CONSUMER KNOWLEDGE AND ACCEPTANCE OF EDIBLE ALGAE IN THE NETHERLANDS AND GERMANY

Research Project Report

Kremerskothen, Bennet
09.06.2023, Aeres University of Applied Sciences

Consumer Knowledge and Acceptance of Edible Algae in the Netherlands and Germany

Author:	Kremerskothen, Bennet
Submitted to:	Rodenburg-Droogh, Alice
Submission date:	09.06.2023
Location:	AERES University of Applied Sciences De Drieslag 2 8251 JZ Dronten The Netherlands

Preface

This research examines how much Dutch and German consumers know about edible algae and their general willingness to eat and buy products containing algae. This research proposal is part of my final research paper needed to graduate from my studies in International Food Business with a double-degree Bachelor.

I chose this topic because I believe that the world consumes too much meat and other animal products, especially in the developed parts of the world. This has a negative impact on the environment and people's health. I believe diversifying our diets and the places we source our foods from will help guide us to a future with higher food security and better living conditions than what we can expect if we continue on the beaten path.

I would like to thank Mrs. Alice Rodenburg-Droogh and Mr. Emmanuel Anom for their guidance and help during my writing and idea-finding process. Furthermore, I would like to thank Mr. Peter van Honk for providing valuable statistical insights.

Improvements have been added to the first two chapters according to feedback given by the second assessor Cynthia Akkermans, as well as feedback from Heather-Anne Grant at Dalhousie University. These changes do not affect the overall scope of the report, but instead, improve understanding for the reader.

Table of Contents

Table of Figures

Table of Tables

Summary

The world's population is consistently increasing and as such is the demand for food. Current industrial farming methods pollute the environment and are unsustainable on multiple levels. To be able to feed future populations it is necessary to look for new, efficient, and more sustainable ways to feed humans. Efforts to create alternatives to protein sources from animal origin are currently being developed and new, innovative products enter the market at a fast rate.

Food that has not been used commonly in the European Union (EU) falls under its Novel Foods Regulation. This means, any novel food needs to first be approved by the EU and added to its novel foods list in order to be legally sold inside its borders, e.g., algae. Consumers often do not have clear expectations regarding novel food products and different drivers have varying levels of impact on a consumer's choice to consume such foods.

Algae come in two main forms: macroalgae such as seaweed, and microalgae commonly known as plankton. Most algae are very nutrient-rich and especially high in protein which makes them well-suited to use in animal protein alternatives. Furthermore, they capture CO_2 and grow in abundance in the oceans around the world. However, commercial cultivation of algae has not been practiced for long and is still being researched.

Before algae are legalized and produced on a large scale it is important to find out how much consumers in Europe know about their benefits as well as if consumers will accept to purchase and consume them. Studies have been conducted in Spain and the UK showing that consumers are generally accepting of algae, however, they often lack important knowledge about them. Germany and the Netherlands are two of the biggest food producers in the EU and have a big market for plant-based protein alternatives. Therefore, this research focuses on consumer knowledge and acceptance of algae in these two countries.

Observations from this research show that knowledge and acceptance of algae are at a high level among German and Dutch consumers with no significant difference between the consumers of both countries. However, specific knowledge about the benefits of algae still lacks behind and needs to be addressed. Furthermore, certain demographics impact the consumers' knowledge and acceptance rate more than others and thus should be considered by producers as the main target groups. Additionally, some drivers greatly influence consumers' willingness to try algae as food and therefore are important when making and advertising algae products to assure the success of such products.

1. Introduction

In 2022, the world's population reached the 8 billion mark (United Nations Department of Economic and Social Affairs, Population Division, 2022). By 2050, the population is expected to increase to somewhere between 9.4 and 10.0 billion people (United Nations Department of Economic and Social Affairs, Population Division, 2022). This rise in population will subsequently lead to increasing demand for food.
Although at the moment, there are enough resources on earth to feed the world, most of the current farming methods and food systems are not sustainable and thus depleting the resources more than necessary (Ehrlich & Harte, 2015). Moreover, countries like the members of the European Union have the funds available to invest in research and to subsidize innovative and sustainable farming methods (European Commission, 2022). While being a first-mover comes with a risk of failure, success will be very profitable as there will be no or only little competition for companies at first.

Especially for animal production, it will be essential to apply new strategies to use available resources efficiently and maintain environmental sustainability to supply national and international demand (Galanakis, 2019). Currently, new and innovative food sources are being researched and developed with the goal to find alternatives to animal products (Wild et al., 2014). These alternatives include plant-based meat alternatives, lab-grown meat as well as insect and algae products (Wild et al., 2014). Compared to meat, the new products are more sustainable, however, even those products are not flawless, often being based on the same few plants, e.g., soybeans, which may be grown under adverse conditions for farmers and nature (World Wildlife Fund, n.d.).

1.1. Sustainable impact of the meat industry

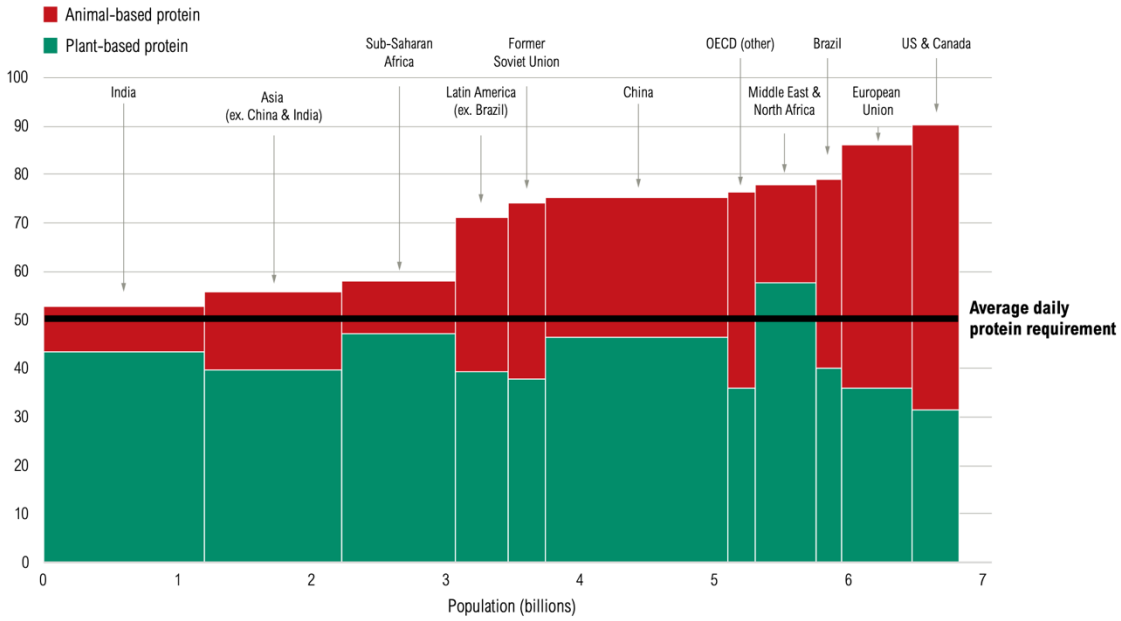
When hearing the term sustainability, the first thing that most people think of is the environmental aspect. However, sustainability can be best described as a triangle, encompassing environmental, social, and economic aspects (SOURCE). The following will try to explain current deficiencies in the sustainability of industrial livestock farming and what efforts have been made to become more sustainable.

Environmental sustainability: Currently, humans rely mostly on meat and other animal products for protein intake, especially in North America and Europe (Galanakis, 2019; Mendes et al., 2022). As can be seen in Figure 1, for most regions in the world, people consume above the required average daily protein with only India coming close to the average (Ranganathan et al., 2016). Furthermore, in most regions, the average is only met through the consumption of animal protein, while only the Middle East and North Africa consume plant-based protein above the average daily protein (Ranganathan et al., 2016).

One major issue with this reliance is the environmental impact that animal farming entails such as emissions of greenhouse gases as well as high land, energy, and water usage (Pimentel & Pimentel, 2003). These environmental impacts of farming contribute to global warming and the waste produced may pollute the groundwater and oceans if it is not properly disposed of (Pimentel & Pimentel, 2003).

Figure 1

Protein Consumption in all the World's Regions (Ranganathan et al., 2016)



Economic sustainability: Economically, meat production as is practiced in the Western world today is not sustainable (Arvidsson Segerkvist et al., 2020). Meat is offered as cheaply as possible, oftentimes even cheaper than certain vegetables, even though the animal ate farmed crops and drank water meaning the farmer had to put more money and resources into the animal than came out. (Arvidsson Segerkvist et al., 2020). This is only possible for farmers due to being heavily subsidized by the respective government, cheap labour and economies of scale by keeping the animals in mass stocks (Arvidsson Segerkvist et al., 2020).

Social sustainability: The social sustainability dimension not only focuses on humans but also animal welfare (Arvidsson Segerkvist et al., 2020). While there are also issues with badly paid workers, these are overall not better or worse than in other forms of farming around the world (Arvidsson Segerkvist et al., 2020). The main problem lies in the treatment of the livestock which includes unhygienic living conditions, over-use of medication and exposure to stress (Arvidsson Segerkvist et al., 2020).

Since these issues are well known and have been the topic of numerous publications, efforts have been made to make animal farming and especially meat production more sustainable (Galanakis, 2019). However, industrial livestock farming cannot be fully sustainable on its current scale due to the amount of waste it produces and the resources it consumes (Horrigan et al., 2002).

1.1.1. Sustainable meat production

As mentioned prior, meat production is usually not practiced in an environmentally sustainable manner. However, it must be said that sustainability not only includes the environmental aspect but also economic and social sustainability (Purvis et al., 2018).

This research focuses on environmental sustainability as social and economic sustainability are less problematic in the European Union (Agovino et al., 2019). For example, subsidies given to farmers by the government ensure that these farms can continuously produce and survive while the meat is sold cheaply in supermarkets (Agovino et al., 2019). Furthermore, subsidies as well as other social benefits like cheap health care, minimum wage, and cheap or free education are methods of trying to give equal opportunities to everyone along the supply chain and thus creating social sustainability (Agovino et al., 2019).

One way of farming more sustainably is to integrate the cattle into the crop rotation (Galanakis, 2019). This not only creates more biodiversity but also reduces costs for the farmer to buy feed as well as optimizes food production (de Faccio Carvalho et al., 2021).
Another method to become more environmentally sustainable is to mainly use by-products from other agribusinesses as feed to finish the animals (Galanakis, 2019). That way, land can be used to grow food crops for humans while the parts that are not digestible by humans are fed to animals. Especially ruminants are specialized in turning high-fibrous feed into meat and other products for human use (Galanakis, 2019).
One last option is the use of so-called meat extenders, substances with high protein content based on plants or mushrooms, to create new meat products with reduced meat content (Pintado & Delgado-Pando, 2020). However, this would only work for processed products and thus only have a limited effect on increasing the sustainability of meat production (Pintado & Delgado-Pando, 2020).

1.2. Meat (protein) alternatives

The term meat alternative commonly refers to products that try to imitate the taste and texture, as well as the other sensory attributes of meat products (Van der Weele et al., 2019). Most frequently, the imitated products are processed foods such as burger patties, sausages, meatballs, cut-up chicken, or breaded chicken (Van der Weele et al., 2019).
The alternatives of these meat products are either vegetarian or completely vegan and derive their protein from plant sources instead of animals (Van der Weele et al., 2019). Furthermore, there are also plant-based alternatives for cheese and other milk products, as well as eggs which along with the meat alternatives can be put together as “protein alternatives” (Van der Weele et al., 2019).

1.2.1. Sustainable production of meat (protein) alternatives

Though methods exist to increase the environmental sustainability of animal farming and meat production, these increments are limited to improving overall efficiency and do not necessarily reduce the negative effects animal farming has on the environment (Galanakis, 2019). This will not be sufficient for the future though, as more food will need to be produced due to the world’s population increasing (Galanakis, 2019).

As mentioned previously, one major issue with meat production is land, energy, and water usage (Pimentel & Pimentel, 2003). This not only includes the land, energy, and water the animal directly needs but also the resources that are used to grow crops to feed those animals (Pimentel & Pimentel, 2003). Therefore, by logical deduction, energy, land, and water usage

would decrease if humans would use the crops to feed themselves and as such need fewer animals for food.

One of the major focuses of developing meat alternatives is to make them nutritiously similar to meat which is usually achieved by using protein-rich ingredients like soy and other pulses (Zhang et al., 2021). However, using soy can also have adverse effects on the environment as it is usually cultivated in tropical areas that have been subject to deforestation (World Wildlife Fund, n.d.). Furthermore, social sustainability may not be given on small farms in those regions as they are being used as cheap labour by bigger companies (World Wildlife Fund, n.d.).

