Consumers' perspectives of innovative and sustainable plant--based food products

Inês Filipa Pereira Magalhães

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Department of Geosciences, Environment and Territory Planning

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Supervisor

Dr. Luís Miguel Cunha, Associate Professor

Faculty of Sciences of University of Porto

Co-supervisor

Dr. Armando Perez-Cueto, Professor

Department of Food, Nutrition and Culinary Science, University of Umeå


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NUTRIÇÃO E ALIMENTAÇÃO
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Abstract

Climate change affects the food chain, while the food systems simultaneously influence the climate itself. In this sense, adopting sustainable and conscious diets represents an action individuals can take to mitigate this current problem.

This dissertation combines two studies: the first, aims to investigate the conceptualization and willingness to eat products with edible algae, in a Portuguese sample; the second, aims to validate two scales, one about the barriers towards plant-based foods, and other related to social, environmental, and economic sustainability.

Both studies used web-based questionnaires, applied via *LimeSurvey* to a Portuguese sample.

In the study of algae, participants (n=494) were grouped in four segments of acceptance; algae were firstly associated to the term "Nature"; gender, level of education, marital status, number of household members, financial situation, occupation, type of diet, healthiness of the diet, consumption of ethnic foods, familiarity, food neophobia, green consumption values and trust in non-governmental organizations showed influence in acceptance of products with edible algae.
For the second study (n=66), the short version of barriers scale may substitute the long version and social, economic, and environmental sustainability scale is reliable.

This work emphasises sustainable diets and alternative food sources, such as plant-based foods, as key strategies to address challenges posed by current unstable food systems. These results contribute to forming a broad understanding of consumers' perspectives of plant-based foods.

Keywords: Sustainability, Innovation, Plant-based foods, Consumers perspectives.

Resumo

As alterações climáticas afetam a cadeia alimentar, enquanto os sistemas alimentares influenciam simultaneamente o próprio meio ambiente. Neste sentido, a adoção de dietas sustentáveis e conscientes representa uma ação que os indivíduos podem tomar para mitigar este problema atual.

Esta dissertação combina dois estudos: o primeiro, tem como objetivo investigar a concetualização e a vontade de comer produtos com algas comestíveis, numa amostra Portuguesa; o segundo, tem como objetivo validar duas escalas, uma sobre as barreiras à alimentação à base de produtos de origem vegetal, e outra relacionada com a sustentabilidade social, ambiental e económica.

Ambos os estudos utilizaram questionários online, aplicados através do *LimeSurvey* a uma amostra Portuguesa.

No estudo das algas, os participantes (n=494) foram agrupados em quatro segmentos de aceitação; as algas foram primeiramente associadas ao termo "Natureza"; o género, o nível de escolaridade, o estado civil, o número de membros do agregado familiar, a situação financeira, a atividade profissional, o tipo de dieta, a salubridade da dieta, o consumo de alimentos étnicos, a familiaridade, a neofobia alimentar, os valores de sustentabilidade e a confiança em organizações não governamentais, mostraram influência na aceitação de produtos com algas comestíveis.
Para o segundo estudo (n=66), a versão curta da escala de barreiras pode substituir a versão longa, e a escala de sustentabilidade social, económica e ambiental é fiável.

Este trabalho enfatiza as dietas sustentáveis e as fontes alimentares alternativas, tais como os alimentos de origem vegetal, como estratégias-chave para enfrentar os desafios colocados pela instabilidade dos sistemas alimentares atuais. Estes resultados contribuem para formar uma compreensão alargada das perspetivas dos consumidores sobre alimentos de origem vegetal.

Palavras-chave: Sustentabilidade, Inovação, Alimentos de origem vegetal, Perceções dos consumidores.

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List of Abbreviations

AC – Acceptors

AIP - Advanced Insights Platform

COMFOCUS - Community on Food Consumer Science

FACT - Food Action Rating

FN - Food Neophobia

FNS – Food Neophobia Scale

GHG - Greenhouse Gas

GS - Green Scale

IPCC - Intergovernmental Panel on Climate Change

KMO - Kaiser-Meyer-Olkin

MA - Moderate Admirers

MC - Moderate Critics

MC Sonae - Sonae MC Serviços Partilhados S.A

RJ – Rejecters

SD – Standard Deviation

1. Introduction

One of the largest problems we currently face is climate change, which has a direct impact on the entire food chain (Ray et al., 2019). The food system is completely affected by the challenges posed by the climate, but at the same time it also contributes for, approximately, 30% of total greenhouse gas (GHG) emissions (Abbass et al., 2022; Crippa et al., 2021; Qin & Horvath, 2022; Tubiello et al., 2022), as well as other issues, such as being responsible for a high consumption of resources, like water (Liu et al., 2022; Mekonnen & Gerbens-Leenes, 2020). Consequently, problems correlated to this issue, such as food waste, food insecurity and unsustainable consumption patterns, contribute to unstable food systems (Dasgupta & Robinson, 2022; Kemp et al., 2022; Qin & Horvath, 2022).

As diets play an important role in human health and environmental sustainability, recent studies show that animal-based diets represent a threat to both, due to the higher risk of non-communicable diseases, and the amount of GHG emissions, land degradation and water use (Espinosa-Marrón et al., 2022; Najjar, 2023). With an increasing growing world population, together with the demand for resources, a sustainable and secure food chain is crucial to ensure welfare, of both present and future generations, and to preserve an habitable planet for all (Mekonnen & Gerbens-Leenes, 2020).

Sustainable diets represent a balance between nutritional adequacy, environmental integrity, and social equity, offering a holistic approach to control the adverse impacts of the current instability of food patterns (El Bilali et al., 2019; Mason & Lang, 2017). Adopting sustainable diets, and exploring sustainable alternative food sources, represents one of the actions that individuals can take to help alleviate the environmental pressures from the food system (Röös et al., 2017). According to some recommendations, such as the EAT Lancet report on healthy sustainable diets (Willett et al., 2019), the Intergovernmental Panel on Climate Change (IPCC) report about "Mitigation of Climate Change" (Shukla et al., 2022) and some recent findings in the literature, reducing meat consumption represents a viable solution to help mitigate the excessive use of natural resources (González et al., 2020). In this sense, plant-based diets are associated with a lower environmental impact compared to animal-based diets (lower emissions of GHG and less use of resources) (Denton et al., 2022), as well as with a lower risk of cardiovascular diseases, diabetes type II and a decreased risk of some types of cancer (Dinu et al., 2017; Espinosa-Marrón et al., 2022; Segovia-Siapco & Sabaté, 2019; Selinger et al., 2022), representing a sustainable and health-conscious alternative to traditional animal-based diets (Sadeghighazichaki et al., 2020). It is known

that the more plant-based a diet is, the more sustainable it is (Chai et al., 2019). Likewise, the IPCC report describes the change to plant-based diets as an "opportunity for mitigating and adapting to climate change" (Shukla et al., 2022).

Sustainable ingredients, such as algae, provide a nutrient-rich alternative in plant-based options (Montero et al., 2018; Ścieszka & Klewicka, 2019). An excellent source of natural bioactive compounds (specially microalgae), and rich in a variety of nutrients (although it varies between different species), algae offer an opportunity for individuals to fulfil dietary requirements, while avoiding the abovementioned ecological consequences, associated with animal-based production (Caporgno & Mathys, 2018; da Rosa et al., 2023; da Silva Vaz et al., 2016; Mendes et al., 2022). Algae have a great protein and omega-3 fatty acids content, and contain polysaccharides, that provide pharmaceutical properties, such as anticancer, antioxidant and antimicrobial (Chaisuwan et al., 2021). Usually, in the literature, the term "algae" includes both macroalgae (also known as seaweed, e.g., kelp) and microalgae (e.g., spirulina), and there has been more interest in using them as an ingredient, due to its potential as sustainable and regenerative ingredients (Diaz et al., 2023; Mendes et al., 2022). Hence, with the aim of a sustainable future, microalgae offer a cost-effective and eco-friendly method for producing food products and lowering GHG emissions (Show, 2022). The sustainability behind algae production is linked to the following aspects: nutrient removal from wastewater, hence the capacity to recycle water and nutrients, minimizing water usage and pollution; microalgae's carbon dioxide bio fixation ability (help mitigate pollution, reducing GHG emissions); and microalgae production of high amounts of protein, consuming less time and resources (Chia et al., 2020; da Silva Vaz et al., 2016; Show, 2022). Also, when cultivating algae, they can grow without freshwater or arable land, and this aligns with sustainability goals due to its resource-efficient nature (Dang et al., 2022; El Shenawy et al., 2020; Herrera et al., 2021). Moreover, as algae do not compete with food crops, it can be a source of food in areas where no arable lands or potable water exist (da Silva Vaz et al., 2016; Diaz et al., 2023).

Due to its potential, at a global scale, the production of algae has been increasing, and although more common in Asia, algae as food is progressively being included in European diets, with an evident growing market (Araújo et al., 2021; Blikra et al., 2021; Boukid & Castellari, 2021; Ullmann & Grimm, 2021; Vazquez Calderon & Sanchez Lopez, 2022). In 2022, the Europe algae products market was valued at 975.63 million US dollars, and it is estimated that by 2030, it will value around 1,540.38 million USD, with a compounded annual growth rate of 6.0% (Research, 2023). This is a significant

growth meaning that this market is active and continuously expanding throughout Europe (Vazquez Calderon & Sanchez Lopez, 2022). In 2022, a report for the European Commission identified 413 companies that produce algae biomass (not only to food sector, but also to different applications (Araújo et al., 2021)) in 24 European countries, with 19 companies identified in Portugal (Vazquez Calderon & Sanchez Lopez, 2022). Portugal is a country with a great variety of algae (Gaspar et al., 2019), and its consumption is marginal (Araújo et al., 2021). Its industry is advanced, with production companies such as *ALGAplus*, *Necton* and *Allmicroalgae*. Despite the growing interest in algae, its consumption is still uncommon in Portugal, except in Açores, that has some dishes that include them (Gaspar et al., 2019). As the population's consumption is low, there is no risk of accumulating heavy metals, so it's considered safe to consume algae-based products (Vellinga et al., 2022). Data from the consumption of algae by Europeans is limited, but what is known is that it is still low so, as a bridge between consumer preferences and needs, and ecological considerations, food market has been trying to convert this, by creating a diverse range of innovative and hedonic algae food products (Mendes et al., 2022).

Through innovation algae can be consumed in different ways either as food additives, food supplements, superfoods or, they can be incorporated as an ingredient into different food products (da Silva Vaz et al., 2016; Nutrição, 2019; Vazquez Calderon & Sanchez Lopez, 2022). Therefore, in addition to the ecological and nutritional advantage over other protein sources, algae offer different sensory characteristics for the development of new products (Caporgno & Mathys, 2018; Francezon et al., 2021; Nova et al., 2020). Color, texture and taste are some of the organoleptic properties that stand out, and can be adapted to the type of product that is aimed to obtain, depending on different types of edible algae (Francezon et al., 2021; Mendes et al., 2022; Shakerardekani & Etemadi, 2023). There is, therefore, a wide variety of possibilities for new products (Ścieszka & Klewicka, 2019). Edible microalgae and macroalgae types have been studied to be used in different food products like yogurts (Barkallah et al., 2017), bread (Graça et al., 2018; Nunes et al., 2020; Uribe-Wandurraga et al., 2019), pasta (Rodríguez De Marco et al., 2014), sauces (Almeida et al., 2021), snacks (Etemadian et al., 2018; Lucas et al., 2018), cookies (Batista et al., 2017) and drinks (Castillejo et al., 2018). Adding algae to these products adds nutritional value to them, while some types of algae also have the potential to contribute to the umami flavour, enhancing the palatability of dishes and food products (da Silva Vaz et al., 2016; Figueroa et al., 2023; Nova et al., 2020).

The success of dietary shifts depends on consumers' willingness to adopt new foods and patterns, which is something that requires collaborative efforts from many food system actors, and also between governments, private sector and civil society (Brouwer et al., 2021; Vermeulen et al., 2020). Restaurants, for example, by designing the menus could use nudging strategies to encourage more sustainable choices and, through the collaboration between chefs and scientists, produce attractive and tasty plant-based options, so that these dishes are appealing and available (Gavrieli et al., 2022; Gravert & Kurz, 2021; Mouritsen et al., 2018; Vermeulen et al., 2020). Also, to create sensory appealing products, innovation alone is insufficient for the success of it, so understanding consumers' acceptance is decisive (Guiné et al., 2020; Nazzaro et al., 2019). As mentioned before, there has been a growing commitment to develop new products with the incorporation of algae, even though, usually, the algae content of the majority of the products is still low (Diaz et al., 2023). Understanding consumers' acceptance and conceptualization is pivotal for tailoring products to meet their preferences and needs (Guiné et al., 2020). The shift towards more plant-based diet faces barriers, that need to be addressed for a better understanding of consumers challenges (Perez-Cueto et al., 2022).

To consumers it can be a challenge to accept and adopt products with algae, as the acceptance is influenced by many interrelated factors, between individual preferences, cultural factors, and others (Nutrição, 2019; Vellinga et al., 2022). Thus, as any other food product, the acceptance of algae food products is influenced by determinants and is crucial to study them to understand the factors that influence consumers' choices (Chen & Antonelli, 2020). One fundamental determinant is the type of diet individuals adopt, since there is a link between the food choices made in each diet and, consequently, the possible integration of algae in dishes. This can significantly impact its acceptance, as it aligns with specific dietary preferences. Additionally, the perceived healthiness of the diet may influence algae' acceptance, since healthier and health conscious consumers prioritize and are aware of nutritious options (Ghvanidze et al., 2017). Also, increased exposure to ethnic foods, such as sushi and miso soup, typical of oriental cultures, might increase the willingness to eat algae, because of the higher exposure and familiarity to the product (Palmieri & Forleo, 2022). However, food neophobia, or the fear of trying new foods, can act as a barrier to acceptance, highlighting the influence of the reluctance of novel foods (Losada-Lopez et al., 2021; Pliner & Hobden, 1992). Food neophobia in food consumer studies remains highly important considering the influence it has on consumers' acceptance (Rabadán & Bernabéu, 2021). Green consumption values, which is defined as the tendency to express the value

of environmental protection, through purchases and consumption behaviours (Haws et al., 2014), and trust in food system actors are vital determinants for environmentally conscious consumers, as they seek sustainable and ethical foods, as algae products (Macready et al., 2020). Finally, sociodemographic characteristics, such as age, income, and education, can influence acceptance by shaping factors like individual preferences, needs, accessibility and availability of information (Baker et al., 2022). Altogether, these determinants form a complex web, that guides the acceptance of algae as a viable and sustainable food source.

