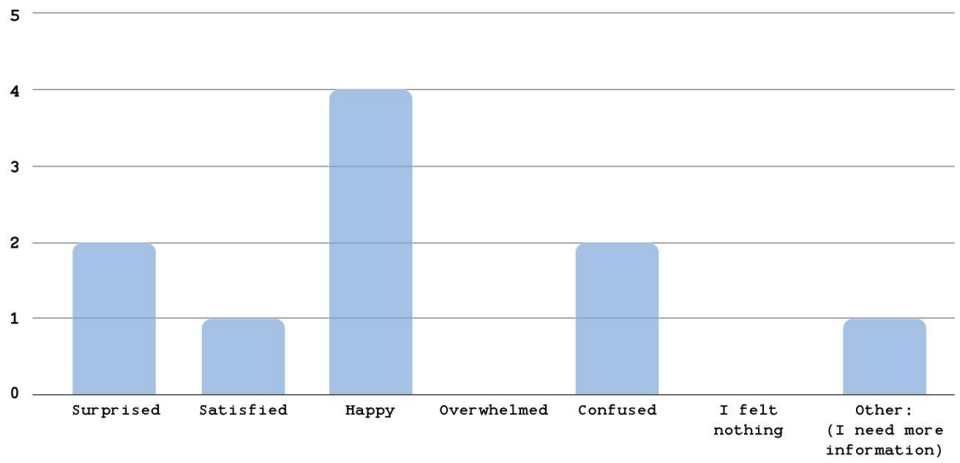

Image 6. Feelings after using the RS prototype.

Image 7. Insights collected from Iteration 4.

5. Conclusion & Discussion

The aim of this study was to provide a solution to help reduce the consumption of ABPs among young adults located in the Netherlands by raising awareness of the environmental problems caused by their production and consumption. With the use of FRSs, a functional prototype based on CA filtering has been developed to analyze the type of dietary preference of the consumer (i.e. flexitarian), and compare it with the selected supermarket products to generate recommendations on alternatives to that product. These alternatives are intended to benefit both the reduction of ABPs, as well as raising sustainability awareness of their purchase to achieve sustainable consumption through notifications, product information, diet information, and news. This study, together with both prototypes, has proven to spark interest among the participants and corresponds to the theories and studies analyzed throughout the literature. Collaborating with a young population has helped to better understand the concerns of the younger generation in the environment, their consumption patterns, and their health. These participants value having choices that are both beneficial to the environment, as well as to their health, and are hence willing to change their dietary style to a reduced ABPs (more than 65% positive responses). On the other hand, it is true that some of these participants have a certain attachment to products such as meat or cheese either due to taste or to the cultural role that certain foods have for them. Nevertheless, more than 65% of participants still answered *'Yes'* to looking for alternatives to reduce their consumption of ABPs to once or twice a week. For those reasons, both prototypes have been favorable to these results for providing new sustainable consumption tools without altering the interaction with other grocery apps. Nevertheless, the study of FRSs focused on environmental awareness and user behavior is a field that still needs to be researched in the fight against climate change.

The use of Mezirow's TLT has demonstrated what the theorist McDonald (2000) advocated. During the interviews and user testing, participants showed greater interest once they were aware of the consequences of producing ABPs. However, as McDonald (2000) herself or Wolstenholme et al (2020) also argued, there is a need for a comprehensive study of how this theory helps users to make a change not only in their consumption behavior per se but also whether this behavior is sustained in the long run, and if so, how and what sustains it. For the moment, this study has managed to demonstrate that despite the new environmental, ethical, and moral values among young adults (Kemper & White, 2021), there is still a lack of information on what we are actually generating for the environmental

well-being as individuals, and what solutions are available for us as consumers, going in line with Dietz (2003) and his *Goog Decision* theory. Experts such as the farmer engineer argued that currently, with regards to the Netherlands, the agriculture and livestock sectors are experiencing this misinformation firsthand due to poor data collection, lack of transparency, and the need for more data-driven solutions, he added. During user testing, participants were particularly surprised to learn about the awareness data, which was in line with the findings of Hartmann and Siegrist (2017) or Perino and Schwirplies (2022). Throughout the tests, they commented on their interest in an app that not only makes it easier for them to shop at different supermarkets but also informs them about *what* they are consuming and *why* they are consuming it. Features such as recipes based on diet type, diet categories, or notifications were added after the third iteration due to the interest shown in being able to perform more actions within the app beyond shopping. A final insight that seemed to resonate with several users is the feasibility of having a tool to measure their personal environmental impact, which may serve in future proposals as a means to encourage continued sustainable consumption as mentioned by Wolstenholme et al (2020).

Regarding the functional prototype, previous studies on the use of FRSs (Elsweiler, Trattner, 2012; Viniski et al, 2021; Toledo, Alzahrani & Martinez, 2019) validate that we can declare that the application of CA-based filtering (in our case for diet preferences) has generated positive effects among participants. This is because it adds the variable of personalization to consumer preferences for a more targeted recommendation and therefore, favors the reach of sustainable awareness. In fact, while prototyping the proposed solution, , the option for a user to *'favorite'* products was replaced with an option for users to read more *'information'* about it, to avoid losing the sustainable recommendation factor as Musto et al (2020) claimed. However, this prototype also has limitations that some participants also raised. As the aforementioned theorists concluded, the use of CA in FRSs remains limited as it needs several context-based variables such as health status, culture, religion, allergies or in this case more environmental data. Taking these context-based variables would be able to provideusers with more personalized recommendations that fit each of their unique lifestyles.. Therefore, despite the significant contribution that the application of CA can have to sustainable awareness of FRSs, there is still a lack of studies that better define its practice.