In conclusion, plant-based alternatives are more sustainable than meat, however, it is important to continuously look for better, more sustainable approaches (Pimentel & Pimentel, 2003). For example, insects and algae are being used in recent development approaches as protein-rich, more sustainable meat substitutes (Pintado & Delgado-Pando, 2020).

1.3. Novel foods and consumer acceptance

Human food in general is subject to the EU General Food Law Regulation (Mendes et al., 2022). Furthermore, the EU Commission devised an Implementing Regulation which established the list of novel foods (European Commission, n.d.-b). According to that regulation, before a novel food can be placed on the EU market, it must first be authorized by the Commission after it has been assessed for any risks by the European Food Safety Authority (EFSA) (European Commission, n.d.-a).

According to the EU regulation, novel foods are defined as “foods that have not been consumed to a significant degree by humans in the EU before 15 May 1997” (EUbusiness, 2022). The list, therefore, includes newly developed foods, food produced with new technologies or new production processes, and foods that have been traditionally consumed outside the EU, the latter would include algae (EUbusiness, 2022). For such food that has been consumed traditionally outside the EU for more than 25 years, a notification system exists which facilitates the product’s entry into the EU market (European Commission, n.d.-a). Examples of novel foods in the EU include algae as well as insect products as they have not been consumed for long enough in the EU.

When it comes to trying novel foods such as algae, different factors may guide the consumers' decision or willingness to accept or reject it (Steptoe et al., 1995). However, these factors to accept or reject novel foods, do not solely depend on product-related attributes and rational factors (Hartmann & Siegrist, 2016). Instead, acceptance or rejection is often determined by emotional and cultural beliefs (Orsi et al., 2019).

Many of the aforementioned factors have been identified by recent studies, specifically in the EU (Van der Pas, 2017). For this research, eight factors for the acceptance and rejection of foods have been chosen to not exceed the scope of this report.
The following sub-chapter will describe these factors in detail, they include the following:

- Convenience and availability
- Familiarity and personal experience
- Health consciousness
- Environmental awareness
- Food neophobia
- Sensory appeal
- Disgust
- Price

(Van der Pas, 2017)

1.3.1. Influence factors to accept or reject novel foods

Convenience and availability: Foods from many different cultures make food choices in the EU and other Western countries plentiful. Especially convenient food, that is food which saves time and facilitates preparation, has affected people's consumption around the globe (Brunner et al, 2010). When products are easier to prepare and can be readily used and purchased, customers are more inclined to purchase them (Steptoe et al., 1995).

Familiarity and personal experience: Acceptance and choice of foods are often formed based on the consumer's familiarity with the product (Aldridge et al., 2009). Familiar foods are usually preferred over unfamiliar ones and thus more likely to be consumed (Cooke, 2007). Therefore, the selection of certain food over others is associated with the consumer's familiarity with the product. In the context of food choice motives, familiarity involves the importance of food being distinct and known, which are those foods a person typically eats, and thus it measures the likeliness of consumers only buying foods they already know (Aldridge et al., 2009).

Health consciousness: Worries about health can have a big impact on consumers' food acceptance or rejection, meaning that food choices vary for people who have health concerns compared to those who do not or worry less about their health (Sun, 2008). Hence, health consciousness has significant relevance to determine acceptance or rejection of food.

Environmental awareness: As mentioned in the previous chapter, meat alternatives are considered to be more environmentally sustainable than comparable meat products. Sustainability in general, as well as sustainable food consumption, are becoming increasingly influential (Verain et al., 2012). A rising number of consumers consider environmental concerns, and many are deciding on more ecological and environmentally sustainable food products (Fraj & Martinez, 2007).

Food neophobia: One of the most important reasons to decline novel foods is food neophobia (Pliner & Hobden, 1992). It can be described as the reluctance to try exotic and unknown foods (Barrena & Sánchez, 2013). In that regard, the more reluctant an individual is to try such unexplored food, the more food neophobic is that individual (Tuorila et al., 2001). Conversely, that means the more food neophobic a person is, the less willing they are to try novel foods.

Sensory appeal: Additionally to food neophobia, a product's sensory appeal is another crucial factor to reject or accept foods in Europe (Magnusson et al., 2001). The sensory appeal includes a food's taste, texture, smell and looks. If food is expected to have a satisfactory taste and/or smell, acceptance is higher, and the food is eaten more frequently (Rozin, 1987).

Disgust: Disgust is a common feeling regarding (novel) foods (Rozin et al., 2008). It is often linked to the anticipated sensory appeal of a food (Rozin et al., 2008). Therefore, disgust towards food is an emotional reaction to something repellent or unpalatable (Dolezalova, 2015). Furthermore, it may be an evolutionary mechanism to refrain from consuming unfamiliar and thus potentially poisonous food (Dolezalova, 2015).

Price: As with most customer goods, price is also an important factor when it comes to food choices (Honkanen & Frewer, 2009). Studies have shown that the cost of food can dictate customers' selection of food (Blanck et al., 2007). Not only do consumers try to buy their food for the minimum price, but some even look at how much food they can purchase for a certain amount of money (Burns et al., 2013). Therefore, the price of a product must be deemed fair at least by customers to make a purchase decision.

1.4. Edible algae and their nutritional values

There are many known edible algae species, however, most likely there are even more that have not been discovered yet. In Europe, over 150 native species of algae are edible while over 650 species of edible seaweed are known worldwide (Mendes et al., 2022). Certain cultures have consumed algae, in particular seaweed, for many generations, mainly in Asia (Vigani et al., 2015). Some of those more famous algae have made it to Western countries, for example Wakame and Nori, and are found in many sushi restaurants.

Algae can be divided into two broad categories: microalgae and macroalgae (Mendes et al., 2022). Microalgae are small organisms that can perform photosynthesis which are commonly referred to as phytoplankton in the ocean where it is food for fish and other marine animals (Mendes et al., 2022). Macroalgae, also known as seaweed, can be described as aquatic plants as they also perform photosynthesis and at times resemble terrestrial plants (Mendes et al., 2022).

Many algae species have nutritional and health benefits for human consumption (Wells et al., 2016). These benefits relate to the algae's biochemical composition as well as their bioactive properties which vary greatly between different species or classes (Wells et al., 2016). Those properties include isolated polysaccharides, proteins, polyphenols, carotenoids as well as n-3 long-chain polyunsaturated fatty acids, all of which are high-value bioactive compounds (Mendes et al., 2022). Regarding algae use in meat alternatives, they would provide higher nutritional value than other meat alternatives that mainly focus on protein (Van der Weele et al., 2019) while algae add an array of healthy nutrients.

Different species of algae may need different environmental conditions for optimal growth and have different nutritional contents (Metsoviti et al., 2019). While most algae need sun and water to grow, varying amounts of each impact the nutritional value of the algae (Metsoviti et al., 2019). Research in this field found that the lipid content of different algae

species increases with increased temperature and light intensity while at the same time the nitrogen-free extractable decreases (Metsoviti et al., 2019). Therefore, when producing algae, it is important to research the specific requirements for the desired species to accomplish optimal growth and use the necessary resources efficiently.

Edible algae in the form of seaweed may be used as a whole food e.g., wakame as a salad (REWE, n.d.). From the author's experience, it may also be used as a component of a food product to add a seafood-like taste, for example in pasta sauces or similar vegan products. Microalgae may be used as food or feed supplements to add protein (KoRo, n.d.) or as a colour agent, e.g., the blue colour of spirulina in smoothies (Innocent, n.d.).

1.4.1. Algae in the European Union

As mentioned prior, over 150 species of algae in Europe are considered edible, 14% of which are microalgae and 86% macroalgae (Mendes et al., 2022). However, so far, the EU only approved 30 of those algae species as novel foods and added them to the list (Mendes et al., 2022). Examples of approved macroalgae include Undaria pinnatifida (commonly known as Wakame) and Pyropia tenera and Pyropia yezoensis (commonly known as Nori) which are used in Asian cuisine, especially in Sushi restaurants (Araujo & Peteiro, 2021). Approved microalgae species include Arthrospira platensis, Arthrospira fusiformis, and Arthrospira maxima (commonly referred to as Spirulina), as well as Chlorella pyrenoidosa, Chlorella sorokiniana, and Chlorella vulgaris (commonly referred to as Chlorella), which are mostly found in food supplements (Araujo & Peteiro, 2021). Moreover, some algae species have been consumed in Europe since before the industrial revolution, usually in fisher communities and isolated islands (Lentini & Venza, 2007). These species are not required to be listed as novel foods (Araujo & Peteiro, 2021). Despite the history of algae consumption in Europe and an increasing number of algae species being added to the EU's novel foods list, for most people in the EU algae are not part of the normal diet, regardless of their nutritional properties (Araujo & Peteiro, 2021).

1.5. Knowledge gap and research objective and questions

1.5.1. Knowledge gap in the state of the art

In general, the topic of algae as human food has been discussed for some time now. Mainly because of the expected benefits for the environment as well as the high nutritional value most edible algae species hold. As some studies suggest, the market for edible insects in Europe will grow in the future (Mendes et al., 2022).
Though the overall topic is not new, it is unclear whether consumers across Europe have the same or similar knowledge and opinions on edible algae. Studies from the UK and Spain have shown that consumers there generally lack knowledge about algae (Lafarga et al., 2021; Mellor et al., 2022). However, these studies have also shown that consumers' perception of algae is generally positive regarding environmental sustainability (Lafarga et al., 2021; Mellor et al., 2022). Moreover, according to the Spanish study, the results are expected to be similar if not the same for other European countries (Lafarga et al., 2021).

To capture a growing market in Europe, it is imperative to investigate consumers' knowledge and attitude toward algae. In the EU, the biggest market and country with the most inhabitants is Germany. Furthermore, the Netherlands are one of the EU's biggest food exporters as well as host to several innovative food companies, including algae producers and processors.

So far, no study has been conducted in these two countries yet, this research will close an existing knowledge gap. Furthermore, will this research provide further insights into what drives consumers to either accept or reject algae as food which can be applied to other Western countries, specifically in the European Union. Therefore, Germany and the Netherlands will be good indicators not only to test if results are indeed similar to the Spanish study but also to get a better overview of what consumers in the EU know and think about algae.

1.5.2. Research objective and questions

The objective of this research is to find out consumers' knowledge and acceptance of algae as food in Germany and the Netherlands as well as potential reasons for differences among consumers. The objective is set to help food companies determine the potential of investing in the algae market in the EU and provide ideas for more sustainable protein alternatives. Furthermore, it will provide an idea of how well-known algae as food are amongst consumers and if further education in this field is needed to grow this market. Additionally, knowing which drivers influence the consumers' acceptance or rejection of algae may give crucial insights to marketers on how to effectively advertise algae products and possibly show food companies how to best cater to the consumers of their products. Therefore, the main question for this research is: *"What is the general level of consumer knowledge and acceptance of algae as protein alternatives in the Netherlands and Germany?".*
The sub-questions for this research are:

1. How do different demographics and education levels influence knowledge of algae as food?

2. How do different demographics and education levels influence the degree of acceptance of algae as food (willingness to consume, willingness to buy)?

3. What are the drivers or determinants for the acceptance of algae-based food?

4. What are the drivers or determinants for the rejection of algae-based food?

2. Research Design and Methodology

The main tool used to conduct this research was a quantitative consumer survey. Other research has shown that using a quantitative survey or gathering qualitative information are both valid options for this kind of research (Mellor et al., 2022; Lafarga et al., 2021). However, as a precaution against the author's bias, a quantitative approach was chosen as then, the author is not interacting with the survey participants.

The survey was distributed in Germany and the Netherlands among different demographics and education levels. The survey's goal was to answer the aforementioned sub-questions to answer the main research question.

The survey was made with Google Forms and distributed exclusively online as the participants live all around Germany and the Netherlands. Accordingly, there were versions of the survey in English, German and Dutch to make sure that participants understand the questions correctly and can answer them confidently. After enough people from both countries answered the survey, the data was retrieved from the platform and further evaluated using Excel and Python. For sub-questions one and two, the Mann-Whitney or Kruskal-Wallis tests were chosen depending on the number of independent variables, while for the other two sub-questions, the chi^2-test was chosen as it looks for associations between the variables. The statistical tests used for each sub-question are described in further detail in the following sub-chapter.

The survey was spread through different social media channels and survey participants were encouraged to further spread the survey among their friends and family. At least 150 consumers from each country were surveyed to assure a valid answer to the main research question. The reason for that number is that the generally accepted minimum sample size is 100 participants to achieve a meaningful result, however, since the population of both countries together is almost 100 million, more participants will bring a more accurate result. On the other hand, anything above 150 participants seemed to be out of reach for the author with the time and tools available. The different versions of the survey can be found in appendices one to three.