For consumer science studies, the validation of instruments, such as scales to implement in questionnaires, adds reliability and credibility to research findings (Boateng et al., 2018). In addition, the creation and validation of short scales, allows for a more efficient and simple method, preventing response failure, derived by problems, like fatigue and lack of time (Sánchez et al., 2021).

The present dissertation is inserted in the scope of two distinct internships, carried out in different phases: firstly, at Sonae MC Serviços Partilhados S.A (MC Sonae), where the study "Consumers' acceptance and conceptualization of innovative food products with edible algae" was done (Section 2.), and then at Umeå University, with the research named "Validation of two scales: consumers barriers and importance of social, environmental and economic sustainability for plant-based foods" (Section 3.). These two studies culminate in the present thesis called: "Consumers' perspectives of innovative and sustainable plant-based food products". The combination of these two works, results in a broad view of the consumers perspectives: on one hand for a comprehensive exploration of consumers' acceptance for innovative food products with edible algae, and, on the other hand, the barriers of plant-based foods and social, economic and environmental sustainable aspects. This provides valuable insights for the progression of sustainable food options in the market and directing future studies towards a better understanding of these aspects.

2. Consumers' acceptance and conceptualization of innovative food products with edible algae

2.1. Abstract

Background: Algae are a sustainable food source, but its adoption depends on consumer acceptance.

Objective: To investigate the conceptualization and willingness to eat products with edible algae, in a Portuguese sample.

Methods: A web-based questionnaire was applied. Free-word association and FACT scale were used. Data was analysed using SPSS v.27 and XLSTAT, and a *p*-value <0.05 was considered significant.

Results: Participants (n=494) were grouped in four segments: Moderate Critics (n=123), Rejecters (n=116), Moderate Admirers (n=182) and Acceptors (n=73). To conceptualize algae, "Nature" was the most cited dimension. Regarding algae related to food, "Food" was the dimension more mentioned. There are differences in the acceptance ($p < 0.001$). Pasta (FACT – 5.6 ± 1.9) and dry seasonings (FACT – 5.6 ± 1.9), have positive evaluations. Gender, level of education, marital status, number of household members, financial situation, occupation, type of diet, healthiness of the diet, consumption of ethnic foods, familiarity, food neophobia, green consumption values and trust in non-governmental organizations showed influence in acceptance.

Conclusion: "Nature" is more associated to algae and "Food" is associated to algae and food. The acceptance of algae is divided into different consumer segments and the determinants studied have an influence on it.

Keywords: Algae, Acceptance, Conceptualization, Innovation, Sustainability.

2.2. Study framework

The current food system is experiencing critical problems and it is predicted that it will face more challenges in the years ahead, particularly concerning climate change (Macdiarmid & Whybrow, 2019). The reduction in the consumption of meat, often used as the main protein source in many Western diets, can reduce environmental impacts (Swain et al., 2018).

Consequently, there is a growing recognition of the need to shift dietary patterns towards more sustainable options, and as the latest IPCC report shows, a dietary shift is a necessary step to try climate change mitigation (IPCC, 2022). Plant-based foods, being resource-efficient and associated with sustainability, offer a viable alternative to conventional meat-based diets (Hartmann & Siegrist, 2017). Hence, all society actors must take rapid action to meet these goals, but a change in food habits is required and faces some challenges (Aschemann-Witzel et al., 2021; Perez-Cueto, 2019).

Algae-based foods have potential due to how sustainable they are, including efficient resource utilization and potential climate change mitigation (Ullmann & Grimm, 2021). Moreover, algae can be integrated in different food products, because of its unique sensory properties, that can enhance the overall acceptance and palatability of plant-based food products, facilitating their integration into consumers diets (Fanari et al., 2023; Francezon et al., 2021).

To the author knowledge, currently, there is a gap in the willingness to eat algae by Portuguese consumers, and the relationship of it with relevant determinants, since there is no information in this field. Portugal has a unique culinary heritage deeply rooted in seafood and marine resources due to its coastal geography (Almeida et al., 2015). Given its strong connection to the sea, investigating consumers acceptance towards algae-based products aligns with the country's growing focus on sustainability and marine conservation (Frazão Santos et al., 2014). Understanding and studying consumer acceptance of algae as a food source is important in practically advancing this sustainable food option. Through informed insights into consumers' perception, willingness to eat and determinants that can influence its acceptance, it can be possible to tailor product development, marketing strategies, and educational campaigns, promoting the adoption of algae-based foods, and ultimately contributing to a more sustainable and environmentally conscious food ecosystem. This interdisciplinary exploration bridges the realms of sustainability, nutrition, and consumer behaviour,

offering a pathway towards a more environmentally resilient and ethically conscious food future.

This study can offer valuable insights to food industry, as well as to retail companies, as it strives to create and offer, respectively, novel products in response to consumer preferences, contributing to the introduction of innovative and nutrient-rich algae products. This also allows the exploration of new culinary horizons, contributing to the growth of a more varied and progressive food culture. The study's originality lies in its exploration of an emerging food trend within a distinct cultural and geographic context, providing information that can be valuable both locally and globally.

This study is a result of a collaborative work of an academic internship conducted between August of 2022 and February of 2023, at MC SONAE (Product Innovation team), for Continente Food Lab. It was through innovation, design thinking and the constant mission to keep up with international food trends, that a relevant work emerged, both for the scientific community and for food industry and retailers.

2.3. Objectives

2.3.1. General objectives

To investigate the conceptualization and willingness to eat different innovative food product categories containing edible algae, in a Portuguese sample.

2.3.2. Specific objectives

a. To identify the conceptualization of algae and algae related to food.

b. To evaluate the willingness to eat different food product categories containing edible algae.

c. To characterize different consumers' segments, if existed, considering their acceptance of algae food products.

c. To characterize the relationship between the acceptance of algae food products, within different consumer segments, and the following determinants: dietary lifestyle, healthiness of the diet, frequency of consumption of sushi, miso soup and algae food products, familiarity, food neophobia, degree of sustainability awareness, trust in actors of the food system and demographic data.

2.4. Materials and methods

2.4.1. Study design and data collection

A web-based questionnaire was developed (section 2.4.2.) and applied via *LimeSurvey* (online survey tool), for 3 weeks, between 27th of November 2022 to 18th of December 2022. The target population was Portuguese adults above 18 years old and the ambition was to obtain an heterogenous sample, as much as possible. Hence, participants were recruited anonymously through social networks by *JuniFEUP* (University of Porto's Engineering Junior Enterprise) (Annex 1), dynamic email of the University of Porto to the entire academic community, and with flyers at MC SONAE' buildings (Portuguese retail company, at Matosinhos and Maia, Portugal) (Annex 2). Consequently, a convenience sampling with different social demographic characteristics was collected. A general description of the study was provided in the recruitment, and participants were not informed about the specific purpose of the study. Also, no mention was made of the word "algae" and no incentives were used.

The inclusion criteria were fully completed questionnaires and participants $\geq$ 18 years old with Portuguese residence. Inconsistent answers on controlling variables, for instance in FN, and "straight-lining" answers (indicator of poor response quality) (Schonlau & Toepoel, 2015) were removed. The term "algae" in this study refers to both macro and microalgae.

This study makes use of the resources of the Community on Food Consumer Science (COMFOCUS) project, funded by the EU Commission under the Horizon 2020 scheme (H2020-INFRAIA-02-2020). A full list of the investigators and funders who contributed to COMFOCUS/collation of the data is available from www.comfocus.eu.

2.4.2. Questionnaire

Initially, the questionnaire (Annex 3) was prepared in English and then translated to Portuguese, based on the expertise and knowledge of the research team. Some scales were already validated in Portuguese, such as food neophobia scale (Paupério et al., 2014).

Both qualitative and quantitative methodology were used, and the questionnaire contained twenty-six questions, divided in five different groups. Table 1 shows the structure of the questionnaire.

Table 1 - Questionnaire' items.

Groups	Parts	Items	Scale
Conceptualization	Conceptualization of "algae" and "algae + food" (Ares et al., 2015; Barone et al., 2020; Guerrero et al., 2010; Sousa et al., 2021; Vidal et al., 2013)	"Indicate the first three words that come to your mind when you think of algae"; "… think of algae and food". "Classify them…".	Free-word association. "Positive", "neither positive nor negative", or "negative".
Acceptance and willingness to eat different categories with algae	Food Action Rating (FACT) scale (SCHUTZ, 1965)	Dehydrated algae Pre-prepared meals Canned meals Fresh ready-to-eat meals Instant meals Pâtés Sauces Dry seasonings Snacks Bakery Salty pastries Sweet pastries Cookies Frozen vegetables Pasta Dairy Drinks	(1) I would eat this if I were forced to. (2) I would eat this only if there were no other food choices. (3) I would hardly ever eat this. (4) I don't like it but would eat it on an occasion. (5) I would eat this if available but would not go out of my way. (6) I like this and would eat it now and then. (7) I would frequently eat this. (8) I would eat this very often. (9) I would eat this every opportunity I had.
Eating behaviour and familiarity	Dietary lifestyle adapted from (Diseases, 2021)	Eating pattern	"omnivore", "flexitarian", "vegan", "lacto-ovo vegetarian", "lacto-vegetarian", "ovo-vegetarian" and "other".
	Healthiness of the diet (Loftfield et al., 2015)	"How healthy is your diet?"	"poor", "fair", "good", "very good" and "excellent".
	Frequency of consumption	Sushi, miso soup and algae 'meal/product	"never", "< 1 day/ month", "1-3 days/month", "1 day/week", "2-3 days/week", "4-5 days/week", "6-7 days/week".
	Familiarity (Bäckström et al., 2004)	Knowledge level regarding meals/food products with algae	"I don't know it", "I know but I have never used it", "I know and have used it"
Neophobia, green values and trust	Food neophobia (FN) (Pliner & Hobden, 1992)	I am constantly sampling new and different foods (R)*. I don't trust new foods. If I don't know what a food is, I won't try it. I like foods from different cultures (R) *. Ethnic food looks too weird to eat. At dinner parties, I will try new foods (R) *.	7-point anchored scale from 1- "Completely disagree" to 7- "Completely agree"

Groups	Parts	Items	Scale
		I am afraid to eat things I have never had before.	
		I am very particular about the food I eat.	
		I will eat almost anything (R) *.	
		I like to try new ethnic restaurants (R) *.	
		It is important to me that the products I use do not harm the environment.	
		I consider the potential environmental impact of my actions when making many of my decisions.	
	Green consumption values (Haws et al., 2014)	My purchase habits are affected by my concern for our environment.	
		I am concerned about wasting the resources of our planet.	
		I would describe myself as environmentally responsible.	
		I am willing to be inconvenienced in order to take actions that are more environmentally friendly.	
	Trust in food system actors adapted from Macready et al. (2020)	Farmers Food manufacturers Retailers Authorities Non-governmental organizations	"totally distrust", "distrust slightly", "trust slightly" and "totally trust".
Sociodemographic profile		Gender	Female, Male, I do not identify with the binary classification, I prefer not to answer.
		Age	Years
		Level of education	Primary school, Elementary school (2nd or 3rd cycle), secondary education, post-secondary education, professional higher technical course, Bachelor's degree, Master's degree, Doctoral degree.
		Nationality	Open ended
		Municipality	Open ended
		Marital status	Single, married, widow(er), divorced.
		Number of household members	Open ended

Groups	Parts	Items	Scale
		Net monthly income (Instituto Nacional de Estatística, 2022)	Less than 560€ 560€ a 790€ 790€ a 1010€ 1010€ a 1260€ 1260€ a 1530€ 1530€ a 1780€ 1780€ a 2120€ 2120€ a 2610€ 2610€ a 3440€ More than 3440 €
		Occupation	Self-employed, Employee, Student, Student Worker, Unemployed, Retired, Other (open-ended.)

R- reversed items.

2.4.2.1. Free word association

From a conceptual and free perspective, qualitative methodology was used in order to analyse the conceptualization that consumers have regarding the use of algae. Therefore, with free association methodology (Ares et al., 2015; Barone et al., 2020; Guerrero et al., 2010; Sousa et al., 2021; Vidal et al., 2013), it was possible to determine what associations consumers make about algae in general, and algae related with food.

2.4.2.2. Acceptance and willingness to eat

To study the acceptance and willingness to eat seventeen food categories were carefully selected. A review was carried out about the existing algae food products categories with the following methodology: Firstly, all the food products with the incorporation of algae, currently in range at MC SONAE, were identified in the platform Advanced Insights Platform (AIP), using the search keywords (in Portuguese and English): "alga(s)", "algae", "seaweed", "wakame", "spirulina", "nori", "agar-agar" and "kombu"; then, to identify product categories in the international market, it was proceeded and analysis at Mintel, and reports including industry trends, consumer trends, expert insights, observations, and news across all categories were selected and studied; and finally, it was identified product categories in IdeaLab reports (co-innovation platform of MC SONAE, to develop disruptive food products), that were previously made.

In the questionnaire, for each category at least one food product with the incorporation of algae were used to exemplify the category (e.g.: bakery - bread with dried algae), and the order of the items in this group was balanced between participants.

To estimate the acceptance and willingness to eat different algae 'food product categories, FACT scale (categorical rating scale) (SCHUTZ, 1965) was used. This scale represents a tool to estimate overall acceptance, as it combines the acceptance together with the willingness to eat (SCHUTZ, 1965). The abovementioned items (Table 1) can translate attitudes and behaviour of consumers, and there's a probability that the participants have never tried these products before, as they are innovative, so it's important to evaluate willingness to eat, rather than studying the liking level (usually used in hedonic scales) (SCHUTZ, 1965).

Based on the interpretation of the scale, the first three items denote a negative evaluation, as they illustrate a non-intention of eating the product. Items 4 and 5 represent a moderate intention, as it says that the individuals don't like it, but they could eat it once in a while. Finally, items 6,7,8 and 9 indicate positive evaluations.

2.4.2.3. Eating behaviour

A group of questions was made to characterize eating behaviour, as shown in Table 1. To evaluate the level of familiarity of participants, a branched question was used. Participants who stated that have never consumed an "algae' meal/product", were redirected to the question that measures familiarity. Consequently, these ones needed to rate their knowledge regarding meals/food products with algae (Bäckström et al., 2004).

2.4.2.4. Food neophobia, Sustainability awareness and trust

The importance to evaluate food neophobia (FN) in food consumer studies remains highly important considering the influence it has on consumers' acceptance (Rabadán & Bernabéu, 2021). The translated Portuguese version of the FN scale (FNS) was used (Paupério et al., 2014).

Half of the items – items 1,4,6,9 and 10 - were reversed and analysed separately as they measure food neophilia (willingness to try new foods (Ristic et al., 2016)). The final score, generated from the scale, can range from 10 (lowest neophobia) to 70 (highest neophobia). A high score represents less willingness to try new or unfamiliar foods (neophobia), while a lower score indicates more willingness to try novel foods (neophilia) (Pliner & Hobden, 1992).