However, this study also suffers from some limitations, some of which are mentioned above. In addition to not taking into account the full consumer’s context, the study does not

take into account the full product range of the selected supermarket, nor does it benchmark against third parties to analyze the accuracy of the recommendations for better evaluation. On the other hand, the demographic study focuses on the Netherlands, a country which, while still in need of progress in environmentally sustainable livestock, is among the most advanced western countries in the consumption of alternatives to ABPs (Weinrich, 2019). Plus, a young sector of the population that is more open-minded to these changes in consumption compared to an older population, which, as the AH team lead also emphasized, has more problems in accepting these new proposals. Finally, the number of participants is too low to represent the opinion of the whole study group and the behavioral progression of the participants in the testing of the solution is not assessed.

The contribution of this study is the approach of the first feasible and publicly accessible data-driven solution for the reduction of ABPs through the application of applied transformational theories and the implementation of FRSs. Previous studies have helped to understand the applied practices of different algorithms, within RSs, in the field of food health (Freyne & Berkovsky (2010); Elahi et al, 2015; Elsweiler & Trattner, 2017; Toledo, Alzahrani & Martínez, 2019;) or sustainability of garments or various items (Gong et al, 2019; Hyun et al, 2020) but not in food sustainability. This study calls for a debate on a problem that has been on the table for the last 21st century (Klarin, 2018) and for which there is still room for a data-driven solution that protects not only human well-being but also de environmental well-being. Therefore, following this research, there are opportunities for studies using awareness-raising in applied tools for behavioral change in the consumption of ABPs and PBPs, as well as their possible application in supermarkets as a response to the need to adapt to the new consumer and new regulations as mentioned by the expert.

This research can be seen as a contribution to all the technologies that are currently being developed such as 3D food printers, fake meat alternatives, or devices for livestock to reduce gas emissions (i.e. ZELP) (European Commission, 2020), but it is among the first ones to be based on theory applied to a practical solution focusing on using the tools and resources that already exist, and focusing on what the consumer can do and not on what the livestock sector lacks.

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8. Appendix

Appendix A

Constent Form: User Testing

HOGESCHOOL UTRECHT

Dear participant,

First of all, I wanna show my appreciation for taking the time to chat with me and collaborate on this research.

The aim of this study is to find out the consumption habits of young adults, mainly located in the Netherlands, regarding animal-based products as opposed to plant-based products and the awareness level on environmental impacts generated by the same livestock sector and consumption (15 minutes). Finally, we will proceed to a brief Usability Testing of the solution proposed. The participant will make use of the prototype, navigate through it, follow tasks given by the researcher, comment on their process, and answer a few question regarding the experience (30 minutes).

Please read this form carefully and sign this before your User Testing date. If you have any questions after today, please contact noravillarc@gmail.com.

	Yes	No
During this usability test I agree to participate in an online session using my computer and/ or telephone if required.	☐	☐
During the session I will be interviewed about the site, asked to find information or complete tasks using the site and asked to complete an online questionnaires about the experience.	☐	☐
I understand and consent to the use and release of the recording by Nora Villar.	☐	☐
I understand that the information and recording are for research purposes only and that my name and image will not be used for any other purpose.	☐	☐
I relinquish any rights to the recording and understand the recording may be copied and used by Nora Villar without further permission.	☐	☐
I understand that participation is voluntary and I agree to immediately raise any concerns I might have.	☐	☐

Please sign below to indicate that you have read and understand the information on this form and that any questions you might have about the session have been answered.

This study, questions, usability testing, and prototype have been developed by the researcher Nora Villar for the Master's Data-Driven Design at the HU, University of Applied Sciences Uthrecth, The Netherlands.