Within a brief introduction, the participant was informed about the purpose and goal of the survey, as well as who is conducting the survey. This was expected to raise the participant's motivation and trust to be willing to answer the survey questions. Furthermore, the consumer data was of course kept confidential and only used for this research. The following sub-chapters will go more into detail about how each sub-question will be answered with the survey and what questions will be asked.

2.1. Sub-question 1: How do different demographics and education levels influence the consumers' knowledge of algae as food?

For the first sub-question consumers had to answer questions about their existing knowledge of algae. Most questions have multiple-choice answers. As the report aims to compare Dutch with German consumers, as well as specific demographics, the first question asks where they currently live with only two answer options, namely 'the Netherlands and 'Germany'. The next questions ask if the consumers are aware of 'Vegan meat alternatives' and that 'Algae can be used as food (supplements)', both have the answer options of 'Yes' and 'No'. The next question asks the consumers about their knowledge of the nutrient content of algae

compared to other key ingredients of meat alternatives. The question is: 'Do you think algae contain more or less protein and beneficial nutrients than other key ingredients for meat alternatives, such as soy, peas, or mushrooms?', with the answer options of 'More', 'Less' and 'I do not know'. As mentioned in section 1.4., Algae contain many different nutrients that can benefit the consumers' health, therefore, respondents prove their knowledge by answering with 'More'. The last survey question for this sub-question is 'Do you think algae production is more environmentally sustainable than the production of other key ingredients for meat alternatives, such as soy?' and the possible answers are 'Yes', 'No', and 'I do not know'. Section 1.2. describes the sustainable impact of meat alternatives. It shows that given alternatives, while more sustainable than meat production, are not all that sustainable and thus novel foods such as algae are gaining more traction due to their increased sustainability. therefore respondents prove their knowledge by answering 'Yes'.

Null hypothesis:
H_0: There is no significant difference in knowledge between Dutch and German consumers.
H_1: There is a significant difference in knowledge between Dutch and German consumers.

H_0: There is no significant difference in knowledge of algae between each of the age groups surveyed.
H_1: There is a significant difference in knowledge of algae between each of the age groups surveyed.

H_0: There is no significant difference in knowledge of algae between each gender surveyed.
H_1: There is a significant difference in knowledge of algae between each gender surveyed.

H_0: There is no significant difference in knowledge of algae between each educational level surveyed.
H_1: There is a significant difference in knowledge of algae between each educational level surveyed.

H_0: There is no significant difference in knowledge of algae between different living places surveyed.
H_1: There is a significant difference in knowledge of algae between different living places surveyed.

Statistical test: For the statistical testing of the difference in existing knowledge of algae as food between age groups, between genders, and between educational levels, the Kruskal-Wallis test was chosen as all have three or more independent variables. For the testing of the differences between different living places and different countries, the Mann-Whitney test was chosen as it has only two independent variables.

2.2. Sub-question 2: How do different demographics and education levels influence the degree of acceptance of algae as food (willingness to consume, willingness to buy)?

To answer this sub-question, first, consumers were asked questions about their age group, gender, highest educational degree, and if they live in an urban or rural area. Such questions

have been asked in similar studies for Spanish and British consumers (Mellor et al., 2022; Lafarga et al., 2021). Therefore, those questions are relevant as they allow to classify consumers in comparable factors. All these questions are multiple-choice, for the gender, the answers are 'male', 'female', 'non-binary', and 'other'. The age groups were selected according to the generations; thus, the answer options are '18-26', '27-42', '43-58', '59-80', and '>80'. For the educational degree, the categories were kept as broad as possible to be able to compare consumers of different countries with different schooling systems. The answer options are 'primary school', 'high school (not eligible for university)', 'high school (eligible for university)', 'Bachelor's', 'Master's', and 'Doctoral'. As a last question regarding the demographics, participants are asked if they live in a city or in the countryside, the answer options are 'I live in an urban area'. and 'I live in a rural area'.
The last two questions aim at the consumers' willingness to consume and buy algae products. The first survey question is: 'Would you generally be willing to consume algae if it is in a product you like?'. The emphasis here is on the fact that it would be a product that the consumer likes where algae may not be as prevalent as eating them raw. The reason for asking the question this way is to differentiate from the question leading up to the drivers which also asks if consumers would try algae. The answer options for this question are 'Yes' and 'No'. The final question asks, 'Would you purchase algae products if they become easily available at a competitive price point?'. This question asks consumers about their buying intent if algae are easily available as other surveys have shown that a high price for unknown foods is a common reason not to buy it (Mellor et al., 2022). The answer options are 'Yes, regularly', 'Yes, sometimes', and 'No, never'.

Null hypothesis:

H_0: There is no significant difference in acceptance between Dutch and German consumers.
H_1: There is a significant difference in acceptance between Dutch and German consumers.

H_0: There is no significant difference in acceptance of algae between each of the age groups surveyed.
H_1: There is a significant difference in acceptance of algae between each of the age groups surveyed.

H_0: There is no significant difference in acceptance of algae between each gender surveyed.
H_1: There is a significant difference in acceptance of algae between each gender surveyed.

H_0: There is no significant difference in acceptance of algae between each educational level surveyed.
H_1: There is a significant difference in acceptance of algae between each educational level surveyed.

H_0: There is no significant difference in acceptance of algae between different living places surveyed.
H_1: There is a significant difference in acceptance of algae between different living places surveyed.

Statistical test: As for the first sub-question, for the testing of the differences between different living places and different countries, the Mann-Whitney test was chosen as it has only two independent variables. Furthermore, for the statistical testing of the difference in willingness to consume and willingness to buy algae between age groups, between genders, and between educational levels, the Kruskal-Wallis test was chosen as all have three or more independent variables.

2.3. Sub-question 3: What are the drivers or determinants for the acceptance of algae-based food?

The third sub-question aims to answer what makes consumers want to try algae. Therefore, based on the consumers' previous answer on if they would consume algae, the participants who answered 'YES' will be forwarded to this question. The survey question asks how much certain drivers influenced their decision to consume algae. Consumers must answer with a five-point Likert scale for each driver where 1 means did not influence the decision at all and 5 means it had a big influence on the decision. The drivers are: 'Convenience', 'Familiarity', 'Awareness of health benefits', 'Environmental awareness', 'Sensory appeal' and 'Price'.

Null hypothesis:
H_0: There is no significant association between the acceptance of algae and (specific driver).
H_1: There is a significant association between the acceptance of algae and (specific driver).

Statistical test: As this sub-question looks for an association, the chi^2-test was chosen to perform the statistical test. The test is designed to examine each driver's potential influence on the acceptance of algae as food and find associations between the assigned importance of a driver and the consumer's acceptance.

2.4. Sub-question 4: What are the drivers or determinants for the rejection of algae-based food?

The last sub-question asks what keeps consumers from wanting to try algae. As for the previous sub-question, based on the consumers' previous answer on if they would consume algae, the participants who answered 'NO' will be forwarded to this question. Again, as with the previous question, it asks how much certain drivers influenced their decision to consume algae. Consumers must answer with a five-point Likert scale for each driver where 1 means did not influence the decision at all and 5 means it had a big influence on the decision. The drivers are the same again: 'Familiarity', 'Environmental awareness', 'Food neophobia', 'Sensory appeal', 'Disgust', and 'Price'.

Null hypothesis:
H_0: There is no significant association between the rejection of algae and (specific driver).
H_1: There is a significant association between the rejection of algae and (specific driver).

Statistical test: As for the third sub-question, it looks for an association between one dependent and multiple independent variables. Therefore, the chi^2-test was chosen to perform the statistical test as the test is designed to examine each driver's potential influence

of the rejection of algae as food and find associations between the assigned importance of a driver and the consumer's rejection.

2.5. Validity

This research can be repeated/reproduced with the same questions and one can expect similar results. Furthermore, the study may be repeated in other European countries by translating the survey. Overall, all measures to ensure the validity of this study will be implemented. A literature review was conducted, including at least ten institutional or peer-reviewed studies. As this is a quantitative study, the answers will be clear and unmistakable, and the author's potential bias will have less of an influence on the results.

3. Results

After the survey was published and spread online, a total of 379 participants responded. Out of all the responses, 181 come from the Netherlands while 198 respondents are from Germany. The test statistics for the different analyses can be found in the appendix. To assure the validity of the results, a confidence interval of 0,95 was chosen. The confidence interval can be described as the expected range of values for an unknown parameter. Thus, to have statistical significance, the result must be smaller or equal to p=0,05).

3.1. Differences in knowledge

In order to find out if there are any differences in knowledge about edible algae between chosen demographical factors, different statistical tests have been chosen. These chosen tests are Mann-Whitney and Kruskal-Wallis. A more in-depth explanation as to why these tests have been chosen can be found in chapter two. To compare the consumers' knowledge, answers to three knowledge-related questions are compared with each other. These questions ask about knowledge regarding algae being used as food, the nutritional benefits of algae, and the environmental impacts of algae.

3.1.1. Knowledge and country

The first part of the first sub-question asks whether there is a difference in knowledge of algae between German and Dutch customers. Out of all the participants (n=379), around 48% are Dutch (n=181) while the remaining 52% are German (n=198). Using the Mann-Whitney test, it was calculated that there is no significant difference in knowledge that algae can be used as food (Germany: n=172, Netherlands: n=145) and knowledge about the nutrient content of algae (Germany: n=104, Netherlands: n=91). However, a significant difference (p=0,05) was determined for knowledge about the environmental sustainability (Germany: n=128, Netherlands: n=99).

3.1.2. Knowledge and gender

This part looks for differences in knowledge between genders. In Germany, around 40% of the participants are male (n=80) and 60% are female (n=118). No person has responded to be non-binary, therefore, instead of the Kruskal-Wallace test, the Mann-Whitney test was chosen. After the test, no significant differences in knowledge about algae being used as food (Female: n=104, Male: n=68), nutritional benefits of algae (Female: n=64, Male: n=40), and their environmental sustainability (Female: n=76, Male: n=52) could be found.
In the Netherlands, around 40% of respondents are male (n=72) while 60% indicated to be female (n=108). One person specified to be non-binary and thus was excluded from the test. As it has been done for the testing of German consumers, the Mann-Whitney test was chosen. The result shows that there is a significant difference (p=0,04) in knowledge that algae can be used as food (Female: n=81, Male: n=63), as well as in knowledge of the environmental sustainability of algae (p=0,00001), (Female: n=45, Male: n=54) while no significant difference could be found in knowledge about the nutritional benefits of algae (Female: n=48, Male:

n=42). Males in the Netherlands have more knowledge when it comes to algae being edible and their environmental sustainability.

3.1.3. Knowledge and age group

In this part, differences in knowledge between age groups were tested. In Germany, around 36% of the participants are in the age group 18-26 (n=72), 23% are in the age group 27-42 (n=46), 26% are in the age group 43-58 (n=52), 13% are in the age group 59-80 (n=26), and around 1% is in the age group above 80 (n=2). Using the Kruskal-Wallis test, no significant differences in knowledge could be found between the age groups. Table 1 shows the absolute numbers of responses from German consumers who have knowledge, divided into the age groups.

Table 1

Knowledge between age groups in Germany (absolute numbers of respondents having knowledge)

	18-26	27-42	43-58	59-80	>80
ALGAE AS FOOD	58	40	46	26	2
NUTRITION	32	24	28	18	2
SUSTAINABILITY	50	32	28	16	2

In the Netherlands, around 75% of the participants are in the age group 18-26 (n=135), 12% are in the age group 27-42 (n=21), 7% are in the age group 43-58 (n=12), 7% are in the age group 59-80 (n=12), and around 0,5% is in the age group above 80 (n=1). Using the Kruskal-Wallis test, no significant differences could be found. Table 2 shows the knowledgeable respondents per age group in the Netherlands.

Table 2

Knowledge between age groups in the Netherlands (absolute numbers of respondents having knowledge)

	18-26	27-42	43-58	59-80	>80
ALGAE AS FOOD	108	18	9	9	1
NUTRITION	69	6	6	9	1
SUSTAINABILITY	72	15	6	6	0

3.1.4. Knowledge and living place

This part of the sub-question asks whether there is a difference in knowledge between people living in urban areas versus rural places. In Germany, most respondents (85%) come from an urban area (n=170) while the remaining 15% answered to live in a rural part of the country (n=28). Using the Mann-Whitney test it was determined that there is a significant difference (p=0,03) when it comes to knowing that algae can be used as food (Urban: n=144, Rural: n=28). People in rural areas have more knowledge. No significant differences could be found about the nutritional benefits (Urban: n=88, Rural: n=16), and environmental sustainability (Urban: n=108, Rural: n=20).
In the Netherlands, about 52% of the respondents are from the countryside (n=94) while 48% come from an urban area (n=87). The statistical testing shows that there is a significant

difference (p=0,0005) in knowledge of the environmental sustainability of algae (Urban: n=36, Rural: n=63). People in rural areas have a higher knowledge. No significant differences could be found about the nutritional benefits (Urban: n=45, Rural: n=46), and algae being used as food (Urban: n=69, Rural: n=76).