To explore the environmental responsibility regarding consumption behaviours, Green Scale (GS) was used (Haws et al., 2014). The final score, generated from this scale, ranges from 6 (lowest sustainability sensibility) to 42 (highest sustainability sensibility).

Consumers with stronger green consumption values are called "green" consumers (Haws et al., 2014).

Trust towards food system actors was also evaluated, since it impacts consumers' confidence, while making food decisions, such as trying a new or unfamiliar product, like algae (Wu et al., 2021). The last part of the questionnaire was dedicated to collect sociodemographic information.

2.4.2.5. Pilot study

Prior to the implementation of the questionnaire, a pre-test was done with ten people, to assess the legibility and the comprehension of the questions, and to measure the time the questionnaire took to fill in (on average 8 minutes). Participants, in the targeted age group, were recruited via snowball sampling in the researchers´ network and they received the link to the survey via online (*Whatsapp*). Afterwards, each participant gave inputs and opinions via phone, to discuss the structure of the survey and to adapt it according to the suggestions. Just a few things were slightly modified in the survey (mainly misunderstanding in some explanations).

2.4.3. Ethical approval and participants' consent

This project was approved by the Ethics Committee of the Faculty of Sciences of the University of Porto (Proc. CE2023/p45) (Annex 4).

Participants were asked for their consent regarding participation in the survey and were aware of the time needed (approximately 8 minutes) prior to completing the questionnaire. A statement regarding the confidentiality and anonymity of the data was provided before the beginning of the survey. Participants were asked to give consent for their data to be used for scientific purposes.

2.4.4. Data management and analysis

Data collected by *LimeSurvey* was downloaded to an Excel file. In this Microsoft app, data was organised, cleaned (according to the exclusion/inclusion criteria) and recoded.

Data from free word association were analysed qualitatively, based on thematic analysis, which allowed grouping the various terms into different dimensions, according to their similarity. Therefore, similar words were categorized in dimensions and, afterwards, grouped in different categories (within each dimension). A double check was done: first, the terms were grouped according to their meaning, based on individual interpretation,

and then the research team analysed them together, defining the final terms of the dimensions consensually (Ares et al., 2015).

Sampling was designed and structured by age group (three groups: 18-34, 35-54 and ≥ 55 years), gender (male and female), and maximum level of education was divided in two groups: higher education (professional higher technical course, bachelor's, master's and doctoral degree) and lower education (every degree until post-secondary education).

The following variables were recoded into:

- Gender: 0 ("male"), 1 ("female") and 2 ("I do not identify with the binary classification").
- Age: 1 ("18-34"), 2 ("35-54") and 3 ("≥ 55 years").
- Maximum level of education: 1 ("lower education") and 2 ("higher education").
- Financial situation was divided in three groups: 1 ("lower income", less than 560€, 560 to 790€ and 790€ to 1010€), 2 ("middle income", 1010€ to 1260€, 1260€ to 1530€, 1530€ to 1780€ and 1780€ to 2120€) and 3 ("higher income", including 2120€ to 2610€, 2610€ to 3440€ and more than 3440 €).
- Healthiness of the diet: -1 ("poor"), 0 ("fair"), 1 ("good"), 2 ("very good") and 3 ("excellent");
- Frequency of consumption: 0 ("never"), 1 ("< 1 day/ month"), 2 ("1-3 days/month"), 3 ("1 day/week"), 4 ("2-3 days/week"), 5 ("4-5 days/week") and 6 ("6-7 days/week");
- Familiarity: -1 ("unknown"), 0 ("I know about it, but I have never eaten it") and 1 ("I know and have used it");
- Food neophobia: 0 ("neophilic") and 1 ("neophobic");
- Green values: 0 ("non-green consumers") and 1 ("green consumers");
- Trust: 0 ("I totally distrust"), 1 ("I partially distrust"), 2 ("I partially trust") and 3 ("I totally trust").

2.4.5. Statistical analysis

For the conceptualization analysis, the words were translated to English and all valid words mentioned by participants were used for data analysis (Ares et al., 2015; Schmitt, 1998). Frequencies of the mentions for each dimension, were calculated, to characterize data from free word association. All the frequencies of mention (words, categories and dimensions) were calculated without taking into account whether the words were

mentioned by the same participant or different participants (Ares et al., 2015; Schmitt, 1998). Consequently, the relative frequencies of category and dimension mentions might surpass 100%.

Correspondence analysis, to measure the association between the different dimensions among different consumers segments considering the degree of acceptance, was made. For this analysis, a minimum frequency percentage value of 5% was set (Ares et al., 2015; Sousa et al., 2021).

Descriptive statistics (frequencies, mean and standard deviation (SD)) were applied to describe socio-demographic characteristics of the sample, as well as chi-square and Kruskal-Wallis test.

To evaluate the level of acceptance of different food categories containing edible algae mean, standard error of mean and Friedman test was applied.

Factorial analysis, with Cronbach's alfa interpretation (to evaluate internal consistency and reliability) (Cronbach, 1951) and Kaiser-Meyer-Olkin (KMO) statistics (used to interpretate sampling adequacy (Kaiser, 1981)) was applied to analyse FACT scale, FNS and GS results.

For FNS and GS a score was generated to characterize neophobic and green consumers, respectively. The methodology was the same for both scales: first, a variable with the score was created; second, the mean of the new variable was calculated; then, the cutoff point was defined (based on the mean value), in order to distinguish the consumers.

To identify different consumer segments considering the degree of acceptance of the different categories of food products, cluster analysis was conducted. Thus, hierarchical cluster analysis, using ward's method, dendrogram and K-mean clustering was applied (Wilks, 2011).

To analyse the relationships between variables, Kruskal-Wallis was used for ordinal variables and, if $p < 0.05$, post-hoc tests were used to identify which specific groups differ significantly from each other (Mann-Whitney for pairwise comparisons). For nominal variables, chi-square was applied.

All statistical tests were applied at 95% confidence level. Data was analysed using Microsoft Excel, XLSTAT and IBM SPSS Statistics 27.

2.5. Results

2.5.1. Willingness to eat food products containing edible algae

Chart 1 shows the mean values of willingness to eat the different food categories, of the whole sample (n=494), in ascending order, and the food categories split into three different groups, in terms of willingness to eat (FACT scale). Based on these results, pasta, bakery, cookies and dairy are grouped together; dry seasonings, frozen vegetables, snacks, and dehydrated algae represent other group; and the other food categories (salty pastries, sauces, pâtes, pre-prepared meals, takeaway meals, canned meals, sweet pastries, beverages and instant meals) fall in the same group.

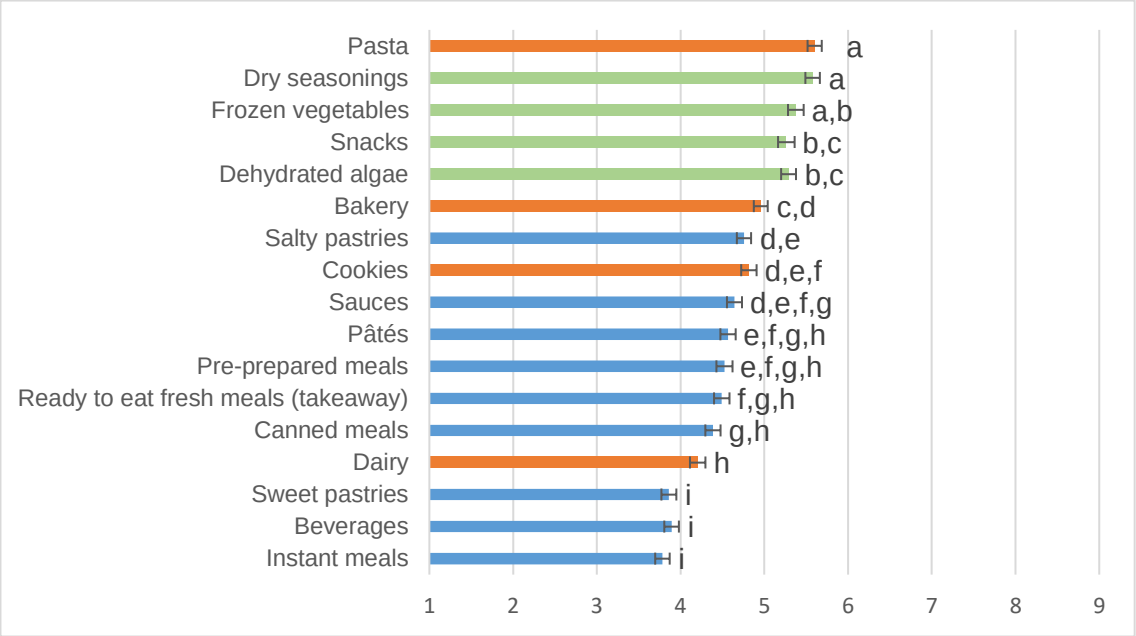

Chart 1 - Mean values of the willingness to eat (FACT) evaluations of the different food categories, with standard error of mean. The colours represent the food categories split into three different groups (orange, green and blue).

Due to Friedman test ($p < 0.001$), there are significant differences between the different categories, i.e., there are differences in the evaluation of the willingness to eat different food categories.

Both pasta (FACT – 5.6 ± 1.9) and dry seasonings (FACT – 5.6 ± 1.9), have the most positive evaluations. Rounding up the number, they have a score of 6 which represents "I like this and would eat it now and then". By contrast, instant meals, beverages, sweet pastries, dairy and canned meals have the lowest evaluations, with a few differences among them. The average evaluation of this food categories is 4 ("I don't like it but would eat it on an occasion"), and it represents a low intention to eat the listed food categories, as the participants don't like it, but could eat it occasionally. Rounding up the numbers, all the other food categories have a score of 5 ("I would eat this if available but would not

go out of my way"), which also demonstrates a moderate low intention to eat the products.

Through factorial analysis, a reduction of the different food categories was run (Table 2). It shows that the food categories, load in three factors (the respective selected names are in the first column of the table) and their correspondent Cronbach's alphas are high (which means that the items are correlated to each other (Tavakol & Dennick, 2011)), ranging from 0.842 to 0.939. This also indicates good internal consistency among the items of the respective constructs (Amirrudin et al., 2020; Vaske et al., 2017). Therefore, three factors are generated and due to Friedman test, there are significant differences between them ($p < 0.001$). The value of sample adequacy is high (KMO=0.964), and Bartlett's test of sphericity has a p-value < 0.001.

Table 2 - Factor analysis of the food categories.

Factors name**	Food Categories	Loadings	Explained variance	Cronbach's alpha
Convenience Food and Meal Solutions	*Ready to eat Fresh meals*	0.844	57.91%	0.938
	Pre-prepared Meals	0.843		
	Pâtes	0.835		
	Instant meals	0.831		
	Canned meals	0.828		
	Salty pastries	0.817		
	Beverages	0.815		
	Sweet pastries	0.769		
	Sauces	0.740		
Preserved and Flavourful Foods	*Frozen vegetables*	0.790	8.35%	0.857
	Dehydrated algae	0.774		
	Snacks	0.726		
	Dry seasonings	0.656		
Bakery Products and Dairy	*Cookies*	0.867	4.68%	0.842
	Bakery	0.834		
	Pasta	0.764		
	Dairy	0.731		

** Friedman Test: $p < 0.001$ – there are significant differences in the three factors.

The name "Convenience Food and Meal Solutions" was suggested to incorporate a group of food categories that share a common theme of being convenient and providing solutions for quick and easy meal preparation. "Convenience Food" emphasizes the convenience aspect of the food categories included and it implies that these food categories are designed to require minimal preparation. The term "Meal Solutions" reinforces the idea that these food categories offer solutions for creating complete meals. Each category listed - ready-to-eat fresh meals, pre-prepared meals, pâtes, instant

meals, canned meals, salty pastries, beverages, sweet pastries, and sauces - can contribute to a meal, either as a main component or as a flavour enhancer.

The name "Preserved and Flavourful Foods," capture the key features of the food categories, including preservation methods and flavour attributes, providing a descriptive name for this group. “Preserved” indicates that some of the items in this group have undergone preservation processes to extend their shelf life. “Flavourful” emphasizes the characteristic taste and flavour aspects of the food categories included. "Snacks" and "dry seasonings" often offer distinct and concentrated flavours, contributing taste enhancements to various dishes.

The third group merge bakery products, such as cookies and bakery, but also pasta and dairy.

2.5.1.1. Consumer segments

With the creation of these three groups of food categories and based on cluster analysis, four different groups of participants were identified according to their degree of overall acceptance (FACT) of the different food categories.

These groups were divided into the following segments (Table 3): segment/cluster 1 (MC, n=123, 24.9% of the total sample), called “Moderate Critics”, because this group provided negative acceptance to group "Convenience Food and Meal Solutions" and a moderate evaluation to the other two groups, indicating a critical yet not entirely rejecting stance; segment/cluster 2 (RJ, n=116, 23.5% of the total sample), the rejecters, with the lowest levels of acceptance for all the groups; segment/cluster 3 (MA, n=182, 36.8% of the total sample), named “Moderate Admirers”, since this group shown positive acceptance for all groups of food categories, except for the group "Convenience Food and Meal Solutions", that have a moderate level of acceptance; and segment/cluster 4, the acceptors (AC, n=73, 14.8% of the total sample), with the highest levels of acceptance for all groups, especially for Preserved and Flavourful Foods. Thus, the participants were grouped in four different segments based on their acceptance of different food categories containing algae: Segment 1, the “Moderate Critics” (MC) (n=123), segment 2, the “Rejecters” (RJ) (n=116), Segment 3, “Moderate Admirers” (MA) (n=182) and Segment 4, the “Acceptors” (AC) (n=73) of algae.

The distribution of consumers is such that MA, characterized by moderate admiration for algae-based products, has the highest number of consumers, followed by MC with a

moderate level of criticism, then RJ, and finally the enthusiastic AC, with the least number of consumers.

Table 3 - Acceptance levels (mean) of different food categories of food products containing algae, regarding consumer segmentation.

Food category	**RJ** Rejecters **(n=116)**	**MC** Moderate Critics **(n=123)**	**MA** Moderate Admirers **(n=182)**	**AC** Acceptors **(n=73)**
Convenience Food and Meal Solutions	2.6	3.4	5.0	6.9
Preserved and Flavourful Foods	3.2	5.4	5.7	7.9
Bakery Products and Dairy	3.0	4.4	5.5	7.1

Figure 1 shows three crossings between the three groups of food categories within the four segments of participants.

In all the intersections there's a growing axis, with the RJ being always at the bottom and the AC on top. Thus, as shown both in Table 3 and Figure 1, RJ and AC are the opposite in the acceptance of algae food categories.