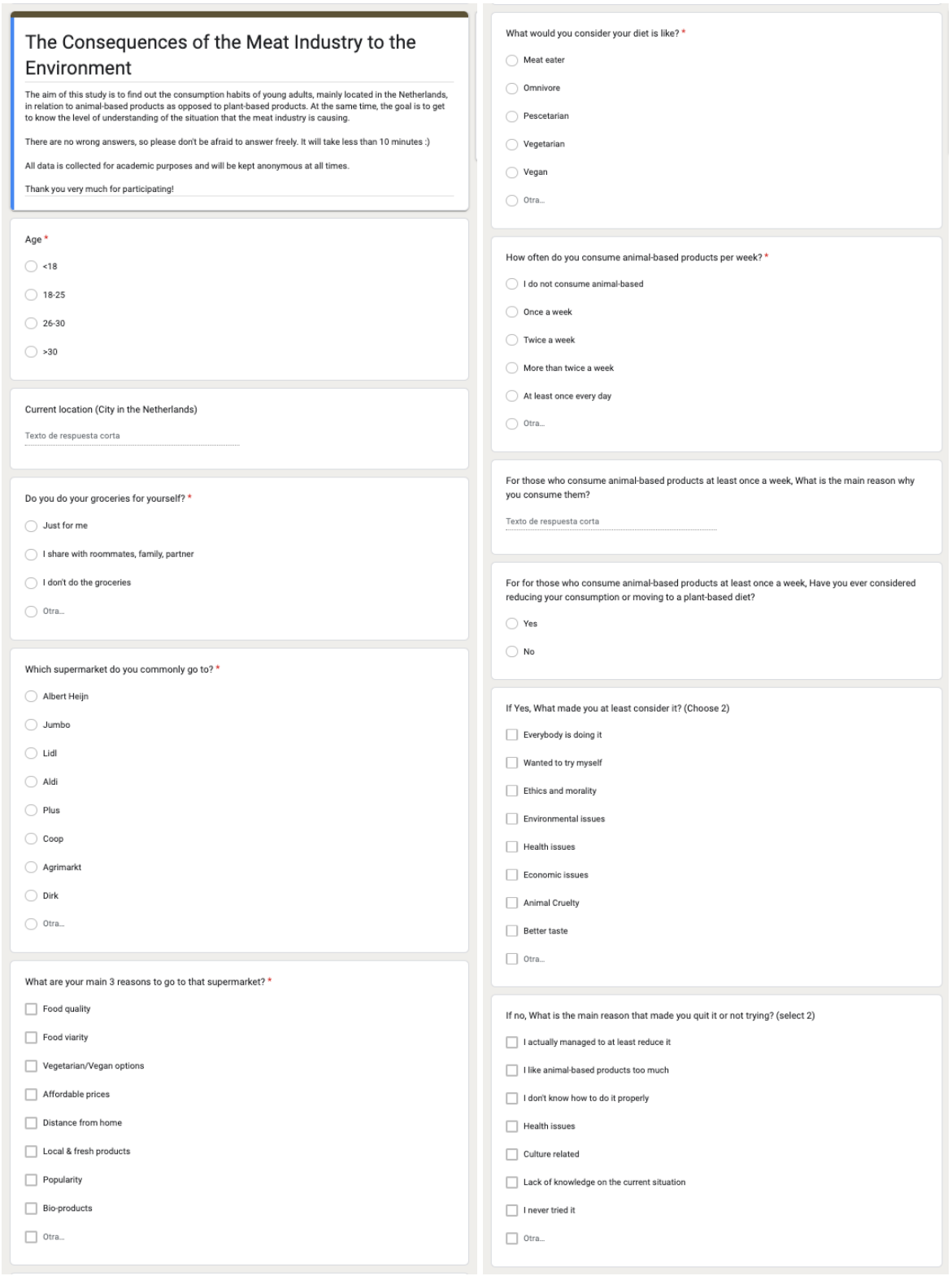
Date: _____ (DD/MM/YYYY)

Your signature/name: _____

Researcher: _____ Nora Villar

Appendix B

Survey 1. Prior survey



The Consequences of the Meat Industry to the Environment

The aim of this study is to find out the consumption habits of young adults, mainly located in the Netherlands, in relation to animal-based products as opposed to plant-based products. At the same time, the goal is to get to know the level of understanding of the situation that the meat industry is causing.

There are no wrong answers, so please don't be afraid to answer freely. It will take less than 10 minutes :)

All data is collected for academic purposes and will be kept anonymous at all times.

Thank you very much for participating!

Age *
- <18
- 18-25
- 26-30
- >30

Current location (City in the Netherlands)
Texto de respuesta corta

Do you do your groceries for yourself? *
- Just for me
- I share with roommates, family, partner
- I don't do the groceries
- Otra...

Which supermarket do you commonly go to? *
- Albert Heijn
- Jumbo
- Lidl
- Aldi
- Plus
- Coop
- Agrimarkt
- Dirk
- Otra...

What are your main 3 reasons to go to that supermarket? *
- Food quality
- Food viarity
- Vegetarian/Vegan options
- Affordable prices
- Distance from home
- Local & fresh products
- Popularity
- Bio-products
- Otra...

What would you consider your diet is like? *
- Meat eater
- Omnivore
- Pescetarian
- Vegetarian
- Vegan
- Otra...

How often do you consume animal-based products per week? *
- I do not consume animal-based
- Once a week
- Twice a week
- More than twice a week
- At least once every day
- Otra...

For those who consume animal-based products at least once a week, What is the main reason why you consume them?
Texto de respuesta corta

For for those who consume animal-based products at least once a week, Have you ever considered reducing your consumption or moving to a plant-based diet?
- Yes
- No

If Yes, What made you at least consider it? (Choose 2)
- Everybody is doing it
- Wanted to try myself
- Ethics and morality
- Environmental issues
- Health issues
- Economic issues
- Animal Cruelty
- Better taste
- Otra...

If no, What is the main reason that made you quit it or not trying? (select 2)
- I actually managed to at least reduce it
- I like animal-based products too much
- I don't know how to do it properly
- Health issues
- Culture related
- Lack of knowledge on the current situation
- I never tried it
- Otra...

If yes, Could you briefly explain?

Texto de respuesta corta

This is what's happening (briefly)

The meat industry is estimated to have a global market value of 1157 billion US dollars by 2025, producing more than 340 million tonnes of meat per year, and resulting in triplicating the meat consumption in the past 50 years. In countries such as the USA, meat consumption raises each year reaching 100Kg of meat consumed per person.

However, in order to keep the demand afloat, the production of meat requires 80% out of the 50% of Earth's land fields just for farming and cultivation of crops leading to the cut-down of 8.2 million hectares in the Amazon for cattle since 2009. Besides, about 4.387Km3 of water is required only in the production of livestock feed meaning that to produce half a kilo of beef, approximately 8.000 liters of water are needed. Finally, the emission of GHG increased to 10-12% in agriculture being meat production three- quarters of the total going up to 7.1 gigatons of CO2 emitted per year. However, if we moved from a meat diet to a vegetarian diet, we would save 920Kg of CO2 per person every year.