3.1.5. Knowledge and education level

The last part of the first sub-question aims to determine differences in knowledge between different educational levels. In Germany, 8% have indicated to have a high school degree without being eligible for university (n=16), 29% have a high school degree and are eligible for university (n=58), 25% have a bachelor's degree (n=50), 33% have a master's degree (n=66), and 4% have a doctoral (n=8). Using the Kruskal-Wallis test, no significant differences could be found. Table 3 displays the absolute numbers of responses from German consumers who have knowledge, divided by educational level.

Table 3

Knowledge between educational levels in Germany (absolute numbers of respondents having knowledge)

	HIGH SCHOOL (N.E.)	HIGH SCHOOL (E)	BACHELOR'S	MASTER'S	DOCTORAL
ALGAE AS FOOD	16	50	40	60	6
NUTRITION	8	30	28	34	4
SUSTAINABILITY	8	38	32	42	8

In the Netherlands, 17% have indicated to have a high school degree without being eligible for university (n=31), 13% have a high school degree and are eligible for university (n=24), 48% have a bachelor's degree (n=87), 22% have a master's degree (n=39), and no respondent indicated to have a doctoral degree. The Kruskal-Wallis determined a significant difference in knowledge of nutrient content (p=0,04) and sustainability of algae (p=0,01). Generally, higher education has more knowledge, and the lowest education level has significantly less knowledge than the others. Table 4 shows the absolute numbers of knowledgeable Dutch respondents by educational level.

Table 4

Knowledge between educational levels in the Netherlands (absolute numbers of respondents having knowledge)

	HIGH SCHOOL (N.E.)	HIGH SCHOOL (E)	BACHELOR'S	MASTER'S
ALGAE AS FOOD	25	18	69	33
NUTRITION	10	9	51	21
SUSTAINABILITY	9	15	54	21

3.2. Differences in acceptance

The second sub-question is looking to find out if there are any differences in acceptance of edible algae between chosen demographical factors. For that, different statistical tests have been chosen. These chosen tests are Mann-Whitney and Kruskal-Wallis. As for the first sub-question, a more in-depth explanation as to why these tests have been chosen can be found in chapter two. To compare the consumers' acceptance, answers to two questions are compared with each other. These questions ask whether consumers would try algae as well as if they would purchase algae products.

3.2.1. Acceptance and country

This first part looks to find differences in acceptance of algae as food between German and Dutch consumers. As was determined for the knowledge part, around 48% of the respondents are Dutch (n=181) and 52% are German (n=198). Using the Mann-Whitney test, no significant difference in acceptance to try algae (Germany: n=186, Netherlands: n=174), as well as to purchase algae (Germany: n=184, Netherlands: n=172) could be found.

3.2.2. Acceptance and gender

This part of the sub-question looks to find differences in acceptance between the different genders. In Germany, again, around 40% of the respondents are male (n=80) and 60% are female (n=118). Using the Mann-Whitney test a significant difference (p=0,02) could be found in willingness to purchase algae products (Female: n=114, Male: n=70) while no significant difference (p=0,06) could be found in acceptance to try algae (Female: n=114, Male: n=72). Females are more willing to purchase algae.
In the Netherlands, also 40% of the respondents are male (n=72) and around 60% are female (n=108) while one person indicated to be non-binary. By using the Mann-Whitney test, no significant differences could be found in willingness to try algae (Female: n=105, Male: n=69) and willingness to purchase them (Female: n=105, Male: n=66).

3.2.3. Acceptance and age group

For this part, differences in acceptance between age groups were tested. In Germany, around 36% of the participants are in the age group 18-26 (n=72), 23% are in the age group 27-42 (n=46), 26% are in the age group 43-58 (n=52), 13% are in the age group 59-80 (n=26), and around 1% is in the age group above 80 (n=2). Using the Kruskal-Wallis test, a significant difference in acceptance to try algae could be found (p=0,004). The highest acceptance can be found among the youngest and oldest consumers, while the lowest acceptance is among people between 59 and 80 years old. Table 5 shows the absolute numbers of German consumers who are willing to try and purchase algae products divided into the given algae groups.

Table 5

Acceptance between age groups in Germany (absolute numbers of respondents accepting algae)

	18-26	27-42	43-58	59-80	>80
TRYING	70	38	52	24	2
PURCHASING	70	40	50	22	2

In the Netherlands, around 75% of the participants are in the age group 18-26 (n=135), 12% are in the age group 27-42 (n=21), 7% are in the age group 43-58 (n=12), 7% are in the age group 59-80 (n=12), and around 0,5% is in the age group above 80 (n=1). Using the Kruskal-Wallis test, significant differences could be found in acceptance to try ($p=2,16e^{-13}$) and acceptance to purchase (p=0,00001). The lowest acceptance in both categories was found among people aged between 27 and 42. The highest acceptance in both categories is found in two age groups, namely 43-58 and 59-80. Table 6 displays the absolute numbers of accepting respondents in the Netherlands divided into the age groups.

Table 6

Acceptance between age groups in the Netherlands (absolute numbers of respondents accepting algae)

	18-26	27-42	43-58	59-80	>80
TRYING	135	15	12	12	0
PURCHASING	132	15	12	12	1

3.2.4. Acceptance and living place

In this part, differences in acceptance of algae between different living places were tested. In Germany, 85% of the respondents live in an urban area (n=170) and 15% come from the countryside (n=28). With the Mann-Whitney test, no significant difference could be found in acceptance to try (Urban: n=160, Rural: n=26), and acceptance to purchase algae (Urban: n=158, Rural: n=26).
In the Netherlands, about 52% of the participants are from the countryside (n=94) while 48% come from an urban area (n=87). Significant differences in acceptance could be found using the Mann-Whitney test, p=0,01 for willingness to try (Urban: n=87, Rural: n=87), and p=0,003 for willingness to purchase (Urban: n=87, Rural: n=85). People in urban areas are more accepting of algae as food.

3.2.5. Acceptance and educational level

This part of the sub-question looks for differences in acceptance among different educational levels. Same as for the knowledge, in Germany, 8% of respondents indicated to have a high school degree without being eligible for university (n=16), 29% have a high school degree and are eligible for university (n=58), 25% have a bachelor's degree (n=50), 33% have a master's degree (n=66), and 4% have a doctoral (n=8). Using the Kruskal-Wallis test, there is a significant difference in willingness to purchase algae products (p=0,02). The differences, however, do not correspond with a higher educational degree as the lowest degree has the highest willingness to try and purchase while the lowest willingness to try is among master's degree respondents and the lowest willingness to purchase is among respondents with a

doctoral. Table 7 gives insights into the total numbers of accepting respondents in Germany by educational level.

Table 7

Acceptance between educational levels in Germany (absolute numbers of respondents accepting algae)

	HIGH SCHOOL (N.E.)	HIGH SCHOOL (E)	BACHELOR'S	MASTER'S	DOCTORAL
TRYING	16	54	48	60	8
PURCHASING	16	54	50	58	6

In the Netherlands, 17% have indicated to have a high school degree without being eligible for university (n=31), 13% have a high school degree and are eligible for university (n=24), 48% have a bachelor's degree (n=87), 22% have a master's degree (n=39), and no respondent indicated to have a doctoral degree. The Kruskal-Wallis test determined a significant difference for the willingness to try algae (p=0,02) and the respondents' willingness to purchase algae products (p=0,007). Similar to German respondents, these differences do not correspond with the level of education. The lowest acceptance to try algae is among high school graduates eligible for university and the lowest acceptance to buy algae products was found among respondents with a master's degree. Table 8 displays the absolute numbers of acceptance among Dutch respondents, divided by educational level.

Table 8

Acceptance between educational levels in the Netherlands (absolute numbers of respondents accepting algae)

	HIGH SCHOOL (N.E.)	HIGH SCHOOL (E)	BACHELOR'S	MASTER'S
TRYING	30	21	87	36
PURCHASING	31	24	84	33

3.3. Association between drivers and acceptance or rejection of algae

To determine whether certain drivers have an impact on the acceptance or rejection of edible algae each driver will be tested against the consumers' willingness to try algae. For that, the Chi^2 test of independence was chosen as it tells if a significant association exists between the driver and the respondents' willingness to eat algae.
Before going into the results, it is important to explain that only very few respondents were unwilling to try algae. Therefore, the results may not be as precise as desired, however, it shows that overall willingness to try algae is relatively high. In Germany, only around 6% of the respondents were unwilling to try algae (n=12). In the Netherlands, even fewer respondents rejected the idea of trying algae with around 4% saying no (n=8).

3.3.1. German consumers

Convenience: For the driver "convenience", a significant association could be determined ($p=5,73e^{-16}$). This means that people consider the product's convenience in their choice to try algae.

Familiarity: When it comes to personal experience with similar products, a significant association was found ($p=1,73e^{-7}$). Therefore, German consumers base their decisions also on familiarity with the product.

Health benefits: The expected health benefits of a product seems to be the most important driver for German consumers to try algae. This driver has the highest association with the willingness to try algae ($p=2,97e^{-35}$).

Environmental awareness: The environmental impacts of algae production also have a big influence on the consumer's decision to try algae. Using the Chi^2 test, a significant association was found ($p=1,98e^{-13}$).

Sensory appeal: Sensory appeal is the only driver that does not show a significant association with the consumers' willingness to try algae ($p=0,33$). Therefore, people do not necessarily consider the product's sensory appeal when deciding to try algae.

Price: The price of the product does have an impact on consumers' decision to try algae. A significant association was found using the Chi^2 test ($p=6,01e^{-15}$).

Food neophobia: The fear of trying new foods does impact the consumers' decision to try algae. There is a significant association between the driver and the respondents' willingness to try ($p=1,18e^{-20}$).

Disgust: Disgust also has a big impact on the consumers' choice to try algae ($p=3,66e^{-35}$). Therefore, if consumers perceive a product as disgusting, they will not try it.

Due to the lack of respondents answering with "no" to the question if they are willing to try algae, the author chose to perform a Kruskal-Wallis test to see if there are significant differences between the driver's means. The test result showed that there are significant differences among respondents who are willing ($p=2,94e^{-12}$), as well as respondents who are unwilling to try algae ($p=0,004$). It showed that perceived health benefits are most influential, while familiarity with similar products was the least influential among respondents who are willing to try algae. For respondents who are unwilling to try algae, the most influential is disgust while the least influential is familiarity with similar products.

3.3.2. Dutch consumers

Convenience: Convenience plays a big role for Dutch customers when deciding to try algae. Using the Chi^2 test, a significant association could be found ($p=4,55e^{-38}$).

Familiarity: A significant association was found for the driver familiarity ($p=7,92e^{-6}$). Thus, Dutch consumers base their decision to try algae also on personal experience with similar products.

Health benefits: The expected health benefits of a product also influence the consumers' decision to try food. As such, a significant association between the driver and the acceptance of algae was determined ($p=1,77e^{-19}$).

Environmental awareness: Environmental concerns have an impact on the respondents' acceptance to try algae. This was confirmed by the significant association from the statistical testing (p=0,002).

Sensory appeal: As could be seen with German consumers, sensory appeal is the only driver that does not show a significant association with respondents' decision to try algae (p=0,34). Therefore, consumers do not seem to consider the product's sensory appeal when making a decision to try algae.

Price: Between the product's price and consumers' willingness to try algae, a significant association was found ($p=3,12e^{-22}$). This concludes that consumers take into account the product's price when making the decision to try algae.

Food neophobia: The fear of trying new foods has a big impact on Dutch consumers' decision to try algae. There is a significant association between the driver and the respondents' willingness to try ($p=1,33e^{-35}$).

Disgust: Disgust has the biggest impact on the consumers' choice to try algae ($p=4,97e^{-40}$). Thus, consumers that perceive a product as disgusting will not try it.

As described in the previous section, the lack of respondents that are unwilling to try algae may impact the accuracy of the test results. Therefore, a Kruskal-Wallis test was performed to compare the drivers for acceptance as well as the ones for rejection to try algae.
The test results made clear that there is a significant difference among the drivers for acceptance of trying algae (p=0,00002). Moreover, there is also a significant difference among the rejection drivers (p=0,009). Most important for acceptance was the price of the product while sensory appeal was the least important. As for rejection, Sensory appeal was actually the most important driver and price the least important.