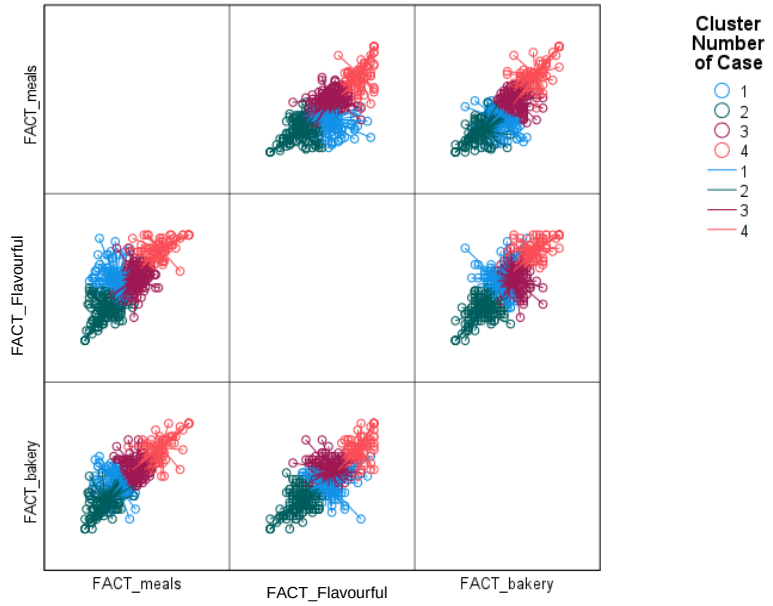

Figure 1 - Matrix scattered plot of the overall acceptance (FACT) of the three groups, within the 4 clusters. FACT_meals = Convenience Food and Meal Solutions; FACT_Flavourful = Preserved and Flavourful Foods; FACT_ bakery = Bakery Products and Dairy. Cluster number of cases represent: 1 (MC), 2 (RJ), 3 (MA) and 4 (AC).

2.5.2. Participants

From the 1445 individuals that opened the questionnaire, 564 completed all the questions. From this sample, 2 of them did not consent to participate in the study and 61 did not given permission for the information collected to be published for scientific purposes. 7 participants gave invalid answers, resulting in a total of 494 valid responses.

Table 4 shows the socio-demographic characteristics across the different segments of consumers. The majority of the sample are females (60.3%) and there's more participants with age between 18-34 years old (47.0%), highly educated (65.8%), Portuguese (96.2%), living in the north of Portugal, single (52.2%), with four household members (29.4%), higher income (43.9%) and employees (46.2%).

Table 4 - Participants' socio-demographic characteristics, N=494.

Characteristic		**Total** n = 494	Rejecters (RJ) n = 116	Moderate critics (MC) n = 123	Moderate admirers (MA) n = 182	Acceptors (AC) n = 73
Gender, n (%)	*Female*	298 (60.3)	66 (56.9)	63 (51.2)	116 (63.7)	53 (72.6)
(p=0.011)[1*]	*Male*	194 (39.3)	50 (43.1)	60 (48.8)	65 (35.7)	19 (26.0)
	Non-binary	2 (0.4)	-	-	1 (0.6)	1 (1.4)
Age (years), mean (sd) *(p=0.561)*[2]		39 (17.1)	40 (21.0)	41 (17.2)	39 (15.0)	37 (14.6)
Age Groups, n (%)	*18-34*	232 (47.0)	62 (53.4)	52 (42.3)	80 (44.0)	38 (52.1)
(p=0.148)[2]	*35-54*	139 (28.1)	19 (16.4)	30 (24.4)	65 (35.7)	25 (34.2)
	≥ 55	123 (24.9)	35 (30.2)	41 (33.3)	37 (20.3)	10 (13.7)
Level of education, n (%)	*Lower education*	169 (34.2)	58 (50.0)	50 (40.7)	35 (19.2)	26 (35.6)
(p<0.001)[2*]	*High education*	325 (65.8)	58 (50.0)	73 (59.3)	147 (80.8)	47 (64.4)
Nationality, n (%)	*Portuguese*	475 (96.2)	114 (98.3)	117 (95.1)	175 (96.2)	69 (94.5)
(p=0.472)[1]	*Others*	19 (3.8)	2 (1.7)	6 (4.9)	7 (3.8)	4 (5.5)
Municipality of residence, n (%)	*Porto*	122 (24.7)	22 (19.0)	31 (25.2)	54 (29.7)	15 (20.5)
(p=0.119)[1]	*V.N.Gaia*	45 (9.1)	14 (12.1)	9 (7.3)	14 (7.7)	8 (11)
	Matosinhos	36 (7.3)	4 (3.4)	14 (11.4)	12 (6.6)	6 (8.2)
	Maia	29 (5.9)	8 (6.9)	6 (4.9)	13 (7.1)	2 (2.7)
	Others	262 (53.0)	68 (58.6)	63 (51.2)	89 (48.9)	42 (57.5)
Marital status, n (%)	*Married*	202 (40.9)	36 (31.0)	64 (52.0)	78 (42.9)	24 (32.9)
(p<0.001)[1*]	*Divorced*	18 (3.6)	2 (1.7)	3 (2.4)	6 (3.3)	7 (9.6)
	Single	258 (52.2)	68 (58.6)	55 (44.7)	96 (52.7)	39 (53.4)
	Widow(ed)	16 (3.2)	10 (8.6)	1 (0.8)	2 (1.1)	3 (4.1)
Nº of household members, n (%)	*1*	55 (11.1)	17 (14.7)	10 (8.1)	19 (10.4)	9 (12.3)
(p=0.005)[2*]	*2*	110 (22.3)	25 (21.6)	19 (15.4)	41 (22.5)	25 (34.2)
	3	141 (28.5)	39 (33.6)	38 (30.9)	46 (25.3)	18 (24.7)
	4	145 (29.4)	30 (25.9)	39 (34.7)	61 (33.5)	15 (20.5)

Characteristic		Total n = 494	Rejecters (RJ) n = 116	Moderate critics (MC) n = 123	Moderate admirers (MA) n = 182	Acceptors (AC) n = 73
	5 or more	43 (8.7)	5 (4.3)	17 (13.8)	15 (8.2)	6 (8.2)
Financial situation, n (%) *(p<0.001)[2*]*	*Lower income*	73 (14.8)	31 (26.7)	11 (8.9)	21 (11.5)	10 (13.7)
	Middle income	204 (41.3)	49 (42.2)	49 (39.8)	70 (38.5)	36 (49.3)
	Higher income	217 (43.9)	36 (31.0)	63 (51.2)	91 (50.0)	27 (37.0)
Occupation, n (%) *(p=0.002)[1*]*	*Self-employed*	60 (12.1)	6 (5.2)	26 (21.1)	20 (11.0)	8 (11.0)
	Employee	228 (46.2)	46 (39.7)	52 (42.3)	94 (51.6)	36 (49.3)
	Student	117 (23.7)	33 (28.4)	32 (26.0)	34 (18.7)	18 (24.7)
	Student-worker	44 (8.9)	11 (9.5)	7 (5.7)	21 (11.5)	5 (6.8)
	Unemployed	15 (3.0)	4 (3.4)	2 (1.6)	6 (3.3)	3 (4.1)
	Retired	22 (4.5)	12 (10.3)	2 (1.6)	5 (2.7)	3 (4.1)
	Others	8 (1.6)	4 (3.4)	2 (1.6)	2 (1.1)	-

[1] Chi-square test.

[2] Kruskal-Wallis test.

* Variables with significant differences (p<0.050).

2.5.3. Relationship between the acceptance of algae food categories and determinants of acceptance

This section demonstrates if there are significant differences between the four segments, regarding each studied determinant.

2.5.3.1. Demographic characteristics

In Table 4, the relationship between sociodemographic characteristics and consumers' acceptance towards algae food categories is presented. The results show that the sample is heterogeneous, with significant differences between the four segments, relatively to gender (between male and female, due to the low representativeness of non-binaries), level of education, marital status, number of household members, financial situation, and occupation. Thus, these determinants, related to sociodemographic characteristics, have influence on the acceptance of algae. Concerning the post hoc tests (Mann-Whitney), these groups have the following differences:

- level of education: MC/MA and RJ/MA differ from each other significantly (p<0.001). Also, MA and AC differ with a p-value of 0.006.
- marital status: the segments of consumers are dependent on this variable.
- nº of household members: MC and RJ and MC and AC differ from each other significantly (p=0.003). Likewise, MA and AC differ with a p-value of 0.006.
- financial situation: MC differs from RJ (p<0.001), MC differs from AC (p=0.049) and RJ are significantly different from MA (p<0.001).
- occupations: the segments of consumers are dependent on this variable.

In all segments, there's more females, more people with age ranging from 18-34 years old, and more highly educated (except group RJ, which is 50/50).

2.5.3.2. Dietary lifestyle

Table 5 shows the frequencies of each segment regarding their dietary lifestyle (with significant differences between them, (p=0.003)). The omnivores are predominant in every group of participants, and 44 participants consider themselves as flexitarians, most of them belong to the group MA (11.5%). The dietary lifestyle with less adherence is lacto-vegetarian, followed by vegan, ovo-vegetarian and lacto-ovo vegetarian.

Table 5 - Frequencies of the relationship between dietary lifestyle and acceptance of algae food categories.

Dietary lifestyle (p=0.003) *	**RJ** Rejecters **(n=116)**	**MC** Moderate Critics **(n=123)**	**MA** Moderate Admirers **(n=182)**	**AC** Acceptors **(n=73)**
Omnivore, n (%)	110 (94.8)	105 (85.4)	151 (83.0)	52 (71.2)
Lacto-ovo vegetarian, n (%)	1 (0.9)	4 (3.3)	6 (3.3)	6 (8.2)
Flexitarian, n (%)	4 (3.4)	11(8.9)	21 (11.5)	8 (11.0)
Ovo-vegetarian, n (%)	1 (0.9)	0 (0)	2 (1.1)	3 (4.1)
Lacto-vegetarian, n (%)	0 (0)	0 (0)	0 (0)	1 (1.4)
Vegan, n (%)	0 (0)	0 (0)	1 (0.5)	2 (2.7)
Other, n (%)	0 (0)	3 (2.4)	1 (0.5)	1 (1.4)

*Chi square test.

2.5.3.3. Healthiness of the diet

In the self-evaluation of the healthiness of the diet (Table 6) (p<0.001), RJ, MC and MA are significant different from AC.

Table 6 - Relationship (mean ± sd) between healthiness of the diet and acceptance of algae food categories.

Dimension	**RJ** Rejecters **(n=116)**	**MC** Moderate Critics **(n=123)**	**MA** Moderate Admirers **(n=182)**	**AC** Acceptors **(n=73)**
Healthiness of the diet (p<0.001)*	0.81^{b}(±0.84)	0.99^{b}(±0.86)	1.42^{b}(±0.88)	0.80^{a}(±1.42)

* Kruskal-Wallis test.
a,b – homogeneous groups, according to the Mann-Whitney Test.

Table 7 shows that the majority of the participants (n=200) consider that their healthiness of the diet is good, and only ten participants assume that it is poor. Just one person of the algae 'food rejecters (RJ) classify their diet as excellent, while seven acceptors evaluate it like that. None of the acceptors find their diet poor.

Table 7 - Frequencies of the relationship between healthiness of the diet and acceptance of algae food categories.

Healthiness of the diet	**MC** Moderate Critics **(n=123)**	**RJ** Rejecters **(n=116)**	**MA** Moderate Admirers **(n=182)**	**AC** Acceptors **(n=73)**
Poor, n (%)	1 (0.8)	5 (4.3)	4 (2.2)	0 (0)
Fair, n (%)	41 (33.3)	38 (32.8)	47 (25.8)	12 (16.4)
Good, n (%)	41 (33.3)	48 (41.4)	86 (47.3)	25 (34.2)
Very good, n (%)	38 (30.9)	24 (20.7)	42 (23.1)	29 (39.7)
Excellent, n (%)	2 (1.6)	1 (0.9)	3 (1.6)	7 (9.6)

2.5.3.4. Frequency of consumption of sushi, miso soup and algae food products

Table 8 shows the relationship between frequency of consumption of ethnic foods and the different segments of consumers.

Table 8 - Relationship (mean ± sd) between frequency of consumption of ethnic foods and acceptance of algae food categories.

Dimension	**RJ** Rejecters **(n=116)**	**MC** Moderate Critics **(n=123)**	**MA** Moderate Admirers **(n=182)**	**AC** Acceptors **(n=73)**
Sushi (times/week) (p<0.001)*	0.15^{b}(±0.61)	0.26^{a}(±0.21)	0.32^{a}(±0.27)	0.28^{a}(±0.32)
Miso soup (times/week) (p<0.001)*	0.02^{d}(±0.08)	0.07^{c}(±0.15)	0.28^{b}(±0.81)	0.19^{a}(±0.28)
Algae products (times/week) (p<0.001)*	0.09^{d}(±0.26)	0.18^{c}(±0.20)	0.62^{b}(±1.04)	0.76^{a}(±0.62)

* Kruskal-Wallis test.
a,b,c,d – homogeneous groups, according to the Mann-Whitney Test.

Tables 9, 10 and 11 show the frequencies of consumption of sushi, miso soup and algae food products, respectively.

RJ represent the group with higher frequencies of zero ("never") consumption of sushi, miso soup and algae food products (69.0%,91.4% and 74.1%, respectively), in their last 12 months, and with the lowest frequencies of consumption (greater or equal to 1 day/week) of sushi (0.9%), miso soup (0.0%) and algae product/meal (0.9%).

While the AC have the lowest frequencies of the answer "never" for the three groups (21.9%, 49.3% and 17.8%, for sushi, miso soup and algae product, respectively), and the highest consumption (greater or equal to 1 day/week) of sushi (8.2%), miso soup (4.2%) and algae product/meal (17.8%).

Table 9 - Frequencies of the relationship between frequency of consumption of sushi and acceptance of algae food categories.

Frequency of sushi consumption	**RJ** Rejecters **(n=116)**	**MC** Moderate Critics **(n=123)**	**MA** Moderate Admirers **(n=182)**	**AC** Acceptors **(n=73)**
Never	80 (69.0)	33 (26.8)	51 (28.0)	16 (21.9)
< 1 day/ month	26 (22.4)	60 (48.8)	73 (40.1)	34 (46.6)
1-3 days/month	9 (7.8)	27 (22.0)	51 (28.0)	17 (23.3)
1 day/week	0 (0)	3 (2.4)	6 (3.3)	6 (8.2)
2-3 days/week	0 (0)	0 (0)	1 (0.5)	0 (0)
4-5 days/week	0 (0)	0 (0)	0 (0)	0 (0)
6-7 days/week	1 (0.9)	0 (0)	0 (0)	0 (0)

Table 10 - Frequencies of the relationship between frequency of consumption of miso soup and acceptance of algae food categories.