Despite the insistence of the vegan movement to move to a plant-based diet, changing the socio- cultural behaviour of millions of people plus the high price of those alternatives on the market, makes it difficult to access sustainable solutions. Nevertheless, if we could all participate in the meat reduction movement by adopting new behaviours, we could reduce by 75% the crop and livestock fields reducing water and land use, decreasing GHG emissions, and still feeding the whole population.

After reading this brief explanation, Could you explain your first reaction? *

Texto de respuesta corta

From 1 to 10, How aware would you say you were about the issue before reading the text? *

	1	2	3	4	5	6	7	8	9	10	
Nothing	○	○	○	○	○	○	○	○	○	○	Up-to-date

From 1 to 10, in your opinion, How much misinformation there is about animal-based products * consumption?

	1	2	3	4	5	6	7	8	9	10	
We really need awareness	○	○	○	○	○	○	○	○	○	○	We are already aware of it

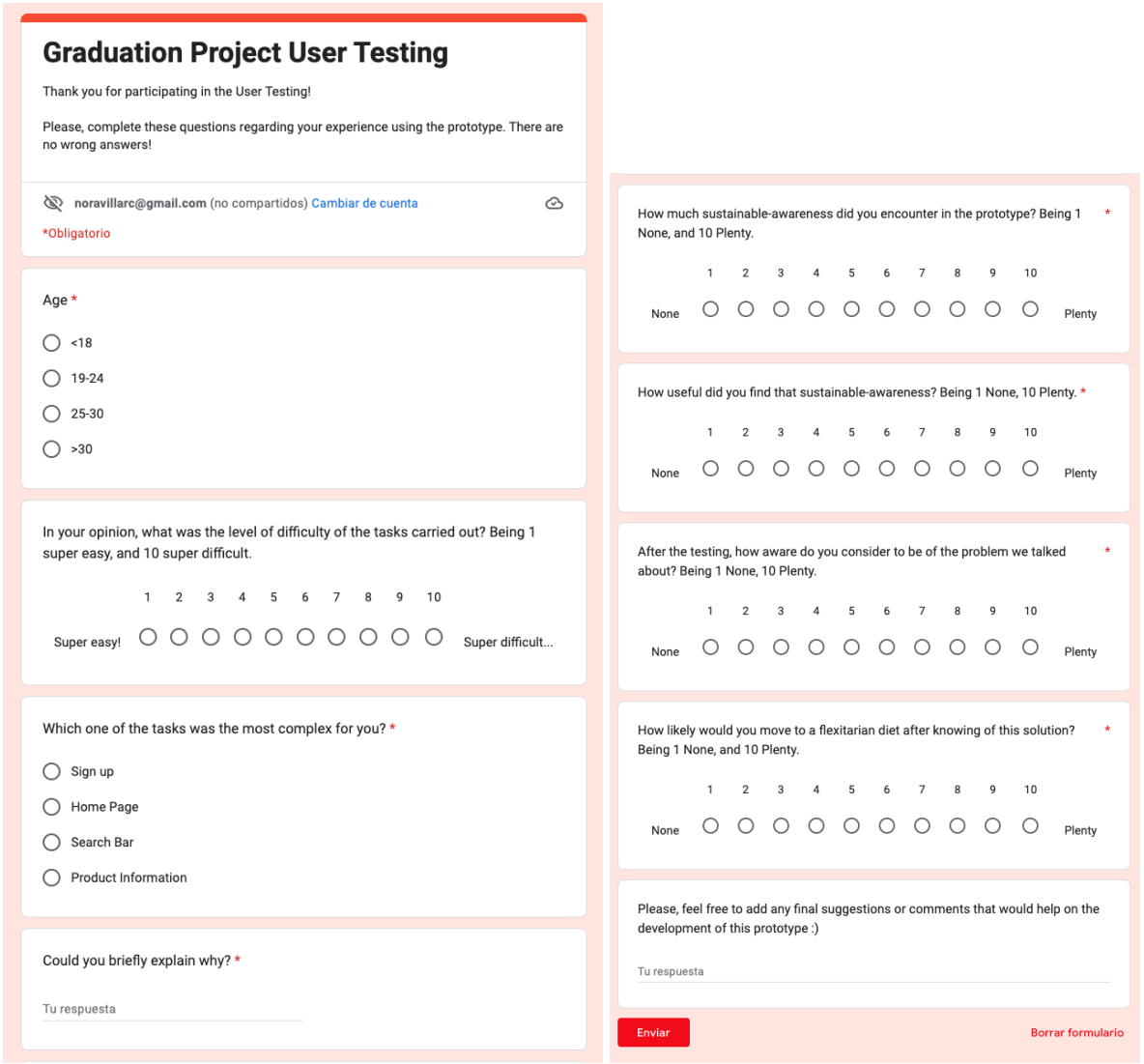
Would you like to know more about the topic (yes/no)?, and if so, What would be your main concern? *

Texto de respuesta corta

If you would like to continue supporting this project through future user testing, please leave your email here. Thank you! :)

Texto de respuesta corta

Survey 2. Iterations 2,3



Graduation Project User Testing

Thank you for participating in the User Testing!

Please, complete these questions regarding your experience using the prototype. There are no wrong answers!

noravillarc@gmail.com (no compartidos) Cambiar de cuenta

*Obligatorio

Age *

- <18
- 19-24
- 25-30
- >30

In your opinion, what was the level of difficulty of the tasks carried out? Being 1 super easy, and 10 super difficult.