4. Discussion of Results

4.1. Reflection on methods used

Overall, the methods used were chosen correctly at the time considering the lack of knowledge about the survey's results beforehand. However, in hindsight, some changes could have been made to facilitate the work and assure more valid results.

Starting with the survey, it would have facilitated later examination of the results if only one survey was made in English, containing the translation into German and Dutch. Another option could have been to have two surveys in English, one with added German translation and the other with a translation into Dutch. Like this, the surveys could have been easily combined and the data cleaned. The way it was done, however, the three surveys had to first be separated into German and Dutch consumers, then all translated back to English and finally all of the German and Dutch consumers combined in a new dataset.

Distributing the survey exclusively online was the right choice as it saves paper and facilitates the analysis as no results had to be typed in manually. However, getting to the desired number of respondents, more or less evenly distributed among the demographic groups, was more difficult than expected. Using different Facebook groups did help to an extent, however, much fewer people care for someone's survey if they do not get a reward. Furthermore, only a few people distributed the survey further among their family and friends even when specifically asked. Even websites like SurveyCircle, where people can post surveys and participate in other ones, did not bring the desired results. Lastly, the survey was not online for long enough at first which made graduating before June unfeasible.
For future surveys, it will be important to find channels where more people can be reached at once and it will have to stay open for a longer time. An option could be to work together with a retailer or other companies and use their customer base, however, that will probably require certain financial means to get started.

For analyzing and interpreting the results, using Python was helpful. It makes it easy to clean the data and create new data frames according to the analysis needs. Furthermore, it helps to create charts and diagrams, and everything can be done with the same medium. When it comes to statistical testing, however, using SPSS may be more advantageous as it was made for that purpose and the results are generally more extensive and understandable to the average person. Furthermore, it was more difficult to get help on the testing with Python as more people at the university know about working with SPSS.

Using the Mann-Whitney and Kruskal-Wallis tests to analyze the significant differences in knowledge and acceptance of algae among different demographic factors was the right choice. The tests are made for these kinds of statistics and worked well. However, again, using SPSS would have possibly been more comprehensive and may have been overall less work to be done by hand, such as calculating the means of the data.

For the last two sub-questions, it became evident during the testing that the survey should have been structured differently and the drivers should not have been divided according to the previous answer if the respondents would be willing to try algae. The way it was done,

the influence ranking of the drivers first had to be combined manually which cost time and also led to some inaccuracies with the drivers that were only shown to one group of respondents. Furthermore, the last two sub-questions could have been combined into one to look for drivers influencing the willingness to try algae instead of acceptance and rejection separately.
Using the Chi^2 test to look for associations between a given driver and the respondents' willingness was the right choice to go with before the survey results came in. Afterwards, it turned out that only a very small percentage of people rejected the idea of trying algae which meant that the test results cannot be deemed accurate. Therefore, a Kruskal-Wallis test was performed to look for significant differences among the drivers and see which ones have a bigger influence on the consumers' decision to try algae than others.

4.2. Interpretation of results

4.2.1. Knowledge of algae

The first sub-question aims to find how high the existing knowledge about edible algae in Germany and the Netherlands is, as well as if certain demographic factors influence that knowledge. Those factors include the age group, education level, gender, and the living place of the respondents. Overall knowledge about algae being used as food is high in both countries with 87% of respondents in Germany and 80% in the Netherlands. Knowledge about the nutrient content and environmental sustainability is less high, however, in both countries above 50%.

Between the two countries, no significant difference in knowledge could be determined when it comes to knowing that algae can be used as food and knowledge about nutrient content. This means both countries have similar levels of knowledge among consumers. However, regarding knowledge of the environmental sustainability of algae, a significant difference was found. When comparing the means of the two countries, it shows that German consumers generally have more knowledge about algae. It is questionable why this is the case as both countries are frontrunners when it comes to innovative food products and new protein sources. However, it may have to do with the fact that the topic of edible algae has been covered more in German media. Furthermore, another reason could be that the German respondents included higher educated people and largely come from bigger cities.

Regarding knowledge differences between the genders male and female, some differences could be found in the Netherlands. In Germany, however, no significant differences could be determined between the genders.
In the Netherlands, men generally have a higher knowledge about algae, significantly so when it comes to algae being used as food and the environmental sustainability of algae. Though, also about the nutrient content males know more. The reason for that is questionable as in Germany the genders have similar knowledge. Moreover, in Germany, females have slightly higher knowledge, though not significantly. A reason could lie in higher interest among Dutch males in that topic or possibly more open-mindedness. Another explanation could be that the males wanted to "show off" their knowledge and responded that they know more while in reality, they do not. Further investigation would be needed to clarify this.

The demographic factor of “living place” distinguishes between respondents from cities with more than 10.000 inhabitants and their metropolitan areas on the one hand, and respondents from rural places with less than 10.000 inhabitants on the other. For Germany, most respondents come from urban areas and only 14% are from the countryside. The Dutch respondents are more evenly divided between the two categories.
Among German consumers, people living in rural places know significantly more about algae being edible while also having slightly higher knowledge about the environmental sustainability and the nutrient content of algae. This significant difference can possibly be attributed to the small number of respondents from the countryside as there was not one respondent that did not claim to have knowledge about algae being edible. However, it is interesting to see this difference as it comes unexpectedly. the expectation was that people in cities would be more informed due to more variety in food stores and restaurants, as well as being more likely to have universities. On the other hand, in Germany, high school education in the countryside is oftentimes better which can be seen in results of school-comparing tests among same-aged high schoolers.
In the Netherlands, knowledge is more evenly distributed. People in urban areas have slightly more knowledge about the nutrient content of algae while respondents from the countryside have marginally higher knowledge about algae being used as food. However, there was a significant difference in knowledge about the environmental sustainability of algae, showing that people in rural areas have higher knowledge. Overall, this can be interpreted that respondents from the countryside care more about sustainability and thus have higher knowledge in that area.

The age groups have been formed according to the generations and look as follows: 18-26, 27-42, 43-58, 59-80, and lastly >80. Looking at the age groups, in Germany the main age groups have been relatively evenly represented, excluding people older than 80 years old. In the Netherlands on the other hand, over 74% are aged between 18 and 26 years old, thus possibly biasing the results.
In Germany, no significant difference was found between the age groups, showing a relatively even knowledge base among all ages. However, when looking at the means of each age group it looks like knowledge slightly increases with higher age. This is unexpected as algae as food have become a topic of discussion only quite recently and thus more of a talking point among younger people.
Among Dutch consumers, there is no significant difference in knowledge between the age groups either. However, contrary to German consumers there is no evidence that higher age equals higher knowledge. Instead, the distribution is more random.

Lastly, the demographic factor educational level has been divided as follows: High School graduation (non-eligible for university), high school graduation (eligible for university), bachelor’s degree, master’s degree, and doctoral degree. Among German respondents, most have a master’s degree while most Dutch respondents have a bachelor’s degree. Apart from the doctoral degree, the education levels of respondents from both countries are distributed relatively evenly. Surprisingly, no Dutch respondent has a doctoral degree.
Among German respondents, there is no significant difference in knowledge between the education levels. Furthermore, there is no evidence of higher education equalling higher knowledge which is surprising. Education was expected to have an influence on knowledge; however, higher education oftentimes specializes in a certain topic thus it seems realistic that

a person with a doctoral degree does not necessarily know more about algae if they have not worked in that field.
Among Dutch respondents, there is a significant difference in knowledge about the nutrient content of algae as well as their environmental sustainability. Regarding the nutrient content of algae, the knowledge goes up with higher education. For the environmental sustainability there is no evidence that higher education equals to higher knowledge as the lowest knowledge is among the lowest education level, however, the highest knowledge comes from respondents with a high school degree that are eligible for university. For knowledge about algae being used as food, higher education seems to influence knowledge slightly.

4.2.2. Acceptance of algae

The second sub-question aims to find what level the acceptance of algae is in Germany and the Netherlands. Furthermore, it investigates if certain demographic factors such as age group, education level, living place and gender play a role in that regard. Acceptance to try algae as well as to purchase algae products is very high in both countries with over 90% of respondents claiming to be willing to try and purchase algae products.

Between German and Dutch respondents no significant differences could be found regarding acceptance of algae products. Therefore, consumers in both countries are generally willing to try algae as well as purchase products containing them. This was expected as consumers in both countries are generally open to trying new foods and have less of a protective stance towards their domestic food culture. Furthermore, consumers in both countries are looking to consume less meat and therefore look for alternatives for their protein intake. Algae could be such an alternative.

When looking at the acceptance of algae between the genders, some differences could be found among German consumers. Among Dutch consumers, however, no significant differences could be found.
In Germany, females are generally more accepting of algae. When it comes to trying algae, females are only slightly more willing than males. However, there is a significant difference in willingness to purchase algae products, meaning that females are more open to buying algae. This result is somewhat surprising as it was not expected to have significant differences between the genders. However, the fact that females generally would be slightly more accepting is not unexpected as females seem to overall be more open when it comes to trying animal protein alternatives than males.
Among Dutch consumers, no significant differences could be found regarding the willingness to try and purchase algae. However, when comparing the means, females are slightly more accepting of algae than males. This adds to the result of German respondents and confirms the hypothesis that females are generally more open to trying new foods and protein alternatives, at least in Germany and the Netherlands.

This next part looks at the difference in acceptance between the living places urban area and countryside. In Germany, no significant differences could be found while in the Netherlands there are significant differences in willingness to try as well as willingness to purchase algae.
In Germany, no significant difference in acceptance could be found. However, when comparing the means one can see that people living in urban areas are overall slightly more

accepting of algae as food. Though a significant difference was expected, it is generally unsurprising that consumers living in cities are more willing to try algae. They have a greater variety of foods to purchase in specialty stores, as well as more restaurants serving different food cultures. A reason why the differences are not significant among German respondents may be because of the small sample size of respondents living in the countryside.
In the Netherlands, there are significant differences in the willingness to try algae as well as purchase them depending on the respondents' living place. When comparing the means, it becomes evident that Dutch respondents living in cities and urban areas are also more willing to try and purchase algae than respondents from rural places. This confirms the expectation that consumers in cities are overall more accepting of algae as food than people from smaller villages and farms. Furthermore, due to the relatively even distribution of respondents, this can be said with relative confidence.

Comparing the differences in acceptance between education levels, one can see some significant differences between them in each country. In Germany, there is a significant difference in acceptance to purchase algae while in the Netherlands there are differences in acceptance to try and to purchase algae.
While there is no significant difference among German respondents when it comes to trying algae, there is one for purchasing algae products. However, in neither category evidence could be found that a higher education equals higher acceptance. When comparing the means of willingness, the acceptance level is distributed relatively randomly among the education levels. Furthermore, the lowest willingness to purchase algae comes from respondents with a doctoral degree. The fact that higher education levels do not equal a higher acceptance rate is not surprising as education level does not have an influence on a person's taste. However, as acceptance to try algae is high in all levels of education, it can be that people with higher education are open to trying new things even though they possibly will not like it. Additionally, the low rate of acceptance to purchase algae products among respondents with a doctoral degree could be related to the small sample number of such respondents.
In the Netherlands, significant differences in acceptance to try and to purchase algae could be found between the education levels. Though these differences are significant, all education levels have a high overall acceptance rate. Furthermore, as could be seen with German respondents, there is no evidence of a higher education equalling higher acceptance. In fact, comparing the means of willingness to purchase algae it seems like higher education brings lower acceptance. This observation is rather unexpected and further investigation would be needed to find out the reason for that.

This last part looks at the differences in acceptance between age groups. The age groups were set up according to the generations to be relevant for future discussions. In Germany, a significant difference in acceptance to try algae could be found while in the Netherlands there are significant differences in willingness to try and willingness to purchase algae.
Though a significant difference in willingness to try algae was found between the age groups in Germany, there is no evidence suggesting that increased age increases or decreases the willingness. In reality, the distribution of acceptance rate is relatively random between the different groups and the lowest overall acceptance exists among respondents from Generation Y. This observation is relatively remarkable as it was expected that younger people would be more accepting and open to trying new foods such as algae. The reasons for that result would have to be further investigated.

In the Netherlands, significant differences among the age groups could be found in the willingness to try and the willingness to purchase algae. However, no evidence was found that increased age de- or increases willingness. Similar to the observation from German consumers, generation Y has the lowest overall acceptance rate. This observation suggests that this generation is possibly more careful when it comes to trying new things or more satisfied with what they already have. However, it must be stated that the number of respondents was very unevenly distributed between the age groups and only around 12% of them are actually millennials. Remarkably, however, out of the 135 respondents from Generation Z, 100% are willing to try algae and 98% would purchase algae products.