Frequency of miso soup consumption	**RJ** Rejecters **(n=116)**	**MC** Moderate Critics **(n=123)**	**MA** Moderate Admirers **(n=182)**	**AC** Acceptors **(n=73)**
Never	106 (91.4)	96 (78.0)	117 (64.3)	36 (49.3)
< 1 day/ month	9 (7.8)	22 (17.9)	49 (26.9)	27 (37.0)
1-3 days/month	1 (0.9)	4 (3.3)	13 (7.1)	7 (9.6)
1 day/week	0 (0)	1 (0.8)	3 (1.6)	1 (1.4)
2-3 days/week	0 (0)	0 (0)	0 (0)	1 (1.4)
4-5 days/week	0 (0)	0 (0)	0 (0)	0 (0)
6-7 days/week	0 (0)	0 (0)	0 (0)	1 (1.4)

Table 11 - Frequencies of the relationship between frequency of consumption of algae product/meal and acceptance of algae food categories.

Frequency of algae product consumption	**RJ** Rejecters **(n=116)**	**MC** Moderate Critics **(n=123)**	**MA** Moderate Admirers **(n=182)**	**AC** Acceptors **(n=73)**
Never	86 (74.1)	54 (43.9)	49 (26.9)	13 (17.8)
< 1 day/ month	24 (20.7)	53 (43.1)	81 (44.5)	20 (27.4)
1-3 days/month	5 (4.3)	14 (11.4)	41 (22.5)	27 (37.0)
1 day/week	0 (0)	2 (1.6)	5 (2.7)	9 (12.3)
2-3 days/week	1 (0.9)	0 (0)	4 (2.2)	1 (1.4)
4-5 days/week	0 (0)	0 (0)	0 (0)	2 (2.7)
6-7 days/week	0 (0)	0 (0)	2 (1.1)	1 (1.4)

2.5.3.5. Familiarity

Familiarity (Table 12) was studied in participants that answer "never" in the frequency of consumption algae product/meal (n=202).

From the n=202 that "never" consumed algae product/meal, 62 consumed sushi and 14 consumed miso soup, in the last 12 months. Regarding their knowledge about meals/food products with algae, 21 of these participants mentioned that "unknow" them. Between the four groups there's statistical differences between them, due to the differences verified between MC and RJ. The RJ have the highest percentage of

participants that don't know meals/food products with algae (44.2%) and that know about it but have never eaten it (40.7%). MC has the highest percentage of participants that consume algae food products.

Table 12 - Frequencies of the relationship between algae' familiarity and acceptance of algae food categories, N=202.

Familiarity (*p*=0.002) *	**RJ**** Rejecters **(n=86)**	**MC**** Moderate Critics **(n=54)**	**MA** Moderate Admirers **(n=49)**	**AC** Acceptors **(n=13)**
Unknown (n=72)	38 (44.2)	13 (24.1)	16 (32.7)	5 (38.5)
I know about it, but I have never eaten it (n=72)	35 (40.7)	14 (25.9)	19 (38.8)	4 (30.8)
I know and have used it (n=58)	13 (15.1)	27 (50.0)	14 (28.6)	4 (30.8)

* Kruskal-Wallis test.

** Mann-Whitney Test - Groups with significant differences: MC/RJ (*p*<0.001).

2.5.3.6. Food neophobia

Table 13 shows food neophobia and neophilia of participants. Sampling adequacy (KMO) is above acceptance and internal consistency (Cronbach's alpha) is high for both neophobia and neophilia.

In food neophilia only item "I will eat almost everything" has factor loading below 0.7, and the same happened, in food neophobia, with item "I am very particular about the foods I will eat".

Both constructs are unidimensional and food neophilia is consistent due to the high loadings of the items (> 0.6).

Table 13 - Factorial structure after Varimax rotation and consistency for the constructs food neophilia and food neophobia.

	(n = 494)		
	Loadings	**Mean (± Std. Dev.)**	**Value**
Food neophilia			
I am constantly sampling new and different foods.*	0.813	4.4 (±1.6)	
I like foods from different cultures.*	0.811	5.4 (±1.6)	
At social eating events (such as dinners or parties), I will try new foods.*	0.815	5.2 (±1.6)	
I will eat almost everything.*	0.666	4.6 (±1.7)	
I like to try new ethnic restaurants.*	0.865	5.0 (±1.7)	
Explained variance			63.511
KMO			0.850
Bartlett's Test			< 0.001
Cronbach's alpha			0.852

	(n = 494)		
	Loadings	**Mean (± Std. Dev.)**	**Value**
Food neophobia			
I do not trust new foods.*	0.782	2.7 (±1.5)	
If I do not know what a food is, I do not try it.	0.753	3.1 (±1.8)	
Ethnic foods look weird to eat.	0.730	2.5 (±1.5)	
I am afraid to eat foods I have never tried before.*	0.805	3.0 (±1.8)	
I am very particular about the foods I will eat.	0.569	4.6 (±1.7)	
Explained variance			53.667
KMO			0.808
Bartlett's Test			< 0.001
Cronbach's alpha			0.778

*Kruskal-Wallis Test – Variables with significant differences.

The mean of food neophobia score (ranging from 10 to 70) is 31.46 ± 11.41, and according to previous studies, this one is used as the cut-off point to distinguish between neophobic and neophilic consumers (Rabadán & Bernabéu, 2021). Thus, two groups were created: neophobics, n=251, 50.8% (score ≥ 31) and neophilics, n=243, 49.2% (score < 31). These two groups depend on the segment of consumers.

Table 14 shows that RJ have the highest percentage of food neophobics and that the AC have the highest percentage of neophilics.

Table 14 - Frequencies of the relationship between food neophobia and acceptance of algae food categories.

Food Neophobia Score (*p*<0.001) *	**MC** Moderate Critics **(n=123)**	**RJ** Rejecters **(n=116)**	**MA** Moderate Admirers **(n=182)**	**AC** Acceptors **(n=73)**
Neophobic (n=251)	70 (56.9)	92 (79.3)	69 (37.9)	20 (27.4)
Neophilic (n=243)	53 (43.1)	24 (20.7)	113 (62.1)	53 (72.6)

* Chi-square test.

2.5.3.7. Sustainability awareness

Table 15 shows green consumption values of participants. Sampling adequacy (KMO) is above acceptance and internal consistency (Cronbach's alpha) is high.

All the items have factor loadings above 0.7 and the construct is unidimensional and consistent due to the high loadings of the items (<0.6).

Table 15 - Factorial structure after Varimax rotation and consistency for the constructs green consumption values.

	(n = 494)		
	Loadings	**Mean (± Std. Dev.)**	**Value**
Green consumption values			
It is important to me that the products I use do not harm the environment.	0.824	5.2 (±1.5)	
I consider the potential environmental impact of my actions when making many of my decisions.	0.881	4.7 (±1.6)	
My purchase habits are affected by my concern for our environment.	0.857	4.5 (±1.5)	
I am concerned about wasting the resources of our planet.	0.751	6.0 (±1.2)	
I would describe myself as environmentally responsible.	0.809	4.9 (±1.3)	
I am willing to be inconvenienced in order to take actions that are more environmentally friendly.	0.771	5.2 (±1.4)	
Explained variance			66.707
KMO			0.874
Bartlett's Test			0.000
Cronbach's alpha			0.899

The mean of green consumption score ranging from 6 (lowest sustainability sensibility) to 42 (highest sustainability sensibility) is 30.5 ± 6.94 and is used as the cut-off point to define between "green" consumers and non- "green" consumers. Hence, 258 consumers (52.2%) are considered green (score ≥ 31), and 236 participants (47.8%) are non-"green" consumers (score ≤ 30). These two groups depend on the segment of consumers.

Table 16 shows that the AC have the highest percentage of green consumers and the lowest percentage of non-green consumers. The opposite is verified with RJ that have the highest percentage of non-green consumers and the lowest number of green consumers.

Table 16 - Frequencies of the relationship between "green" values and acceptance of algae food categories.

Green Score (*p*<0.001) *	**RJ** Rejecters **(n=116)**	**MC** Moderate Critics **(n=123)**	**MA** Moderate Admirers **(n=182)**	**AC** Acceptors **(n=73)**
Green consumers (n=258)	37 (31.9)	47 (38.2)	113 (62.1)	61 (83.6)
Non-green consumers (n=236)	79 (68.1)	76 (61.8)	69 (37.9)	12 (16.4)

* Chi-square test.

2.5.3.8. Trust in actors of the food system

According to Kruskal-Wallis just the non-governmental organizations (NGOs) present significant differences, between groups MC and MA (Mann-whitney, *p*=0.010), and MC with AC (Mann-whitney, *p*=0.020). Table 17 shows that for the five food system actors,

the majority of the participants slightly trust in them. The actors that the trust (slightly and completely) is higher for the different groups is the following: for MC is farmers; for the RJ is the authorities; for MA is NGOs; finally, for the AC is both farmers and NGOs. Thus, NGOs demonstrate significant differences among the consumer segments. MC and MA exhibit a significant disparity in their trust levels towards NGOs, highlighting divergent perceptions within these consumer groups. Moreover, MC also show significant variations in trust compared to AC, emphasizing distinct levels of trust towards NGOs between these two segments.

Table 17 - Frequencies of the relationship between trust in food system actors and acceptance of algae food categories.

Trust in Farmers (*p*=0.495) *	**RJ** Rejecters **(n=116)**	**MC** Moderate Critics **(n=123)**	**MA** Moderate Admirers **(n=182)**	**AC** Acceptors **(n=73)**
Completely distrust	4 (3.45)	2 (1.63)	5 (2.75)	2 (2.74)
Slightly distrust	23 (19.8)	25 (20.3)	29 (15.9)	10 (13.7)
Slightly trust	57 (49.1)	67 (54.5)	107 (58.8)	37 (50.7)
Completely trust	32 (27.6)	29 (23.6)	41 (22.5)	24 (32.9)
Trust in Food manufacturers (*p*=0.581) *				
Completely distrust	14 (12.1)	7 (5.69)	15 (8.24)	5 (6.85)
Slightly distrust	31 (26.7)	40 (32.5)	55 (30.2)	19 (26.0)
Slightly trust	60 (51.7)	56 (45.5)	89 (48.9)	38 (52.1)
Completely trust	11 (9.48)	20 (16.3)	23 (12.6)	11 (15.1)
Trust in Retailers (*p*=0.463) *				
Completely distrust	9 (7.76)	7 (5.69)	9 (4.95)	5 (6.85)
Slightly distrust	20 (17.2)	34 (27.6)	54 (29.7)	14 (19.2)
Slightly trust	76 (65.5)	65 (52.8)	94 (51.6)	39 (53.4)
Completely trust	11 (9.48)	17 (13.8)	25 (13.7)	15 (20.5)
Trust in Authorities (*p*=0.155) *				
Completely distrust	6 (5.17)	5 (4.07)	3 (1.65)	5 (6.85)
Slightly distrust	20 (17.2)	26 (21.1)	25 (13.7)	8 (11.0)
Slightly trust	67 (57.8)	56 (45.5)	101 (55.5)	36 (49.3)
Completely trust	23 (19.8)	36 (29.3)	53 (29.1)	24 (32.9)
Trust in Non-governmental organizations (*p*=0.026) *				
Completely distrust	6 (5.17)	4 (3.25)	4 (2.20)	3 (4.11)
Slightly distrust	25 (21.6)	33 (26.8)	22 (12.1)	9 (12.3)
Slightly trust	65 (56.0)	69 (56.1)	127 (69.8)	44 (60.3)
Completely trust	20 (17.2)	17 (13.8)	29 (15.9)	17 (23.3)

*Kruskal-Wallis test.

2.5.4. Free word association

Regarding consumers' conceptualization of "algae", a total of 237 different terms were used. The terms were triangulated, divided into 38 categories, and then were grouped into 16 dimensions (Table 18).

The dimension with the highest frequency was "Nature", representing 87% of the total percentage of participants. Of the five categories in this dimension, "aquatic environment", "natural elements" and "animals" had the greatest impact.

Table 18 - Frequency in which the categories relating to algae were mentioned and examples of the terms (in brackets) that make up each one (n = 494).

Dimensions	Categories (examples of terms)	Participants (%)	Number of mentions			
			Positive	Neutral	Negative	Total
Nature	Aquatic environment (sea, ocean, water)	82	297	160	4	461
	Nature (beach, plants)	28	75	83	4	162
	Animals (fish)	9	22	18	2	42
	Biodiversity and Biosphere (ecosystem, biodiversity)	7	33	2		35
	Total	**87**				**700**
Sensorial characteristics	Appearance (green, dark)	35	60	111	7	178
	Taste (salty, tasty)	10	19	27	6	52
	Texture and Consistency (viscous, slippery)	8	9	16	18	43
	Odor (smell, strong smell)	1	2	1	4	7
	Humidity (humid)	1		3		3
	Total	**44**				**282**
Food	Asian Food (sushi, Chinese food)	28	109	28	9	146
	Culinary (food, culinary)	8		35	5	40
	Seasonings (salt, seasonings)	6	12	10	7	29
	Food products (vegetables, soup)	5	14	10		24
	Diet (vegan, vegetarian)	3	7	7	1	15
	Edible algae (nori, spirulina)	3	10	5		15
	Food chain (food chain, heterotrophy)	1	2	5		7
	Supplements (supplements)	<1	2	1		3
	Barriers (difficult to cook)	<1			1	1
	Total	**48**				**280**
Health	Health (healthy, health)	8	36	2		38
	Medicines and treatments (medicine, medicines)	3	14			14
	Total	**10**				**53**
Nutrition	Nutrients (iodine, protein)	5	22	1	1	24
	Nutritional properties (nutritious, nutritional)	2	9			9
	Total	**7**				**33**
Science	Organisms (organism, bacteria)	2	3	3	2	8
	Biological components (chlorophyll, oxygen)	2	5	3	1	9
	Biological processes (photosynthesis)	1	6			6
	Fields of Study (biology, biotechnology)	1	4			4

Dimensions	Categories (examples of terms)	Participants (%)	Number of mentions			
			Positive	Neutral	Negative	Total
	Total	**5**				**29**
Avoidance	Disgust (disgusting, dirt)	3			13	13
	Aversion (weird, strange)	1		1	4	5
	Total	**3**				**18**
Acceptance	Positive evaluation (good, great)	1	7	1		8
	Negative evaluation (bad, boring)	<1		1	2	3
	Willingness to try (try, curiosity)	<1	3			3
	Total	**2**				**14**
Innovation	Innovation (innovation, new)	2	8			8
	Potential (alternative, future)	1	6			6
	Total	**3**				**14**
Sustainability	Sustainability (sustainable, sustainability)	3	13			13
	Environmental impact (pollution)	<1			1	1
	Total	**3**				**14**
Activities	Holidays (holidays, summer)	2	8		1	9
	Activities (work, fishing)	<1		2		2
	Total	**2**				**11**
Asia	(Chinese, Japan)	**2**	6	5		**11**
Dermatological aesthetics	(skin, creams)	**2**	6	3	1	**10**
Weather conditions	(cold)	**1**	6			**6**
Location	(Algarve, Vila Nova de Gaia)	**<1**	4			**4**
Lack of knowledge	(unknown)	**<1**	1	1		**2**

Regarding consumers' conceptualization of "algae" and "food", a total of 352 different terms were used. The terms were triangulated, divided into 46 categories, and then were grouped into 20 dimensions (Table 19).