	1	2	3	4	5	6	7	8	9	10	
Super easy!	○	○	○	○	○	○	○	○	○	○	Super difficult...

Which one of the tasks was the most complex for you? *

- Sign up
- Home Page
- Search Bar
- Product Information

Could you briefly explain why? *

Tu respuesta

How much sustainable-awareness did you encounter in the prototype? Being 1 None, and 10 Plenty. *

	1	2	3	4	5	6	7	8	9	10	
None	○	○	○	○	○	○	○	○	○	○	Plenty

How useful did you find that sustainable-awareness? Being 1 None, 10 Plenty. *

	1	2	3	4	5	6	7	8	9	10	
None	○	○	○	○	○	○	○	○	○	○	Plenty

After the testing, how aware do you consider to be of the problem we talked about? Being 1 None, 10 Plenty. *

	1	2	3	4	5	6	7	8	9	10	
None	○	○	○	○	○	○	○	○	○	○	Plenty

How likely would you move to a flexitarian diet after knowing of this solution? Being 1 None, and 10 Plenty. *

	1	2	3	4	5	6	7	8	9	10	
None	○	○	○	○	○	○	○	○	○	○	Plenty

Please, feel free to add any final suggestions or comments that would help on the development of this prototype :)

Tu respuesta

Enviar Borrar formulario

Survey 3. User Testing Iteration 3, A/B Testing.

Graduation Project - A/B Testing

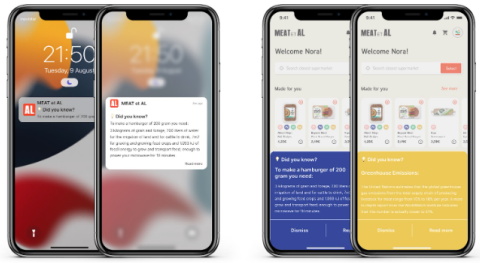
Thank you for participating in this A/B Testing!

Here are the images of the screenshots shared above. The aim is for you to analyse these screens and select the one you think best meets the objectives of navigation, accessibility and experience.

This will help to create a better user experience and to better understand what are the problems or needs of consumers.

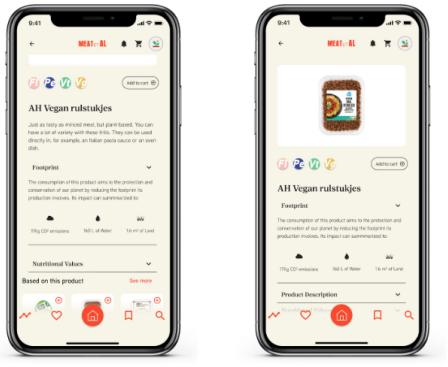
Please, complete these questions regarding your experience using the prototype. There are no wrong answers!