4.2.3. Drivers influencing acceptance and rejection of algae

As mentioned in the previous chapter, only very few numbers of respondents are unwilling to try algae in both countries. Therefore, the Chi^2 test of independence is not accurate as a minimum of five responses per driver influence level (1-5) is recommended, however, at least one response should exist. Since there are only twelve responses from German and eight from Dutch consumers it was impossible to have five answers per category. Furthermore, the answers given by the consumers did not span over all influence levels, thus, not even one answer per influence level per driver exists. The Chi^2 test was performed anyway, however, afterwards, a Kruskal-Wallis test was performed also to find out how much the drivers influence the decisions.

When it comes to the association between the drivers and acceptance or rejection of algae, except for sensory appeal all drivers have a significant association with the willingness to try algae according to the Chi^2 test result. This is true for Dutch as well as German consumers. This would mean that consumers do not take the products' sensory appeal such as smell, taste, texture, or visual appeal as much into account as the other factors. Though possible, this does not seem very realistic as when confronted with a new food most consumers would use their senses to determine if they would try the product or not. Furthermore, oftentimes one negatively perceived sensory aspect can completely cancel out a positively perceived one if not all of them. E.g., a product may taste and smell very good, however, the consistency may cause the consumer to gag, thus completely undermining the positive traits of the product.
Additionally, the least important drivers after sensory appeal according to the Chi^2 test results are familiarity with this or similar products for German respondents and environmental awareness for Dutch consumers. This does seem realistic as these are factors not everyone takes into account when trying new products, however, why there are differences between German and Dutch respondents would have to be investigated further.

When looking at the test results of the Kruskal-Wallis test, the importance of the drivers changes. The result shows that there are significant differences in importance between the drivers' influence on the respondents' acceptance of algae in both countries.
When comparing the means, among German consumers the perceived health benefits are the most important driver to accept algae while familiarity is the least important. This result seems logical as the healthiness of a product is an important factor to consider and many Germans look for healthier alternatives for meat. Why familiarity is the least important is not directly obvious and would have to be further investigated. It would seem that people would

be more inclined to try a product they know or at least have tried products similar to. However, an explanation could be that the respondents just did not have any familiarity with algae or similar products and thus it did not affect their decision much.
Among Dutch consumers, the most important driver to accept algae is the product's price while the least important is the product's sensory appeal. That price is most important for Dutch consumers does not surprise as Dutch people are rather stingy and care for every cent they have to pay, no matter if said person is rich or poor. This mindset is ingrained in Dutch culture and may have its roots in the times when the Netherlands was a merchant republic and cheaper prices were the difference between buying at one place over the other. However, why the sensory appeal of an algae product is the least important for accepting algae is not directly evident and would have to be investigated further. An explanation could be that if a product does not have any negatively perceived sensory aspects, it does not matter much in the consumers' decision.

The results of the Kruskal-Wallis test regarding the influence of drivers on the rejection of algae show significant differences between the drivers in Germany and the Netherlands. Not surprisingly, the results also differ from the Chi^2 test results.
For German respondents, the most important driver for rejection is perceived disgust of the product, closely followed by lack of sensory appeal which makes sense as these drivers are somewhat related. Least important for rejection was again familiarity with this or similar products. That perceived disgust is most important for German respondents to reject algae makes sense as most people will not try a product if they think it is disgusting. Why they think it is disgusting, however, is a different question that would need a follow-up investigation as part of a different research. Seeing that familiarity is also not very important for German consumers' decision to accept algae, it makes sense that it also does not influence their rejection much. Though one would expect someone to rather reject food because they know they do not like it or do not like similar products, it may be that the respondents just do not have any familiarity with this or similar products they could fall back to.
For Dutch consumers, the most important driver to reject algae is the lack of sensory appeal while the least important is the price. This may look like it does not make sense as these are the same drivers that are most and least important for the acceptance of algae, just inverted. However, while the price of the product may be an important factor for accepting algae, it certainly does not have to be the most important one when making a decision against algae. Other aspects as, for example, a lack of sensory appeal or food neophobia come first when rejecting algae. Meaning, the consumer will first decide if he thinks he dislikes the product before looking at its price. Thus, the lack of sensory appeal makes sense to be very influential, however, perceived disgust was expected to be more important.

4.3. Scope of results

Though the research did not answer all questions perfectly there are takeaways from it that could be helpful for the intended target group. The influence or lack thereof on knowledge and acceptance of certain demographic factors could be helpful for marketers to decide on who to target for more effective advertising. Furthermore, the influence of certain drivers on consumers' willingness to try algae could help algae-producing companies create more successful products that avoid rejection factors.

4.3.1. Insights on knowledge

Overall knowledge about algae and their benefits is relatively high in both countries, therefore, companies or governments do not need to increase to educate consumers more but instead keep up a consistent information flow about algae. However, it might be reasonable for policy to consider education on foods and their nutritional and environmental benefits in high school, especially in Germany. One reason for that consideration is that, at least in Germany, there is no such education at a normal high school. Furthermore, the survey showed that younger people generally had a little less knowledge, showing that most respondents learned about algae after graduating from high school. However, as previously mentioned, overall knowledge about algae is already relatively high in both countries and should not be prioritized.

4.3.2. Insights on acceptance

The observations about the acceptance of algae could be very helpful for marketers as well as algae producers. First of all, overall acceptance of algae as food is surprisingly very high in both countries, therefore, companies should start capturing the market as soon as relevant algae species get added to the EU`s List of Novel Foods and thus become legal to sell. If food companies find the right product for the consumers' taste, they can expect relatively fast growth as the only real obstacle will be the product's attributes and not a negative mindset about algae by the consumers. Thus, it is all in the hands of the producers and marketers at that point.

For marketers, observations about the demographic factors influencing consumer acceptance may be helpful to target the right customers. That is, either demographic groups where acceptance is not yet very high to increase acceptance among them, or demographics with an already high acceptance to market algae products and thus generate a high number of sales.
Regarding the first marketing strategy, marketers should look to address males and especially millennials as these groups had overall lower acceptance rates. Furthermore, they could also target people living in the countryside more. However, it seems as targeting males makes the most sense due to the fact that men today often still earn more money than women and thus have more money to spend which is especially useful if products are rather expensive. Targeting millennials should not be underestimated though, as they are still young and thus could be retained as customers for longer than older generations. While millennials may not have much money to spend yet compared to older generations, this is likely to increase the longer they work and go up in their career. Targeting consumers living in rural areas should be the least priority of those three as that would not pay off as well relative to the other two groups. Cities have the advantage of many people living closely together and thus fewer resources are needed to reach many people at once compared to advertising in small villages. Regarding targeting groups with higher acceptance rates, targeting females, people living in cities, and members of Generation Z should be considered. Most importantly here is probably targeting Generation Z. Though, most of them are just beginning to enter the workforce and thus mostly do not have a lot of money to spend yet, there is great potential in retaining them as long-term customers due to their young age. Furthermore, they are already very accepting of algae as foods and thus will not need expensive marketing campaigns to be convinced of

the benefits of algae. As mentioned previously, marketing toward people living in cities should be prioritized over rural areas because one can reach more potential customers at once. Furthermore, people living and especially working in cities generally have a higher disposable income than people living in the countryside. Females are another group that has a generally high acceptance of algae and thus should be marketed towards. Though it was mentioned previously that males often still earn more than females, recent policy changes and shifts in the public mindset point towards more equal pay in the future and possibly females being in higher positions due to being better educated. Thus, they are an important group to target as well.

4.3.3. Insights about drivers' influence on acceptance and rejection

Observations from the survey about certain drivers' influence on the acceptance or rejection of algae may help producers of algae products to better cater to their intended target group. It may also help marketers to advertise more effectively.

In the Netherlands, companies should try to provide less expensive products in order to get more customers among the people that are willing to try algae. Obviously, the producer should still be making a profit, but they should not be much more expensive than their competition to be successful. Furthermore, products should be convenient and easy to use for consumers.
To avoid rejection, producers should look to create sensorial appealing products that look, taste and smell nice and have the right texture. Furthermore, to decrease rejection due to food neophobia it should also be considered to not only make visually appealing products but possibly make them look like known foods or incorporate algae in existing food products. Examples could be vegan meat alternatives, or as an additive in ready meals, smoothies or other processed products.
Marketers should emphasize the health benefits of the products due to the incorporated algae. Furthermore, it may be useful to also advertise the environmental benefits of algae, especially if the product is marketed as an alternative to animal-based products.

In Germany, the focus should be less on the products' price and more on their sensory appeal as that influences the consumers' willingness to try algae more. However, offering the product at a competitive price point will also be beneficial here.
More important, though, is to advertise the products' health benefits and environmental impact as those are the most important drivers regarding the acceptance of algae in Germany. This could be combined with sustainable packaging to validate the company's efforts to be sustainable. Other marketing strategies playing into that narrative are also possible.
To avoid rejection producers should again focus on the sensory appeal driver as well as disgust. Conducting studies into what customers perceive as disgusting may be necessary, however, seeing as that is the most influential driver for rejection of algae, it probably will be worth it. Food neophobia is less of a reason to reject algae in Germany compared to the Netherlands, though it should not be disregarded and incorporating algae into known foods may be a good starting point to enter the market.

4.4. Relation of results to literature and other studies

When comparing the findings of this study with existing ones from Spain and the UK, one can find some similarities between the consumers as well as some distinct differences. Generally, however, one can say that consumer behaviour is similar among European consumers from these countries.

Regarding the study conducted in the UK, acceptance levels to consume algae are high as it was in Germany and the Netherlands. Furthermore, knowledge levels in the UK were not high, especially when it comes to the nutritional and environmental benefits of algae. Though in Germany and the Netherlands, basic knowledge on algae being used as food is relatively high, specific knowledge of algae benefits is lacking similar to the UK study.
Moreover, the UK study found that increasing knowledge about algae could moderate rejection due to taste expectations and lack of familiarity. Though these drivers are not the most influential for acceptance or rejection of algae among German and Dutch consumers, increasing knowledge may diminish its influence on rejection here too. This would have to be further investigated in future research. Lastly, the UK study also found that algae products should be priced appropriately to increase willingness to purchase algae products which is an observation from the German/Dutch study as well.

Regarding the study conducted among Spanish consumers, a major difference is that knowledge is lacking behind in Spain while German and Dutch consumers already have a certain knowledge level. However, Spanish consumers were also asked more specific questions about the production of microalgae. Knowledge on that most likely also lacks behind among German and Dutch consumers as this is almost professional knowledge that most "normal" consumers do not get in touch with.
The Spanish study found that age and education level have the biggest influence on knowledge about algae. This corresponds in part to observations from German and Dutch consumers. Knowledge was found to marginally increase with increased age in Germany while in the Netherlands, at least some aspects of knowledge increase with increased education. To prove the hypothesis that age and education level have the biggest influence on knowledge of algae, however, would need further investigation in the future.
Generally, acceptance was found to be high among Spanish consumers, however, lack of familiarity is a main reason to not consume them. Furthermore, when asked about what products would be best to incorporate microalgae, baked products as well as pasta were the preferred answer from Spanish consumers. This somewhat corresponds to conclusions made from the German/Dutch study that food neophobia is an important driver for rejection and that familiar and processed products should be used to incorporate algae, at least in the beginning, to accustom customers to the idea of consuming algae.

Overall, the drivers influencing food choices identified by other studies have also proven to be influential when it comes to algae. However, the levels at which the drivers influence acceptance prove to be different than some literature suggests.
For one, food neophobia and sensory appeal are not the major drivers for German consumers to reject algae, instead, health consciousness and perceived environmental impacts dictate their decision to try algae. Furthermore, familiarity with the product or lack thereof is one of the least influential drivers for acceptance and rejection in both countries which is a big

surprise as people usually choose familiar products over unfamiliar ones. Moreover, perceived disgust ranks lower than expected as a rejection driver for Dutch consumers. However, for German consumers, it is the most influential driver, showing that it mainly depends on the consumers asked and possibly how they grew up. Similar observations could be made for the influence of price on the Dutch and German consumers' acceptance of algae which was high in the Netherlands and rather low in Germany.

It can be concluded that, while all drivers influence consumer choice to some extent, no generalizations can be made about the level of influence of the drivers. Other factors probably play a role in that as well which could include education, (food) culture, personal upbringing, and possibly even genetics. Confirming this should be the subject of future studies diving deeper into why certain drivers influence consumers' food choices to the extent they do.

5. Conclusion and Recommendations

The aim of this research has been to find if there are differences in knowledge and acceptance of edible algae between consumers from the Netherlands and Germany. Furthermore, to better understand where any differences derive from, the influence of different demographic factors on knowledge and acceptance was analyzed, as well as the impact of certain drivers on the consumers' acceptance to try algae.