Table 19 - Frequency in which the categories relating to algae and food were mentioned and examples of the terms (in brackets) that make up each one (n = 494).

Dimensions	Categories (examples of terms)	Participants (%)	Number of mentions			
			Positive	Neutral	Negative	Total
Food	Asian food (sushi, Asian food)	48	149	97	13	259
	Food products (vegetables, snack)	14	60	17	4	81
	Diet (vegan, vegetarian)	8	25	17		42
	Culinary (restaurant, food)	7	21	15		36
	Seasonings (spices, salt)	4	12	7		19
	Edible algae (nori, spirulina)	2	10	5	1	16
	Supplements (supplements, supplementation)	2	8	4		12
	Side dish (complement, starters)	2	7	3		10
	Drinks (smoothie, drink)	1	1	5		6
	Food habits (food habits)	<1	2			2
	Digestion (indigestion)	<1	1		1	2
	Total	**67**				**485**
Sensorial characteristics	Taste (salty, taste)	14	31	19	24	74
	Appearance (green, exotic)	10	18	30	1	49
	Texture and Consistency (crunchy, viscous)	6	11	9	10	30
	Dehydration (dehydrated, dry)	2	2	7		9
	Odor (smelly, smell)	<1		1	1	2
	Humidity (humid)	<1		1		1

Dimensions	Categories (examples of terms)	Participants (%)	Number of mentions			
			Positive	Neutral	Negative	Total
	Total	**27**				**165**
Health	Health (healthy, health)	28	133	4		137
	Medicines and treatments (antibiotics, medicine)	<1	4			4
	Immunology (allergies)	<1		1	3	4
	Total	**29**				**145**
Innovation	Innovation (different, innovative)	12	44	17		61
	Potential (alternative, future)	8	33	5	1	39
	Novelty (unusual, new)	5	10	10	2	22
	Change (trend, change)	1	2	3	1	6
	Total	**22**				**128**
Acceptance	Positive evaluation (good, delicious)	8	42	5		47
	Negative evaluation (bad, unpleasant)	6	1	5	31	37
	Willingness to try (curiosity, try)	5	19	9		28
	Total	**19**				**112**
Nutrition	Nutrients (protein, vitamins)	8	41	5		46
	Nutritional properties (nutrition, nutritious)	8	34	5		39
	Total	**15**				**85**
Avoidance	Aversion (weird, exquisite)	12	1	24	37	62
	Disgust (disgusting, disgust)	2	1		9	10
	Total	**14**				**72**
Nature	Animals (fishes, feed)	6	20	11		31
	Aquatic environment (sea)	4	14	2	2	18
	Nature	2	8	4		12
	Biodiversity and Biosphere (environment, biodiversity)	1	3			3
	Total	**12**				**64**
Asia		**12**	20	42		**62**
Viability	Adequacy (edible, possible)	4	16	4		20
	Benefits (benefits, practical)	2	11	1		12
	Inadequacy (difficult, impossible)	2	1	6	6	10
	Total	**8**				**42**
Sustainability	(sustainability, sustainable)	**5**	23			**23**
Science	Biological characteristics (bio, biological)	3	14	1	1	16
	Fields of Study (farming, sciences)	1	3	1		4
	Biological processes (photosynthesis)	<1	1			1
	Total	**4**				**21**
Weather conditions	(cool, cold)	**3**	8	7	1	**16**
Lack of knowledge	(doubts, unknown)	**2**	2	11	1	**14**
Emotions and skills	(creativity, crazy)	**2**	7	2	3	**12**
Price	(expensive, price)	**2**		2	10	**12**
Diversity	(diversification, variety)	**2**	7		1	**8**
Applications	Applications (package, resource)	1	2	2	2	6
	Esthetics (collagen, hygiene)	<1	2			2
	Total	**2**				**8**
Safety and security	Insecure (dangerous, caution)	1	1	1	3	5
	Safe (safe)	<1		1		1
	Total	**1**				**6**
Numbers	(one, three)	**<1**	2			**2**

2.5.4.1. Conceptual differences between participants from different acceptance segments

Tables 20 and 21 show the frequencies (for "algae" and "algae/food" study, respectively) of each main dimension mentioned (with frequency percentages greater than 5%, as mentioned in Table 18 and Table 19, respectively), for each consumer segment.

The dimensions that have significative differences are also shown, and those are the ones with differences between the four consumer segments. When (-) is presented, it means that the dimension is significantly lower, so is significantly less cited by that segment. If (+), it means the opposite – the dimension is cited significantly more by that segment.

Taking this into account, Table 20 (conceptualization regarding "algae") shows that, in one hand, RJ have a significantly higher association to "Nature", "Sensorial Characteristics" and "Avoidance". On the other hand, they have a significantly lower association to "Food", "Health", "Nutrition" and "Innovation". Meanwhile, AC present a significantly higher association to "Food" and "Nutrition", and a significantly lower association to "Nature". MA and AC have a significantly higher connection to the "Food" dimension, and RJ and MC have a significantly lower connection to it.

Relatively to the conceptualization of "Algae and Food", Table 21 shows that RJ have a significantly lower association to "Health", "Innovation" and "Nutrition", and exhibit a significantly higher association to the dimension "Sensorial Characteristics", "Acceptance" and "Avoidance". AC present a significantly higher association to "Acceptance" and "Price", and a significantly lower association to "Avoidance" and "Asia".

The Correspondence Analysis resulted in the perceptual maps shown in Figure 2 (Algae) and Figure 3 (Algae and Food), constructed from the main dimensions mentioned, with frequency percentages greater than 5% (mentioned in Table 18 and Table 19, respectively), for each consumer segment.

Table 20 - Frequencies of mention of each dimension (of the Algae study), according to consumer acceptance segments.

Dimension \ Consumer segments	Rejecters (RJ) (n=116)	Moderate critics (MC) (n=123)	Moderate admirers (MA) (n=182)	Acceptors (AC) (n=73)
Nature	186 (+)	201 (+)	237 (-)	76 (-)
Sensorial characteristics	80 (+)	67	94	42
Food	44 (-)	56 (-)	127 (+)	53 (+)
Health	6 (-)	12	27 (+)	8
Nutrition	0 (-)	6	16	11 (+)
Science	8	6	8	7
Avoidance	8 (+)	6	2 (-)	2
Acceptance	4	1	5	4
Innovation	0 (-)	1	9 (+)	4
Asia	2	1	6	2
Dermatological aesthetics	4	5	1	0

+/-, significative differences according to the Chi-square and Fisher's exact test, per cell.

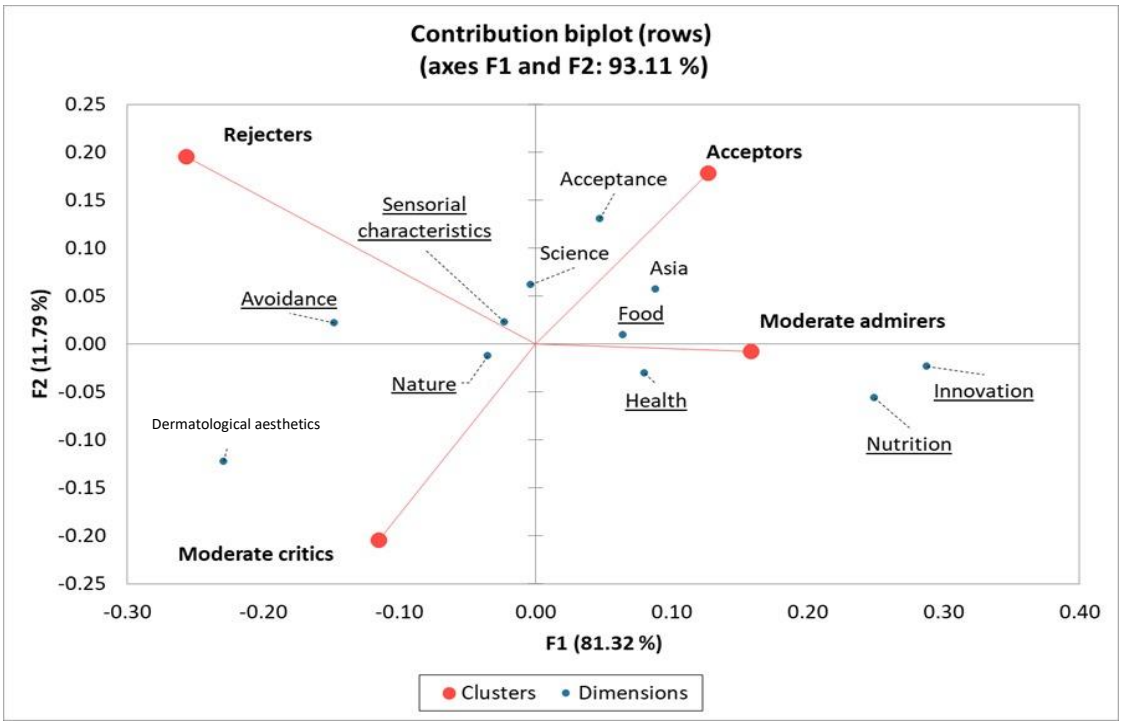

Figure 2 - Projection of the clusters (consumer segments) relating to the study of the concept of Algae in the correspondence analysis space (dimensions F1 and F2). Underlined are the dimensions with significant differences.

Table 21 - Frequencies of mention of each dimension (of the Algae and Food study), according to consumer acceptance segments.

Dimension \ Consumer segments	Rejecters (RJ) (n=116)	Moderate critics (MC) (n=123)	Moderate admirers (MA) (n=182)	Acceptors (AC) (n=73)
Food	101	133	186	65
Sensorial characteristics	56 (+)	32	52	25
Health	15 (-)	47 (+)	64	19
Innovation	20 (-)	28	61 (+)	19
Acceptance	40 (+)	21	26 (-)	25 (+)
Nutrition	11 (-)	20	35	19
Avoidance	41 (+)	17	14 (-)	0 (-)
Nature	16	14	20	14
Asia	17	22	20	3 (-)
Viability	7	10	21	4
Sustainability	2	9	8	4
Science	4	5	11	1
Weather conditions	3	2	7	4
Knowledge	5	2	7	0
Price	1	1	2	8 (+)

+/-, significative differences according to the Chi-square and Fisher's exact test, per cell.

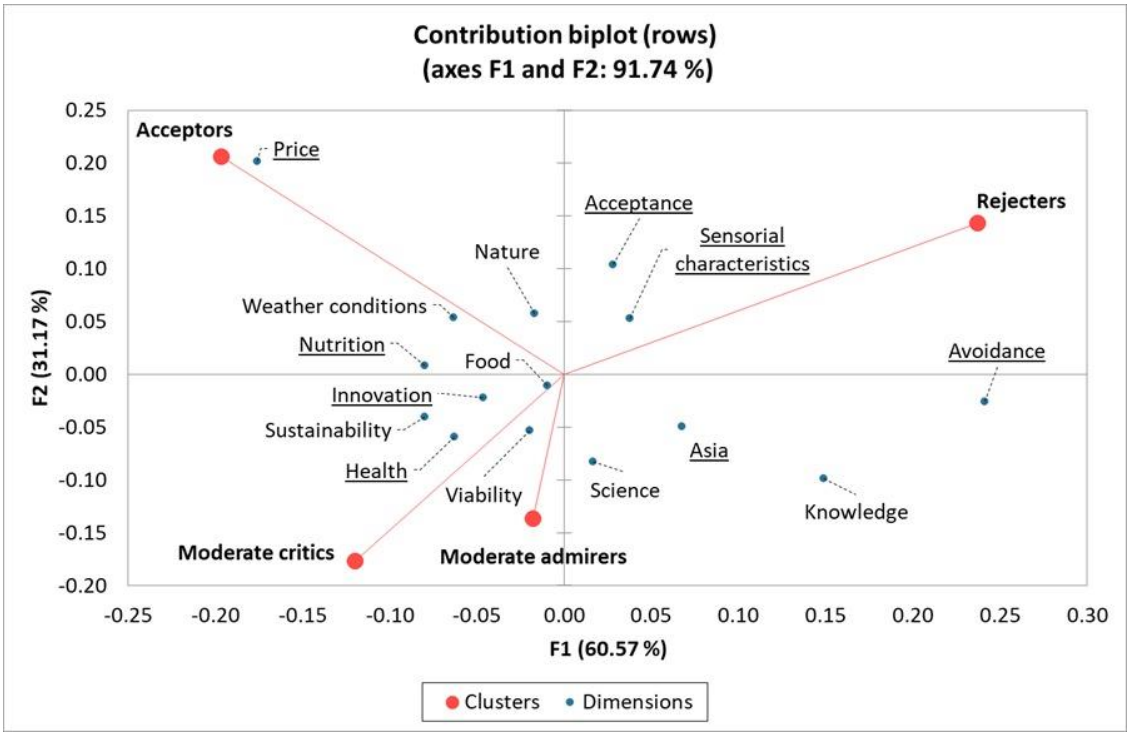

Figure 3 - Projection of the clusters (consumer segments) relating to the study of the concept of Algae and Food in the correspondence analysis space (dimensions F1 and F2). Underlined are the dimensions with significant differences.

2.6. Discussion

Innovation allows for the exploration of new ingredients, flavours, and food products, and it leads to the creation of diverse attractive food options (Bigliardi & Galati, 2013). This is essential to attract consumers to try new healthy, convenient and tasty products or to improve their characteristics, in order to meet consumer wants and needs (Azanedo et al., 2020; Carlson & Wilmot, 2006).

When incorporated into food, algae can offer nutritional and sensory value that enhance the quality of the products, and its efficient growth requires minimal resources, making it an environmentally sustainable option (Caporgno & Mathys, 2018; Francezon et al., 2021; Nova et al., 2020). Integrating algae into food products is a promising step towards a nutritious and eco-friendly food industry (Deng et al., 2021).

But the acceptance of consumers can be influenced by several factors, such as: dietary preferences, food neophobia, familiarity and others. The significance of consumers' acceptance and conceptualization of a food product cannot be overstated, as it is essential for its successful development, integration into the market by the food industry and retailers, and eventual incorporation into individuals' diets (Augustin et al., 2016). Hence, this study examines how consumers conceptualize and are open to eat various food categories incorporating algae, and also analyse the interplay between acceptance of algae-based foods and various acceptance' determinants.