Sustainable-awareness notifications *

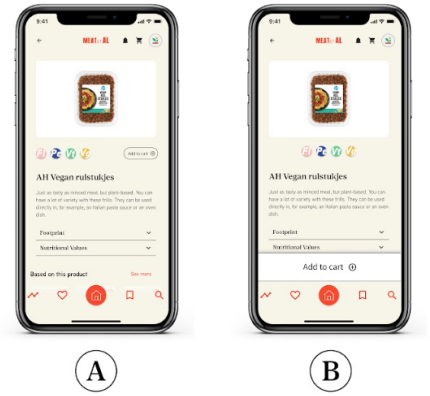


- A
- B

Regarding sustainable-awareness? *

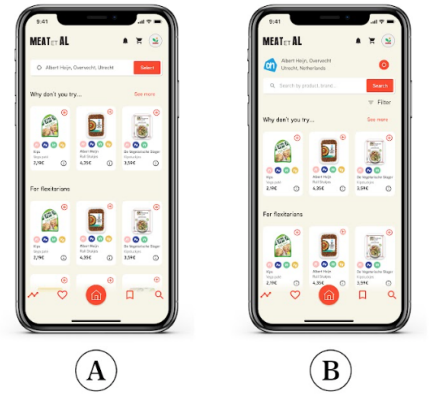


Regarding purchasing options? *



- A
- B

Regarding location and supermarket options? *

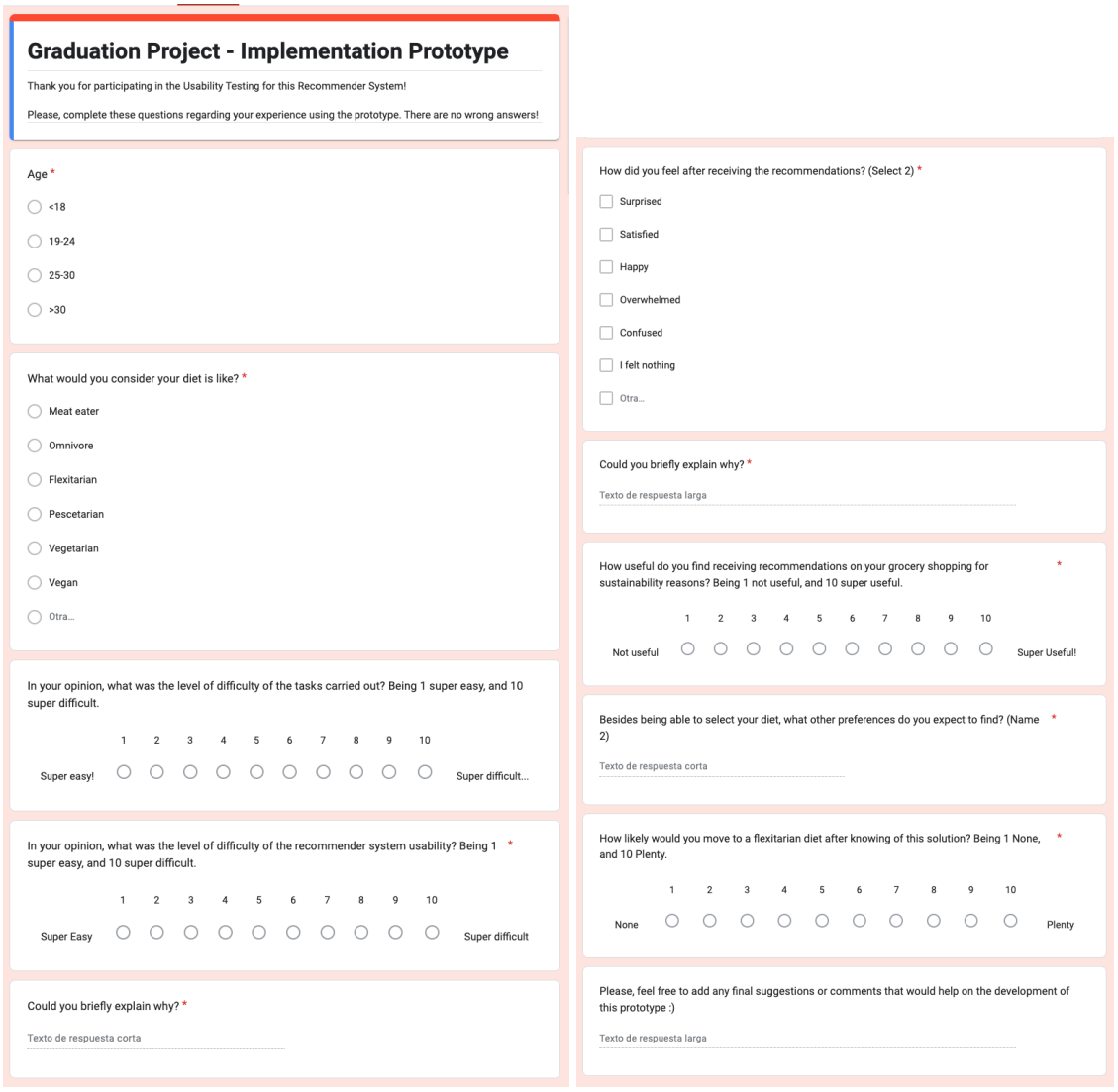


- A
- B

Enviar

Borrar formulario

Survey 4. Iteration 4, Recommender System Usability Testing.



Graduation Project - Implementation Prototype

Thank you for participating in the Usability Testing for this Recommender System!

Please, complete these questions regarding your experience using the prototype. There are no wrong answers!

Age *

- <18
- 19-24
- 25-30
- >30

What would you consider your diet is like? *

- Meat eater
- Omnivore
- Flexitarian
- Pescetarian
- Vegetarian
- Vegan
- Otra...

In your opinion, what was the level of difficulty of the tasks carried out? Being 1 super easy, and 10 super difficult.

	1	2	3	4	5	6	7	8	9	10	
Super easy!	○	○	○	○	○	○	○	○	○	○	Super difficult...

In your opinion, what was the level of difficulty of the recommender system usability? Being 1 super easy, and 10 super difficult. *

	1	2	3	4	5	6	7	8	9	10	
Super Easy	○	○	○	○	○	○	○	○	○	○	Super difficult

Could you briefly explain why? *

Texto de respuesta corta

How did you feel after receiving the recommendations? (Select 2) *

- ☐ Surprised
- ☐ Satisfied
- ☐ Happy
- ☐ Overwhelmed
- ☐ Confused
- ☐ I felt nothing
- ☐ Otra...

Could you briefly explain why? *

Texto de respuesta larga

How useful do you find receiving recommendations on your grocery shopping for sustainability reasons? Being 1 not useful, and 10 super useful. *

	1	2	3	4	5	6	7	8	9	10	
Not useful	○	○	○	○	○	○	○	○	○	○	Super Useful!

Besides being able to select your diet, what other preferences do you expect to find? (Name 2) *

Texto de respuesta corta

How likely would you move to a flexitarian diet after knowing of this solution? Being 1 None, and 10 Plenty. *

	1	2	3	4	5	6	7	8	9	10	
None	○	○	○	○	○	○	○	○	○	○	Plenty

Please, feel free to add any final suggestions or comments that would help on the development of this prototype :)

Texto de respuesta larga

Appendix C

Interview 1. User Interview Questions

Introduction

Hi, **[name]**! Thanks so much for taking the time to participate in this User Testing Interview for my graduation project. My name is Nora, and I'm a Data-Driven Design master's student at the HU in Utrecht. This study aims to understand young adults' consumption habits located in the Netherlands, concerning animal-based products as opposed to plant-based products (15 minutes). The second part of this interview will consist of a short user testing of the prototype that's being designed as a solution to the problem mentioned above (30 minutes). This will help me understand if what I'm doing is coherent, would fulfill its purposes, and would be of help to the target group.

If it's all right with you, we'd like to get your permission to record this interview. This will help us with our internal note-taking and will not be released in any form. All data is collected for academic purposes and will be kept anonymous at all times. There are no wrong answers, so please don't be afraid to answer freely! Thank you very much for participating!