In conclusion, knowledge and acceptance of algae as food was generally found to be on a high level among Dutch and German consumers while no significant difference could be found between the two countries. However, looking more specifically into the knowledge, it is somewhat lacking regarding the environmental and nutritional benefits of algae in Germany as well as the Netherlands. Nonetheless, over 50% of respondents in each country have that knowledge showing that the topic is not all that new for consumers.

Different demographic factors have an influence on consumers' knowledge and acceptance of algae. Most notably, the rural population of both countries has more knowledge about algae than urban dwellers of the same country. However, when it comes to acceptance, the urban population has a higher rate.
Between the genders, acceptance is generally slightly higher among females in both countries. Differences in knowledge between the genders could be found and in Germany was slightly higher among females while in the Netherlands, knowledge between the genders varies depending on the specific topic.
While some significant differences could be found between education levels among Dutch consumers, no evidence could be found that higher education overall increases knowledge level. This was more evident among German consumers as there are no significant differences in knowledge among the education levels. The same is true for acceptance of algae as there is no indication that higher education in- or decreases acceptance levels in both countries.
No significant differences in knowledge exist among different age groups of respondents in both countries. When it comes to acceptance significant differences could be found. In both countries most accepting are members of Generation Z while surprisingly least accepting are millennials.

Certain drivers influence the consumers' acceptance or rejection of trying algae, however, some are significantly more important than others. The most important driver for acceptance is the expected health benefits from a given product for German consumers while Dutch consumers are mainly driven by the price of a product. Furthermore, the most important driver for rejection among Germans is the perceived disgust of a product and for Dutch a sensorial unappealing perception of a product.

Future research should take a deeper look into why those differences exist between different demographics, especially among the age groups it is unclear why millennials have such a low acceptance rate. Furthermore, it may be relevant to more in-depth compare the different demographic factors with each other to find out what factors are more important for consumers' knowledge and acceptance of algae.
For the long term, policymakers should consider providing better education for the wider population on nutritional and environmental aspects of different foods, especially algae to

increase overall knowledge in these fields. Furthermore, research similar to this one should be conducted once algae are more commonly in use as food to see if the general knowledge and acceptance level has deviated from its current level and to be able to make conclusions about future developments in this field.

References

Agovino, M., Casaccia, M., Ciommi, M., Ferrara, M., & Marchesano, K. (2019). Agriculture, climate change and sustainability: The case of EU-28. *Ecological Indicators*, *105*, 525–543. https://doi.org/10.1016/j.ecolind.2018.04.064

Aldridge, V., Dovey, T. M., & Halford, J. C. (2009). The role of familiarity in dietary development. *Developmental Review*, *29*(1), 32–44. https://doi.org/10.1016/j.dr.2008.11.001

Alexandratos, N., & Bruinsma, J. (2012). *World agriculture towards 2030/2050: The 2012 revision* (ESA Working Paper No. 12-03). Food and Agriculture Organization (FAO). Retrieved December 15, 2022, from https://www.fao.org/3/ap106e/ap106e.pdf

Araujo, R., & Peteiro, C. (2021). *Algae as food and food supplements in Europe* (No. JRC125913). Publications Office of the European Union. Retrieved January 19, 2023, from https://www.researchgate.net/profile/Cesar-Peteiro/publication/353719348_Algae_as_food_and_food_supplements_in_Europe/links/610c2e4c1e95fe241ab38768/Algae-as-food-and-food-supplements-in-Europe.pdf

Arvidsson Segerkvist, K., Hansson, H., Sonesson, U., & Gunnarsson, S. (2020). Research on Environmental, Economic, and Social Sustainability in Dairy Farming: A Systematic Mapping of Current Literature. *Sustainability*, *12*(14), 5502. https://doi.org/10.3390/su12145502

Barrena, R., & Sánchez, M. (2013). Neophobia, personal consumer values and novel food acceptance. *Food Quality and Preference*, *27*(1), 72–84. https://doi.org/10.1016/j.foodqual.2012.06.007

Blanck, H. M., Yaroch, A. L., Atienza, A. A., Yi, S. L., Jian Zhang, & Mâsse, L. C. (2007). Factors Influencing Lunchtime Food Choices Among Working Americans. *Health Education &Amp; Behavior*, *36*(2), 289–301. https://doi.org/10.1177/1090198107303308

Brown, L. R. (2005). *Outgrowing the Earth: The Food Security Challenge in an Age of Falling Water Tables and Rising Temperatures* (1st ed.). Taylor & Francis. https://doi.org/10.4324/9781849772112

Brunner, T. A., van der Horst, K., & Siegrist, M. (2010). Convenience food products. Drivers for consumption. *Appetite*, *55*(3), 498-506. https://doi.org/10.1016/j.appet.2010.08.017

Burns, C., Cook, K., & Mavoa, H. (2013). Role of expendable income and price in food choice by low income families. *Appetite*, *71*, 209–217. https://doi.org/10.1016/j.appet.2013.08.018

Cooke, L. (2007). The importance of exposure for healthy eating in childhood: a review. *Journal of Human Nutrition and Dietetics*, *20*(4), 294–301. https://doi.org/10.1111/j.1365-277x.2007.00804.x

de Faccio Carvalho, P. C., de Albuquerque Nunes, P. A., Pontes-Prates, A., Szymczak, L. S., de Souza Filho, W., Moojen, F. G., & Lemaire, G. (2021). Reconnecting Grazing Livestock to Crop Landscapes: Reversing Specialization Trends to Restore Landscape Multifunctionality. *Frontiers in Sustainable Food Systems*, *5*. https://doi.org/10.3389/fsufs.2021.750765

Dolezalova, T. (2015). *Insects as a food source: assessing the disgust factor* [Master thesis]. Wageningen University.

Ehrlich, P. R., & Harte, J. (2015). To feed the world in 2050 will require a global revolution. *Proceedings of the National Academy of Sciences*, *112*(48), 14743–14744. https://doi.org/10.1073/pnas.1519841112

EUbusiness. (2022, February 11). *Union list of novel foods*. EUbusiness.com. Retrieved December 12, 2022, from https://www.eubusiness.com/topics/food/novel-foods/

European Commission. (2022, December 6). *EU to invest €13.5 billion in research and innovation for 2023-2024* [Press release]. https://ec.europa.eu/commission/presscorner/detail/en/IP_22_7404

European Commission. (n.d.-a). *Authorisations*. European Commission Website. Retrieved December 12, 2022, from https://food.ec.europa.eu/safety/novel-food/authorisations_en

European Commission. (n.d.-b). *Union list of novel foods*. European Commission Website. Retrieved December 12, 2022, from https://food.ec.europa.eu/safety/novel-food/authorisations/union-list-novel-foods_en

European Council. (2022, November 8). *EU budget for 2022*. https://www.consilium.europa.eu/en/policies/the-eu-budget/eu-annual-budget/2022-budget/

Fraj, E., & Martinez, E. (2007). Ecological consumer behaviour: an empirical analysis. *International Journal of Consumer Studies*, *31*(1). https://doi.org/10.1111/j.1470-6431.2006.00565.x

Galanakis, C. M. (2019). *Sustainable Meat Production and Processing*. Elsevier. https://doi.org/10.1016/C2017-0-02230-9

Hartmann, C., & Siegrist, M. (2016). Becoming an insectivore: Results of an experiment. *Food Quality and Preference*, *51*, 118–122. https://doi.org/10.1016/j.foodqual.2016.03.003

Honkanen, P., & Frewer, L. (2009). Russian consumers' motives for food choice. *Appetite*, *52*(2), 363–371. https://doi.org/10.1016/j.appet.2008.11.009

Horrigan, L., Lawrence, R. Z., & Walker, P. O. (2002). How sustainable agriculture can address the environmental and human health harms of industrial agriculture. *Environmental Health Perspectives*, *110*(5), 445–456. https://doi.org/10.1289/ehp.02110445

Innocent. (n.d.). *innocent – innocent Plus [Direktsaft + Vitamine]*. Retrieved May 18, 2023, from https://www.innocentdrinks.de/dinge-die-wir-machen/innocent-plus

KoRo. (n.d.). *Bio Spirulina Pulver kaufen | KoRo Germany*. Retrieved May 18, 2023, from https://www.korodrogerie.de/bio-spirulina-pulver-500-g

Lafarga, T., Rodríguez-Bermúdez, R., Morillas-España, A., Villaró, S., García-Vaquero, M., Morán, L., Sánchez-Zurano, A., González-López, C. V., & Acién-Fernández, F. G. (2021). Consumer knowledge and attitudes towards microalgae as food: The case of Spain. *Algal Research*, *54*, 102174. https://doi.org/10.1016/j.algal.2020.102174

Lentini, F., & Venza, F. (2007). Wild food plants of popular use in Sicily. *Journal of Ethnobiology and Ethnomedicine*, *3*(1). https://doi.org/10.1186/1746-4269-3-15

Magnusson, M. K., Arvola, A., Koivisto Hursti, U., Åberg, L., & Sjödén, P. (2001). Attitudes towards organic foods among Swedish consumers. *British Food Journal*, *103*(3), 209–227. https://doi.org/10.1108/00070700110386755

Mellor, C., Embling, R., Neilson, L., Randall, T., Wakeham, C., Lee, M. D., & Wilkinson, L. L. (2022). Consumer Knowledge and Acceptance of “Algae” as a Protein Alternative: A UK-Based Qualitative Study. *Foods*, *11*(12), 1703. https://doi.org/10.3390/foods11121703

Mendes, M., Navalho, S., Ferreira, A., Paulino, C., Figueiredo, D., Silva, D., Gao, F., Gama, F., Bombo, G., Jacinto, R., Aveiro, S., Schulze, P., Gonçalves, A. T., Pereira, H., Gouveia, L., Patarra, R., Abreu, M. H., Silva, J., Navalho, J., . . . Speranza, L. (2022). Algae as Food in Europe: An Overview of Species Diversity and Their Application. *Foods*, *11*(13), 1871. https://doi.org/10.3390/foods11131871

Metsoviti, M. N., Papapolymerou, G., Karapanagiotidis, I. T., & Katsoulas, N. (2019). Comparison of Growth Rate and Nutrient Content of Five Microalgae Species Cultivated in Greenhouses. *Plants*, *8*(8), 279. https://doi.org/10.3390/plants8080279

Orsi, L., Voege, L. L., & Stranieri, S. (2019). Eating edible insects as sustainable food? Exploring the determinants of consumer acceptance in Germany. *Food Research International*, *125*, 108573. https://doi.org/10.1016/j.foodres.2019.108573

Pimentel, D., & Pimentel, M. (2003). Sustainability of meat-based and plant-based diets and the environment. *The American Journal of Clinical Nutrition*, *78*(3), 660S-663S. https://doi.org/10.1093/ajcn/78.3.660s

Pintado, T., & Delgado-Pando, G. (2020). Towards More Sustainable Meat Products: Extenders as a Way of Reducing Meat Content. *Foods*, *9*(8), 1044. https://doi.org/10.3390/foods9081044

Pliner, P., & Hobden, K. (1992). Development of a scale to measure the trait of food neophobia in humans. *Appetite*, *19*(2), 105–120. https://doi.org/10.1016/0195-6663(92)90014-w

Purvis, B., Mao, Y., & Robinson, D. (2018). Three pillars of sustainability: in search of conceptual origins. *Sustainability Science*, *14*(3), 681–695. https://doi.org/10.1007/s11625-018-0627-5

Ranganathan, J., Vennard, D., Waite, R., Dumas, P., Lipinski, B., Searchinger, T., & GLOBAGRI-WRR model authors. (2016). *Shifting Diets for a Sustainable Food Future*. World Resources Institute. https://files.wri.org/d8/s3fs-public/Shifting_Diets_for_a_Sustainable_Food_Future_1.pdf

REWE. (n.d.). *Sushi Circle Wakame Salat 100g*. Retrieved May 18, 2023, from https://www.rewe.de/produkte/sushi-circle-wakame-salat-100g/8486803/?ecid=pla_google_vs_nonbr_pm_fleisch-fisch_lia___pid%3A_ch%3Alocal_nn_d%3Ac&marketCode=1465116

Rozin, P., & Fallon, A. E. (1987). A perspective on disgust. *Psychological Review*, *94*(1), 23–41. https://doi.org/10.1037/0033-295x.94.1.23

Rozin, P., Haidt, J., & McCauley, C. R. (2008). Disgust. In M. Lewis, J. M. Haviland-Jones, & L. F. Barrett (Eds.), *Handbook of Emotions* (Third). The Guilford Press. Retrieved from https://cpb-us-w2.wpmucdn.com/web.sas.upenn.edu/dist/7/206/files/2016/09/DgLewisHbk2008-psiby3.pdf

Steptoe, A., Pollard, T. M., & Wardle, J. (1995). Development of a Measure of the Motives Underlying the Selection of Food: the Food Choice Questionnaire. *Appetite*, *25*(3), 267–284. https://doi.org/10.1006/appe.1995.0061

Sun, Y. H. C. (2008). Health concern, food choice motives, and attitudes toward healthy eating: The mediating role of food choice motives. *Appetite*, *51*(1), 42–49. https://doi.org/10.1016/j.appet.2007.11.004

Tuorila, H., Lähteenmäki, L., Pohjalainen, L., & Lotti, L. (2001). Food neophobia among the Finns and related responses to familiar and unfamiliar foods. *Food Quality and Preference*, *12*(1), 29–37. https://doi.org/10.1016/s0950-3293(00)00025-2

United Nations Department of Economic and Social Affairs, Population Division. (2022). *World Population Prospects 2022: Summary of Results* (UN DESA/POP/2021/TR/NO. 3). United Nations (UN). Retrieved December 15, 2022, from https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/wpp2022_summary_of_results.pdf

Van der Pas, L. (2017). *Dutch consumers' willingness to try insects: The influence of food choice motives on intentions*[MSc Thesis]. Wageningen University.