Overall, the Portuguese consumers in this study associate the concept of "algae" primarily with "nature", essentially to "aquatic environment", mentioning terms such as "sea" and "ocean". This dimension is more cited by the groups that reject algae, which means that their first thought when thinking of algae is not to associate this ingredient with food. The associating to "plants" and "beach" is often made, probably due to Portuguese coast, that usually has algae in the sea, mainly in the North of Portugal, that is where the majority of participants of this study live. Followed by this dimension, arises "sensorial characteristics", mainly appearance and taste (characteristics like colours and salty, respectively). Compared to other groups of consumers, the rejecters of algae mentioned more words in this dimension, but these were negatively classified, citing words like "slimy" and "bad smell". Words falling in the dimension "food" were mentioned by 48% of the participants, associating them more in the category "Asian food", specially to sushi, which is positively classified. The groups with higher acceptance of algae, connect more times "Food" to algae, than the groups that reject it. This is particularly curious and shows the low association that people, who often reject algae, have.

Other interesting point is that these consumers associate it more with the dimension "avoidance" that gather terms like "disgusting", "weird" and "trash". Once again, showing the bad association that rejecters have towards algae.

In relation to the conceptualization of "algae and food", the Portuguese participants associate it more to "Asian food" category that is part of the dimension "food". Once again, when associating algae to food, these consumers think essentially of sushi. This aspect will also be interpreted later in the familiarity. "Food products" with terms like "vegetables" and "snacks" were mentioned by 14% of participants of this category. This emphasises that algae can be associated literally to products with the incorporation of algae, as the ones studied in this work. Again, the dimension "sensorial characteristics" is the second more associated to algae and food, with more emphasis in "taste" and "appearance", for the rejecters. "Health" represents the third more mentioned, and "healthy" is the most cited word in this dimension. Curiously, MC mentioned more this group than the other consumers. MA refer more to "innovation" when thinking of algae and food. Regarding the "acceptance", it's important to note that the results show that RJ mentioned more this dimension but, when analysing the words that they referred, these are classified as negative, such as "non-attractive" and "bad" (that were grouped in the category "negative evaluation"). While the AC, also mentioned this dimension, but with terms that fall in the "positive evaluation" category. Once again, "avoidance" was more mentioned by RJ, and less by both groups that have higher acceptance of algae.

So, in general the conceptualization that the consumers of this study have about algae is mainly related to the concepts of nature, sensorial characteristics, and food. And that the conceptualization that they have about algae and food is connected to the concepts of food (specially, Asian food), sensorial characteristics, health and innovation.

Regarding the differences in the acceptance of each algae food category, for a clear understanding about the willingness to eat algae among Portuguese consumers, four segments of consumers were created, presenting different acceptance levels. Although not directly related to this study, research in the adoption intention of Spirulina-enhanced food, had a similar aim of identifying consumer segments (Moons et al., 2018). Both studies have the utility of directing food industry and retailers to answer consumers' needs, taking into account, the segmentation present in the results.

In this study, the consumers that accept more algae food products (AC) have a positive acceptance for all the food categories. AC would frequently eat the food categories from group "Convenience Food and Meal Solutions" (ready-to-eat fresh meals, pre-prepared meals, pâtes, instant meals, canned meals, salty pastries, beverages, sweet pastries,

and sauces) and would eat the group with Bakery Products and Dairy very often. Based on the research, this group has significantly higher acceptance across all food categories compared to the others. This is the group with the least number of consumers, however, they hold a clear and positive outlook on algae-based products, showing strong acceptance and enthusiasm for these items. In contrast, algae' rejecters (RJ) would hardly ever eat algae food products, due to the evaluation they gave to all food categories. Quite similar to this group are the MC, that don't accept algae food products, except for Preserved and Flavourful Foods products, where they have a moderate acceptance. This moderate acceptance for this group might exist, due to the fact that those products are more likely to sell in Portuguese market, than the others. This group have a discerning view and offer negative feedback, but not to the extent of outright rejection. Finally, MA don't accept algae food products as AC do, but, in general, have a positive acceptance. This group has the highest number of consumers, and these consumers like the products to a certain extent but might have some reservations or suggestions for improvement. In summary, the acceptance of algae-based products varies across the segments, ranging from enthusiastic acceptance in acceptors 'group to moderate levels of acceptance with some reservations in MC and MA, and rejection in RJ segment.

In the surveyed sample for this study, the evaluation of consumers' acceptance of algae-based products displayed a discernible variability across the four segments. The highest level of acceptance achieved a score of 6 ("I like this and would eat it now and then") out of 9. This score denotes a favourable inclination towards the algae-based food categories, though not reaching the higher levels of willingness to eat. The food categories pasta and dry seasonings have the highest acceptance, without taking consumer segmentation into account. In Grahl et al. (2018), the authors studied what was the most promising product category for integrating the microalga spirulina, with German, French, and Dutch populations. Among three different products, pasta filled with spirulina was the most liked across the three nationalities, concluding that product marketing does not need to be culture-orientated (Grahl et al., 2018). Even though they performed Sensorial Analysis, our results align with that. Grahl et al. (2020) studied the effect of expectations on liking of pasta filled with spirulina in Germany, France and Netherlands. The results showed that it the pasta flavours sounded appealing (like our study, where pasta had the highest willingness to eat), but the expectations of the sensory test were not met (Grahl et al., 2020). Based in our results, this suggests that it could be interesting to further investigate the sensorial acceptance of both food categories with higher acceptance, pasta and dry seasonings. In the MC SONAE

platform AIP, both of them already exist in the market and consumers might be familiarized with them.

On the other hand, instant meals, beverages, sweet pastries, dairy and canned meals scored the lowest in terms of acceptance among the various food categories examined. It's important to emphasize that although these categories ranked lowest in acceptance, this does not imply intolerance towards algae-based products within these groups. The classification suggests that consumers might not readily choose these options for everyday consumption but are open to consuming them on specific occasions. This insight highlights the potential for expanding consumer acceptance and encouraging occasional consumption of algae-based options within these food categories, thus promoting a more diverse and sustainable dietary approach.

Relatively to the relationship between the acceptance of algae food products, within different consumer segments, and the studied determinants, in this study, the sociodemographic characteristics, gender, level of education, marital status, number of household members, financial situation, and occupation, play a role in influencing the attitudes or opinions of the consumers regarding algae acceptance. Characterizing AC results, 72.6% are females (even though, all consumer' segments have higher percentage of females), 64.4% have higher education (RJ have 50% of higher education), 53.4% are single, 34.2% have 2 household members (including themselves), 49.3% have middle income and 49.3% are employees.

According to the data from this study, the determinants dietary pattern, healthiness of the diet, frequency of consumption of ethnic foods, familiarity, food neophobia, green consumption values and trust in NGOs, have influence on the acceptance of food product categories incorporating algae. Our findings align with Birch et al. (2019) study that concluded that familiarity, food neophobia, food consumption and health consciousness are predictors of likelihood to eat seaweed products.

Weinrich and Elshiewy (2019) while studying consumer preferences for meat substitutes based on micro-algae, concluded that consumers who see no need for meat in their diet (like vegetarians), have a higher likelihood to choose plant-based meat substitutes produced with micro-algae. These results are similar to ours, since AC are characterized by the group with more vegetarian consumers (including lacto-ovo vegetarian, ovo-vegetarian, lacto-vegetarian and vegan all together). Thus, one possible explanation for this could be attributed to a pre-existing openness and positive attitude towards alternative and plant-based food sources (Rothgerber, 2017). Also, 94.8% of RJ are omnivores, aligning again with the findings of Weinrich and Elshiewy (2019), that show

that consumers with a strong habit for meat have a negative willingness to pay for algae-based meat substitutes.

When measuring health consciousness, in a study of consumers acceptance of algae in meat substitutes, van Hassel (2020) concluded that, participants who gave more positive evaluation to algae burger, had higher levels of health goals, suggesting that health conscious consumers are willing to try algae burgers. Consistent with this research, based on the outcomes about self-evaluation of the healthiness of the diet, compared with other segments, we observed that AC self-evaluated themselves more positively than the others. The disparity in the perceptions of diet' healthiness between the different segments can be explained by the fact that AC, who evaluate their diet as good, very good or excellent, may also exhibit a higher degree of health consciousness, as evidenced by their favourable evaluation of diet healthiness.

The frequency of consumption of food products typically cooked with algae, such as sushi and miso soup, is a determinant of acceptance that can influence the familiarity that consumers have on algae in food and, consequently, affecting the acceptance. These two determinants may be related to the willingness to eat algae, because the exposure to these products increases familiarity with algae-based products. As Grahl et al. (2018) verified, familiarity with algae products was deduced from the frequency of consumption of the food categories. In our study, AC have a higher level of consumption of ethnic foods, which means that that might be more familiar with algae as an ingredient, thus being more willing to eat them incorporated in foods. On the other hand, RJ represent the group with the lowest consumption of sushi and miso soup. Thus, less willingness to eat algae-foods can also be explained by the less exposure to sushi, miso soup, and algae-based products. As these individuals may not be accustomed to the flavours and ingredients in ethnic dishes that integrate algae, their acceptance is low.

These results are in line with the aversion or fear to trying new or unfamiliar foods, including algae-based products, because RJ have the highest amount of neophobics, in contrast to AC that have the highest of neophilics. Similarly to previous studies, food neophobia likely acts as a significant barrier for RJ, impeding their acceptance and willingness to incorporate algae foods into their diet (Lafarga et al., 2021; Losada-Lopez et al., 2021; Mellor et al., 2022; Palmieri & Forleo, 2020). Moreover, their reluctance to try algae-based products might be driven by the unfamiliarity with consuming something outside their comfort zone. Strategies to promote algae foods to RJ segment should focus on addressing and mitigating their food neophobia. Providing clear information about the safety, nutritional benefits, and sustainability of algae foods in a reassuring

and familiar context could potentially encourage them to overcome their neophobia and give these products a try, since lack of information can decrease the acceptance of a novel food (Maehle & Skjeret, 2022). By contrast, the AC, characterized by higher levels of food neophilia, display a keen interest and openness to try algae-based products. These results suggest that they are likely more adventurous in their food choices and willing to experiment with diverse flavours and ingredients. Food neophilia acts as a driving factor for this segment, encouraging them to seek out new food experiences and embrace innovative dietary options like algae-based products. This adventurousness extends to their choice of meals, leading to a greater frequency of consuming sushi and miso soup, as mentioned before, both of which are culturally diverse and often considered exotic or novel to many individuals (as observed in the conceptualization study). Their enthusiasm for trying new foods enables a positive attitude towards algae foods and enhances their willingness to eat them.

Maehle and Skjeret (2022) found that environmental concern has significant positive effect on consumers' attitude and purchase intentions towards microalgae-based food. In our study, consumers' environmentally responsible behaviour was analysed, and this is an essential determinant to consider, often expressed through their purchases and consumption behaviours (Haws et al., 2014). The degree to which individuals prioritize sustainability in their consumption habits significantly influences their acceptance of novel and eco-friendly food alternatives (Haws et al., 2014). Among the AC of algae-based products, a substantial majority identify as green consumers, emphasizing a pronounced inclination towards sustainable choices. This representation of green consumers underscores a heightened awareness and commitment to environmentally responsible practices within this consumer segment. In contrast, only a minority are identified as non-green consumers among the AC, indicating a prevalent eco-conscious mindset. Conversely, RJ have an inverse distribution concerning green consumption values. Within this group, the majority comprise non-green consumers, indicating a prevailing lack of emphasis on sustainability in their consumption patterns, and suggesting a relatively lower propensity to prioritize sustainable choices, in their dietary preferences. This dichotomy in green consumption values between the AC and RJ highlights a potential correlation between sustainability awareness and the acceptance of algae-based food products. The higher proportion of green consumers within the AC implies that sustainability considerations may positively influence their openness to novel, environmentally friendly dietary options such as algae-based foods. On the other hand, the prevalent non-green consumer orientation among the RJ suggests that a lack

of emphasis on sustainability may contribute to their resistance towards incorporating algae-based products into their dietary options.

Trust in food system actors influences how consumers perceive the safety, quality, and reliability of the products they consume, particularly novel or unconventional ones such as algae-based products (Wu et al., 2021). This trust is a fundamental factor that can influence consumers to feel confident and comfortable in trying new or innovative food options (Wu et al., 2021). In this study, examining the general trend of trust across the five food system actors, a prevalent pattern emerges. The majority of participants across all consumer segments express a moderate level of trust, leaning towards a slight inclination. However, these levels of trust manifest differently for each consumer segment in relation to specific food system actors: MC demonstrate a higher level of trust, particularly in farmers, indicating a relatively more positive perception of the agricultural sector and its role within the food system; RJ have greater trust in authorities, suggesting a sense of reliance and confidence in regulatory bodies overseeing the food system; MA place a higher level of trust in NGOs, emphasising their belief in the proactive role of NGOs within the food system; Finally, AC have higher trust levels in both farmers and NGOs, indicating a dual confidence in the agricultural sector and the initiatives of NGOs. The disparities in trust, particularly regarding NGOs, emphasize the importance of considering trust as a critical factor when designing strategies to promote the acceptance of algae-based food products. Tailored communication and engagement with these trusted food system actors could potentially enhance consumer acceptance within each segment. Additionally, building trust and confidence in food system actors, may play a central role in encouraging a positive attitude towards innovative and sustainable food alternatives like algae-based products.

To the knowledge of the author, this study is a pioneer among Portuguese consumer surveys that addresses consumers acceptance and conceptualization towards algae-based products. The strengths of this work are: the large sample (n=494), that allowed an comprehensive and extensive analysis of the conceptualization of algae and the willingness to eat it, segmenting the sample in different acceptance groups. This also contributed to higher study power; the results from the acceptance and willingness to eat, not only fuels innovation in the food industry, but also empowers retailers to strategically position new or improved products that meet different consumers segments´ needs; the common methodology for the survey in COMFOCUS platform that allows for cross-country comparisons.

Besides this, the limitations of this study are also acknowledged. In particular, the sample distribution in terms of gender, educational level and residential location, since the sample had an overrepresentation of females, high level educated participants and people living in the north of the country. Also, it was quite difficult to name each group of foods (after Factorial Analysis), considering the diverse range of food items, finding a single word or name that perfectly encompasses all of them can was challenging. Also, the frequency of consumption of the food categories without the incorporation of algae could have been addressed, to analyse the difference between the frequency of consumption of the categories, and the willingness to eat the same ones but with algae.

Further research and tailored strategies may enhance consumer willingness and advance the adoption of algae-based food offerings, based on the findings of this study.

2.7. Conclusions

This study examines the intricate dynamics that influence consumer acceptance of algae-based food products, shedding light on the crucial interplay between determinants of acceptance. This study seeks to investigate how consumers conceptualize and are open to incorporating algae into various food categories, analysing the relationship between acceptance and its determinants.