First part

1. What are your first thoughts when talking about the livestock sector and the environment?
2. Do you think this topic is receiving enough importance nowadays?
3. How important is it in your day-a-day environments? (Friends, family groups)
4. In your opinion, what would be a good way to combat the environmental costs created by the livestock sector? Either individually or in society.
5. Do you know of any measurements taking place in order to raise awareness and fight it? If not, why do you think so?

About your journey

1. Regarding your weekly diet, what diet do you consider to be currently following? Why?
2. Have you ever considered the idea of reducing meat? (Why? / Why not?)

About the solution

1. Is this prototype something you would be interested in using as a consumer? (Why? / Why not?)

The floor is yours.

Interview 2. Dietitian Interview Questions

About you:

1. Could you tell me a bit more about your professional background?
2. What is your experience with the type of diets mentioned above?
    a. What is your opinion as a professional?

About the problem:

1. Were you aware of the problem before this interview?
2. What can you tell us about it as a professional?
3. In your day-a-day as a dietitian, have you experienced patients asking or moving toward a diet in which meat plays a small role? Why/why not?
4. Do you consider it a relevant issue in our society?

About the solution:

1. What is your professional opinion regarding the solution proposed above?
2. What is your biggest concern as a professional regarding the solution proposed?
3. Do you have any tips regarding the recommendations that I could use to make sure nobody's playing with the health of the users?

The floor is yours.

Interview 3. Supermarket Interview Questions

About you:

1. Could you tell me a bit more about your background?
2. What is your experience with the type of diets mentioned above?

About the problem:

5. Were you aware of the problem before this interview?
6. What can you tell us about it from the point of view of Albert Heijn?
7. Do you consider it a relevant issue in our society?
8. In your experience working at Albert Heijn, have you experienced a shift in the consumer's consumption? Why do you think that? Why don't you think so?
9. From your point of view, Which group of people is most likely to make that change?
10. I see Albert Heijn is taking some steps such as adding vegetarian and vegan products to their options or highlighting them on their website. Do you think that is making a difference in consumption?
11. Can you tell me of other measurements they are taking?

The floor is yours.

Interview 4. Farmer Interview Questions

About you:

1. Could you tell me a bit more about your background?
2. What is your experience with the issue mentioned before? (livestock sector and its environmental impacts?

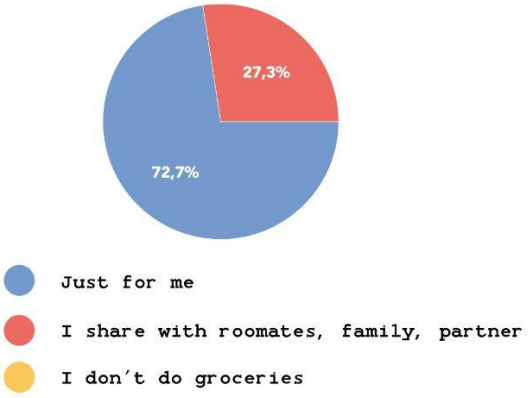
About the problem:

3. What can you tell us about it from the point of view of an agricultural farmer?
4. Do you consider this a relevant issue in our society? (Why? / Why not?)
5. In your experience working as a farmer, have you experienced a shift in the consumer's consumption? Why do you think that? Why don't you think so?
6. In which ways have you experienced this change?
7. When you distribute your products, is it important for you to generate the least impact possible?
8. Is the consumer aware of it?
9. Can you tell me of other measurements you are taking or that you know are currently being developed?
10. Could you tell me a bit more about the new regulations taken by the dutch government?
11. Do they affect you in any way?
12. Would you consider them a possible solution to the issue we're discussing?
13. Do you believe there is a place for a solution such as the one I'm developing?

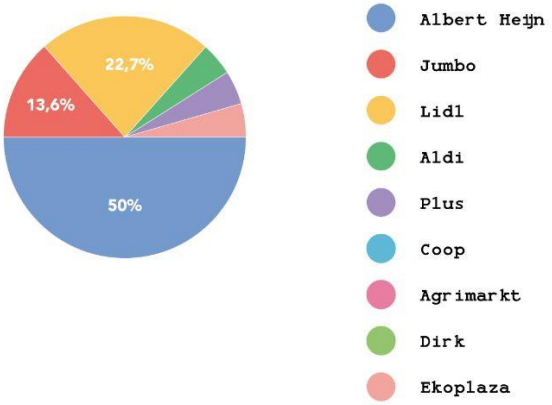
The floor is yours.

Appendix D

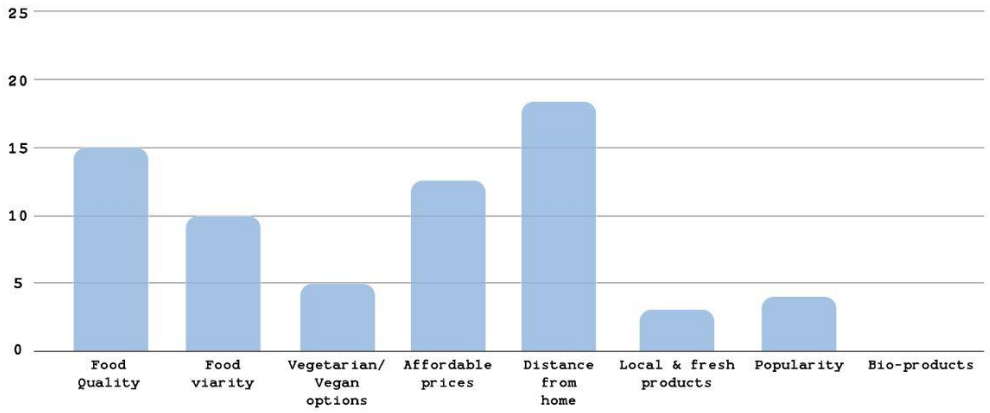
Do you do groceries for yourself?