Van der Weele, C., Feindt, P., van der Goot, A. J., van Mierlo, B., & van Boekel, M. (2019). Meat alternatives: an integrative comparison. *Trends in Food Science &Amp; Technology*, *88*, 505–512. https://doi.org/10.1016/j.tifs.2019.04.018

Verain, M. C., Bartels, J., Dagevos, H., Sijtsema, S. J., Onwezen, M. C., & Antonides, G. (2012). Segments of sustainable food consumers: a literature review. *International Journal of Consumer Studies*, *36*(2), 123–132. https://doi.org/10.1111/j.1470-6431.2011.01082.x

Vigani, M., Parisi, C., Rodríguez-Cerezo, E., Barbosa, M. J., Sijtsma, L., Ploeg, M., & Enzing, C. (2015). Food and feed products from micro-algae: Market opportunities and challenges for the EU. *Trends in Food Science &Amp; Technology*, *42*(1), 81–92. https://doi.org/10.1016/j.tifs.2014.12.004

Wells, M. L., Potin, P., Craigie, J. S., Raven, J. A., Merchant, S. S., Helliwell, K. E., Smith, A. G., Camire, M. E., & Brawley, S. H. (2016). Algae as nutritional and functional food sources: revisiting our understanding. *Journal of Applied Phycology*, *29*(2), 949–982. https://doi.org/10.1007/s10811-016-0974-5

Wild, F., Czerny, M., Janssen, A., Kole, A., Zunabovic-Pichler, M., & Domig, K. J. (2014). The evolution of a plant-based alternative to meat. From niche markets to widely accepted meat alternatives. *Agro Food Industry Hi-Tech*, *25*(1), 45–49. https://www.researchgate.net/profile/Florian_Wild/publication/261878915_The_evolution_of_a_plant-based_alternative_to_meat_From_niche_markets_to_widely_accepted_meat_alternatives/links/57eeb18808ae91deaa51019b/The-evolution-of-a-plant-based-alternative-to-meat-From-niche-markets-to-widely-accepted-meat-alternatives.pdf

World Wildlife Fund [WWF]. (n.d.). *Soy | Industries | WWF*. World Wildlife Fund. Retrieved December 9, 2022, from https://www.worldwildlife.org/industries/soy

Zhang, T., Dou, W., Zhang, X., Zhao, Y., Zhang, Y., Jiang, L., & Sui, X. (2021). The development history and recent updates on soy protein-based meat alternatives. *Trends in Food Science &Amp; Technology*, *109*, 702–710. https://doi.org/10.1016/j.tifs.2021.01.060

Appendix 1: Survey English

What country are you currently living in?
- ☐ Germany
- ☐ The Netherlands

Are you aware of (vegan) meat alternatives?
- ☐ Yes
- ☐ No

Are you aware that algae can be used as food (supplement)?
- ☐ Yes
- ☐ No

Do you think algae contain more or less protein and beneficial nutrients than other key ingredients for meat alternatives, such as soy, peas, or mushrooms?
- ☐ More
- ☐ Less
- ☐ I do not know

Do you think algae production is more environmentally sustainable than production of other key ingredients for meat alternatives, such as soy, peas, or mushrooms?
- ☐ Yes
- ☐ No
- ☐ I do not know

What age group do you belong to?
- ☐ 18-26
- ☐ 27-42
- ☐ 43-58
- ☐ 59-80
- ☐ >80

What gender do you identify as?
- ☐ Female
- ☐ Male
- ☐ Non-binary
- ☐ Other

Where do you live?
- ☐ Urban area (medium to large city and metropolitan area)
- ☐ Countryside (e.g., farm or small village)

What is your highest degree of education?
- ☐ Primary school
- ☐ High school (non-eligible for university)
- ☐ High school (eligible for university)

- Bachelor's
- Master's
- Doctoral

Would you generally be willing to consume algae if it is in a product you like?

- Yes
- No

Would you purchase algae products if they become easily available at a competitive price point?

- Yes, regularly
- Yes, sometimes
- No, never

Based on your previous answer, what influence do the following drivers have on your willingness to try algae?
Please rate each of these on a scale from 1 (not influential at all) to 5 (highly influential)

- Convenience 1-2-3-4-5
- Familiarity or personal experience with similar products 1-2-3-4-5
- Awareness of health benefits 1-2-3-4-5
- Environmental awareness 1-2-3-4-5
- Sensory appeal 1-2-3-4-5
- Price 1-2-3-4-5

Based on your previous answer, what influence do the following drivers have on your unwillingness to try algae?
Please rate each of these on a scale from 1 (not influential at all) to 5 (highly influential)

- Familiarity or personal experience with similar products 1-2-3-4-5
- Environmental awareness 1-2-3-4-5
- Food neophobia (fear or disliking of trying new foods) 1-2-3-4-5
- Sensory appeal or lack thereof 1-2-3-4-5
- Disgust 1-2-3-4-5
- Price 1-2-3-4-5

Appendix 2: Survey German

In welchem Land leben Sie derzeit?

- ☐ Deutschland
- ☐ Niederlande

Wissen Sie was (vegane) Fleischalternativen sind?

- ☐ Ja
- ☐ Nein

Wissen Sie, dass Algen als Lebensmittel(zusatz) verwendet werden können?

- ☐ Ja
- ☐ Nein

Denken Sie Algen enthalten mehr oder weniger Eiweiße und andere wertvolle Nährstoffe als andere Hauptzutaten für Fleischalternativen, wie zum Beispiel Soja, Erbsen, oder Pilze?

- ☐ Mehr
- ☐ Weniger
- ☐ Ich weiß es nicht

Denke Sie die Produktion von Algen ist umweltfreundlicher als die Herstellung anderer Hauptzutaten für Fleischalternativen, wie zum Beispiel Soja, Erbsen, oder Pilze?

- ☐ Ja
- ☐ Nein
- ☐ Ich weiß es nicht

Zu welcher Altersgruppe gehören Sie?

- ☐ 18-26
- ☐ 27-42
- ☐ 43-58
- ☐ 59-80
- ☐ >80

Als welches Geschlecht identifizieren Sie sich?

- ☐ Frau
- ☐ Mann
- ☐ Nicht binär

Wo leben Sie?

- ☐ Stadtgebiet (mittlere bis Großstadt und Metropolregion)
- ☐ Auf dem Land (z.B., Hof oder kleines Dorf)

Welches ist ihr höchster Bildungsgrad?

- ☐ Grundschule
- ☐ Schulabschluss ohne direkte Universitätszulassung (z.B., Realschule oder Hauptschule)
- ☐ Abitur oder vergleichbarer Abschluss

- Bachelor
- Master
- Doktorat

Wären Sie generell bereit Algen zu probieren, wenn diese in einem Produkt, welches Sie mögen enthalten sind?

- Ja
- Nein

Wären Sie generell bereit Algenprodukte zu kaufen, wenn diese zu einem wettbewerbsfähigen Preis und leicht erhältlich sind?

- Ja, oft
- Ja, ab und zu
- Nein, nie

Ausgehend von Ihrer vorherigen Antwort, welchen Einfluss haben die folgenden Faktoren auf Ihre Bereitschaft Algen zu probieren?
Bitte bewerten Sie jeden dieser Faktoren auf einer Skala von 1 (kein Einfluss) bis 5 (großer Einfluss)

- Bequemlichkeit/Erreichbarkeit 1-2-3-4-5
- Vertrautheit oder persönliche Erfahrung mit ähnlichen Produkten 1-2-3-4-5
- Kenntnis der gesundheitlichen Vorteile 1-2-3-4-5
- Umweltbewusstsein 1-2-3-4-5
- Sensorisch ansprechend 1-2-3-4-5
- Preis 1-2-3-4-5

Ausgehend von Ihrer vorherigen Antwort, welchen Einfluss haben die folgenden Faktoren auf Ihre mangelnde Bereitschaft Algen zu probieren?
Bitte bewerten Sie jeden dieser Faktoren auf einer Skala von 1 (kein Einfluss) bis 5 (großer Einfluss)

- Vertrautheit oder persönliche Erfahrung mit ähnlichen Produkten 1-2-3-4-5
- Umweltbewusstsein 1-2-3-4-5
- Lebensmittelneophobie (Angst oder Abneigung gegenüber neuen Lebensmitteln) 1-2-3-4-5
- Sensorisch nicht ansprechend 1-2-3-4-5
- Ekel 1-2-3-4-5
- Preis 1-2-3-4-5

Appendix 3: Survey Dutch

In welk land woont u momenteel?

- ☐ Duitsland
- ☐ Nederland

Bent u op de hoogte van (veganistische) vlees alternatieven?

- ☐ Ja
- ☐ Nee

Weet u dat algen kunnen worden gebruikt als voeding (supplement)?

- ☐ Ja
- ☐ Nee

Denkt u dat algen meer of minder eiwitten en gezonde voedingsstoffen bevatten dan andere belangrijke ingrediënten voor vleesalternatieven, zoals soja, erwten of paddenstoelen?

- ☐ Meer
- ☐ Minder
- ☐ Ik weet niet

Denkt u dat de productie van algen milieuvriendelijker is dan de productie van andere belangrijke ingrediënten voor vleesalternatieven, zoals soja, erwten of paddenstoelen?

- ☐ Ja
- ☐ Nee
- ☐ Ik weet niet

Tot welke leeftijdsgroep behoort u?

- ☐ 18-26
- ☐ 27-42
- ☐ 43-58
- ☐ 59-80
- ☐ >80

Als welk geslacht identificeert u zich?

- ☐ Vrouw
- ☐ Man
- ☐ Niet-binaire

Waar woont u?

- ☐ Stedelijk gebied (middelgrote tot grote stad en metropoolregio)
- ☐ Platteland (bijv., boerderij of klein dorp)

Wat is uw hoogste graad van onderwijs?

- ☐ Basisschool
- ☐ Middelbare school (VMBO/Mavo/Havo)
- ☐ Middelbare school (VWO)

- Bachelor
- Master
- Doctoraal

Zou u in het algemeen bereid zijn algen te consumeren als ze in een product zitten dat u lekker vindt?

- Ja
- Nee

Zou u algenproducten kopen als ze gemakkelijk verkrijgbaar zijn tegen een concurrerende prijs?

- Ja, regelmatig
- Ja, soms
- Nee, nooit

Op basis van uw vorige antwoord, welke invloed hebben de volgende factoren op uw bereidheid om algen te proberen?
Geef elk van deze punten een cijfer op een schaal van 1 (helemaal niet invloedrijk) tot 5 (zeer invloedrijk)

- Gemak/ Toegankelijkheid 1-2-3-4-5
- Bekendheid of persoonlijke ervaring met soortgelijke producten 1-2-3-4-5
- Bewustzijn van gezondheidsvoordelen 1-2-3-4-5
- Milieubewustzijn 1-2-3-4-5
- Sensorische aantrekkingskracht 1-2-3-4-5
- Prijs 1-2-3-4-5

Op basis van uw vorige antwoord, welke invloed hebben de volgende factoren op uw onwil om algen te proberen?
Geef elk van deze punten een cijfer op een schaal van 1 (helemaal niet invloedrijk) tot 5 (zeer invloedrijk)

- Bekendheid of persoonlijke ervaring met soortgelijke producten 1-2-3-4-5
- Milieubewustzijn 1-2-3-4-5
- Voedsel neofobie (angst voor of afkeer van het proberen van nieuw voedsel) 1-2-3-4-5
- Sensorisch niet aantrekkelijk 1-2-3-4-5
- Walging 1-2-3-4-5
- Prijs 1-2-3-4-5