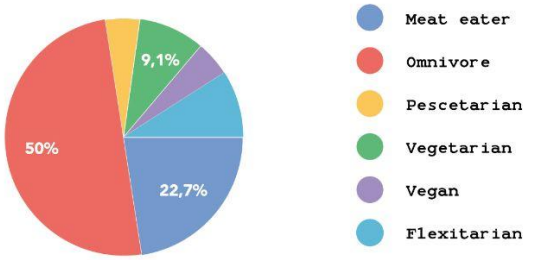
Which supermarket do you normally go to?



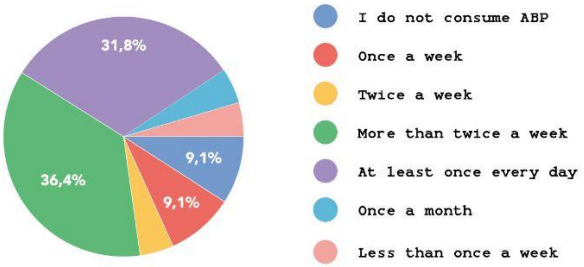
What are your main 3 reasons to go to that supermarket?



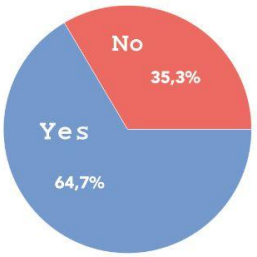
What would you consider your diet is like?



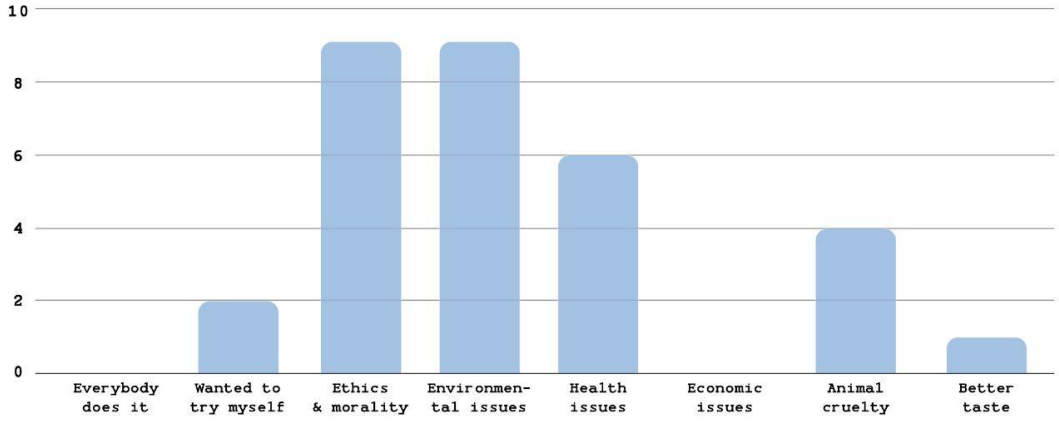
How often do you consume ABP?



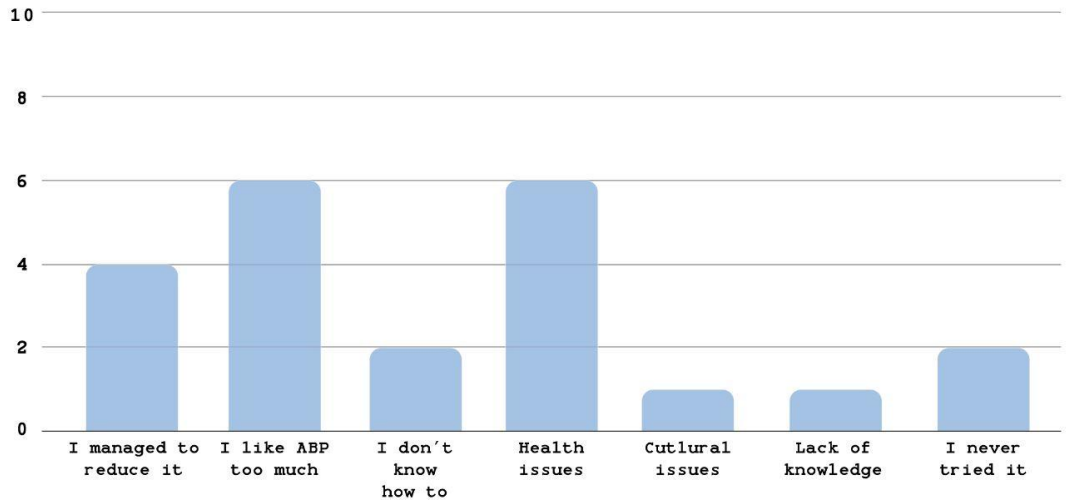
Have you ever considered reducing your consumption or moving to a plant-based diet?



If Yes, what made you at least consider it? (Choose 2)



If No, What is the main reason? (Choose 2)



Would you consider yourself self-aware of the consequences the consumption of animal-based products has on the Environment?