The findings of this study demonstrate that Portuguese consumers primarily associate the concept of algae with nature, particularly the aquatic environment, the sea and ocean. Notably, those who reject algae often fail to associate it with food, revealing a distinct lack of familiarity. Moreover, sensory characteristics, such as appearance and taste, significantly influence consumer perception, especially among those who reject algae, citing negative attributes like "slimy" and "bad smelling."

In terms of conceptualizing algae and its relation to food, an association is made with Asian cuisine, particularly sushi. Health is another dimension linked to algae, with a predominant focus on its healthy aspects. Additionally, the dimension of "innovation" is associated, suggesting the potential for innovative applications of algae in food.

Segmentation of consumers into distinct acceptance groups, highlights the varying levels of willingness to consume algae-based products. The "Acceptors" group displays a positive acceptance across all food categories, indicating a strong enthusiasm for algae-based items. On the other hand, the "Rejecters" group exhibits reluctance and a marked disinclination to consume algae-based products.

The determinants dietary pattern, healthiness of the diet, frequency of consumption of ethnic foods, familiarity, food neophobia, green consumption values and trust in NGOs, have influence on the acceptance of food product categories incorporating algae.

3. Validation of two scales: consumers barriers and importance of social, environmental and economic sustainability for plant-based foods

3.1. Abstract

Background: Building credible scientific evidence to develop intervention strategies for a sustainable and healthy food system, contributes to a better knowledge of consumers' perspectives. Changing current food consumption patterns is a vital step that needs attention in our society.

Objective: To validate scales, one about the barriers towards plant-based foods, and other related to social, environmental, and economic sustainability.

Methods: Two web-based questionnaires, were applied with a 2-weak break, to a Portuguese sample. The first questionnaire addressed the short version of the barriers scale, and the second the long. Social, environmental, and economic sustainability scale was used in both questionnaires, for test re-test analysis. Cronbach's alfa, Pearson's and Spearman's correlations were used. Bland-Altman plots were used to evaluate the agreement between short and long scale. Data was analysed using SPSS v.27 and XLSTAT, and a *p*-value < 0.05 was considered significant.

Results: Participants (n=66): 74.2% were female, mean age 31 years old (±11), and 84.8% had higher education. Cronbach's alpha for the short barriers scale is 0.721 (satisfactory level of reliability and internal consistency). The short version of the scale is in good agreement with the long version, and correlation is strong (Pearson correlation coefficient = 0.701, p < 0.0001). Social, environmental and economic sustainability scale is reliable and stable over time (Cronbach's alpha = 0.790; Spearman correlation coefficient = 0.672, *p* < 0.0001).

Conclusion: Short version of barriers scale may substitute the long version and social, economic, and environmental sustainability scale is reliable.

Keywords: Plant-based foods, Sustainability, Consumer attitudes, Scale validation, innovation.

3.2. Study framework

The world faces an urgent and imminent challenge: the escalating climate emergency (Ripple et al., 2022). Urgent and transformative actions are required to mitigate irreversible damage (Gills & Morgan, 2022; Ripple et al., 2022). Food systems play a significant role in carbon footprints, resource usage, and environmental degradation, thus a shift towards sustainable dietary choices is essential particularly the adoption of plant-based foods, which play an important step in reducing the environmental burden associated with traditional diets (Newbold et al., 2015; Norton et al., 2021; Perez-Cueto et al., 2022; Stein & Santini, 2022; Willett et al., 2019)

However, the adoption of plant-based foods faces barriers from different factors such as taste, accessibility, availability, information and price (Aschemann-Witzel et al., 2021; Giacalone et al., 2022; Perez-Cueto et al., 2022). Hence, it is crucial to recognize these obstacles in order to promote a change towards sustainable consumption (Graça et al., 2019). Understanding the barriers allows food services to shape the products and offers taking into account consumers' needs and wants, promoting the consumption of plant-based foods effectively (Perez-Cueto et al., 2022). In parallel, acknowledging the significance of social, economic, and environmental sustainability is crucial in promoting plant-based food consumption (Assembly, 2022; Krzywonos & Piwowar-Sulej, 2022). These dimensions are symbiotic, and their connection point out the importance of adopting a holistic approach towards sustainability, involving societal well-being, economic viability, and environmental preservation.

In this sense, consumer studies play a vital role in comprehending these factors and highlighting the importance to design questionnaires that can contribute to create credible scientific evidence (Krosnick, 2018). A validated scale adds credibility to research findings, enabling comparisons across different studies and populations and promoting cross-cultural applicability (Boateng et al., 2018).

Short scales, compared to longer versions have a succinctness that not only saves time for both researchers and respondents, but also facilitates increased survey completion rates, minimizing respondent fatigue and enhancing overall data quality (Sánchez et al., 2021). Additionally, short scales contribute to expanding scientific research by facilitating more simplified investigations into complex constructs (Sánchez et al., 2021).

This study's contribution extends to validating scales measuring consumer barriers and sustainability attitudes, forming the basis for effective strategies promoting sustainable dietary behaviours. Moreover, this validation process supports academic and scientific

publication, and contributes to a robust body of knowledge that drives the evolution of plant-based dietary trends and practices. Seen as critical resources, this deepen understanding of consumer perspectives, aiding evidence-based interventions to promote sustainable diets.

This study is a result of a collaborative work of an academic internship conducted between March and June of 2023 at Umeå University (Department of Food, Nutrition, and Culinary Science), for the EU HealthFerm project. It is within this framework that we embark on this scientific journey, recognizing the gravity of the climate crisis and the need for sustainable dietary choices to shape a healthier, more equitable, and sustainable world.

3.3. Objectives

3.3.1. General objectives

The general aim of this study is to validate two scales, one about the barriers towards plant-based foods, and other related to social, environmental, and economic sustainability.

3.3.2. Specific objectives

a. To validate a short version of a long scale, about the barriers towards plant-based foods.

b. To validate a scale about the attitudes towards social, economic, and environmental sustainability.

3.4. Materials and Methods

3.4.1. Study design and data collection

Two web-based questionnaires were developed (section 3.4.2.) and applied separately via *LimeSurvey* (online survey tool), to a Portuguese sample. The first questionnaire (Q1) (Annex 5) ran between 25th of July 2023 until 5th September 2023, and the second questionnaire (Q2) (Annex 6) was applied 2 weeks after answering Q1.

Participants were recruited anonymously through researchers' personal social networks (LinkedIn and Instagram) and by dynamic email of the University of Porto to the entire academic community. Consequently, a convenience sampling was collected. A general description of the study was provided in the recruitment.

At the end of Q1 an invitation was made for the respondents of the 1st phase, to continue participating in the study. Afterwards, a new link was generated (apart from the questionnaire), asking participants to voluntary provide the email address, so that the researchers could send the Q2 using that method, 2 weeks later. To cross-check the answers of both questionnaires, and in order to guarantee anonymous and confidential participation, in both surveys, the respondents were requested to provide a code, with the first letters of the name and surname and the year of birth (e.g., Maria Antónia Silva, born in 1994: MS1994). The delay between administrations allows for the assessment of test-retest reliability, which measures the consistency of responses over time. No incentives were used to participate in this study.

The inclusion criteria were consented and fully completed questionnaires (both in the first and second round) and participants $\geq$ 18 years old with Portuguese residence. "Straight-lining" (indicator of poor response quality) (Schonlau & Toepoel, 2015) and contradictory answers were removed.

3.4.2. Questionnaires

Initially, the questionnaires were prepared in English and then translated professionally to Portuguese, based on the expertise and knowledge of the research team. These surveys are part of the EU project HealthFerm (https://www.healthferm.eu/), which means that prior to this study, the long version of the barriers scale and the social, economic and environmental sustainability scale had already been developed. Thus, the short version was a result of the project, and the aim of this study is only to validate it.

To correspond the answers of the long barriers scale with the short version of it, and to perform a test re-test for the social, economic and environmental sustainability scale, two questionnaires were developed, as already mentioned.

To assess the legibility and comprehension of the scales, a pre-test was made in March 2023, by students at the Department of Food, Nutrition and Culinary Sciences, University of Umeå (n=21). With their insights and feedback, slightly changes were made (mainly regarding the explanation and clarity of the topics).

a) Q1

With a total of sixteen questions, integrated in three main groups, Q1 aims not only to evaluate the short barriers scale towards plant-based foods, but also to collect data to characterize the sample about sociodemographic characteristics (group 1) and eating behaviour (group 2).

Table 22 shows the structure of the questionnaire.

Table 22 - Q1' items.

Groups	Parts	Items	Scale
Sociodemographic data		Sex	Feminine, masculine, other, prefer not to say.
		Age	Years
		Weight	Kilograms
		Height	Centimetres
		Nationality	Portuguese, other (open-ended).
		Residence type	Urban, semi-urban, rural.
		Occupation	Self-employed, employee, student, student-worker, unemployed, retired, other (open-ended).
		Level of education	Elementary school, basic education 2nd cycle, basic education 3rd cycle, secondary education, post-secondary education, professional higher technical course, Bachelor's degree, Master's degree, Doctoral degree
		City	Open-ended
Eating behaviour	Dietary lifestyle adapted from (Diseases, 2021)	Eating pattern	Omnivore, flexitarian, pescetarian, lacto-ovo

Groups	Parts	Items	Scale
			vegetarian, lacto-vegetarian, ovo-vegetarian, vegan.
	Length of the diet	"For how long have you been following your current dietary lifestyle?"	Less than 6 months, 6 months to 2 years, 2 years to 5 years, More than 5 years, Since I was born.
	Frequency of consumption	Cereals and derivatives Fruits Vegetables Pulses and legumes Nuts and seeds Fats and oils Potatoes and other tubers Dairy products Eggs Red meat Poultry Processed meat products Fish and seafood Commercial frozen and pre-prepared meals Plant-based meat alternatives Plant-based drinks Plant-based cheese and yoghurts Tofu	Never Less than once a month 1-3 times a month 1-3 times a week 4-6 times a week Once a day 2 or more times a day
	Consumption quantity	"Compared to a year ago, how much meat are you eating now?"	A lot less, Slightly less, No change, Slightly more, A lot more.
Barriers and attitudes towards social, environmental, and economic sustainability.	Short version of barriers scale	Plant-based foods are nutritionally sufficient (protein, iron, calcium, Vit. B12, etc.) for a healthy and balanced diet. Plant-based foods are satisfying, filling and fulfil my energy requirements. Plant-based foods are tasty and pleasant. Plant-based foods are convenient. Plant-based foods are affordable and available in grocery shops and foodservice. I know what and how to prepare a meal that includes plant-based foods. It would be easy for me to include more plant-based foods in my diet.	7-point scale: Strongly disagree Disagree Somewhat disagree Neither agree nor disagree Somewhat agree Agree Strongly agree

Groups	Parts	Items	Scale
		Plant-based foods facilitate a sustainable and healthy dietary transition.	
	Intention to increase or reduce the consumption in the next 6 months.	Dairy products Meat products	I intend to consume less I intend to consume a little less I intend to consume the same I intend to consume a little more I intend to consume more
	Attitudes towards social, economic, and environmental sustainability.	Everyone should have equal access to education, healthcare, and basic human rights. Communities should be inclusive and diverse. Policies should promote social equity, such as affirmative action and progressive taxation. Businesses should contribute positively to society and support local communities. Economic growth should be balanced with environmental protection and social equity. Sustainable business practices, such as circular economy models and responsible supply chain management, should be encouraged. Economic policies should prioritize the well-being of people and the planet over corporate profits. Alternative economic systems, such as the sharing economy and cooperatives, should be promoted. Climate change is a pressing issue that requires immediate action. Policies should promote the use of renewable energy sources and reduce greenhouse gas emissions. Businesses should reduce their environmental impact and promote sustainable practices. Conservation efforts, such as protecting natural habitats and preserving biodiversity, should be prioritized.	7-point scale: Strongly disagree Disagree Somewhat disagree Neither agree nor disagree Somewhat agree Agree Strongly agree

As presented in Table 22 the short version of the barriers scale addresses eight items, that were developed and adapted from a long pre-tested scale (Banyte et al., 2022; Perez-Cueto et al., 2022) with 23 statements (presented on Table 23). The short version was included in the 1st phase of the study, to balance the length and the duration of the questionnaires.

b) Q2

Thus, the second survey, presented in Table 23, addressed the long barriers scale, as well as the attitudes towards social, economic, and environmental sustainability scale, already used in Q1.

Besides the code provided by the respondents, a few demographic data was added to facilitate matching the data from each participant.

Table 23 - Q2' items.

Groups	Parts	Items	Scale
Demographic data		Sex	Feminine, masculine, other, prefer not to say.
		Age	Years
		City	Open-ended
Barriers and attitudes towards social, environmental, and economic sustainability.	Long version of barriers scale	There is not enough protein in plant-based food products. There is not enough iron in plant-based food products. I would be worried about my health (e.g., vit. B12, calcium) if I was only eating plant-based food products. I would get indigestion, bloating, gas, or flatulence when eating plant-based food products. I wouldn't get enough energy or strength from plant-based food products. I would need to eat a large quantity of plant-based foods to feel full. Plant-based food products would not be filling enough. I think humans are meant to eat lots of animal-based meat. Plant-based food products would not be tasty enough. Plant-based food products look too unusual. Plant-based food products are inconvenient.	7-point scale: Strongly disagree Disagree Somewhat disagree Neither agree nor disagree Somewhat agree Agree Strongly agree

Groups	Parts	Items	Scale
		I do not enjoy eating plant-based food products. Plant-based food products do not look appetizing or appealing. I don't want to change my eating habits or routine. My family/partner won't eat plant-based food products. Plant-Based foods are not safe There is not enough choice in plant-based food when I eat out. Plant-based meals or snacks are not available when I eat out. I need more information about plant-based food products. The plant-based foods I would need are not available where I shop or eat out. Plant-Based foods are not affordable I don't know how to prepare plant-based meals. I don't know what to eat instead of lots of animal-based meat.	
	Attitudes towards social, economic, and environmental sustainability.	**Same scale as Q1 (Table 22)**	7-point scale: Strongly disagree Disagree Somewhat disagree Neither agree nor disagree Somewhat agree Agree Strongly agree

3.4.3. Participants' consent

In the beginning of the inquiries, participants were asked for their permission to participate in the study and were informed of the time needed complete it (approximately 8 minutes for Q1 and 3 minutes for Q2). Informed confidentiality and anonymity were guaranteed at both questionnaires. Participants were asked to give consent for their data to be used for scientific purposes. All participants provided informed consent to participate in the study.

3.4.4. Data management and analysis

Firstly, data from both questionnaires, collected by LimeSurvey was downloaded to and Excel file, and organised. The exclusion criteria were applied to remove and clean the data.

Sampling was structured by sex (male and female), age group (three groups: 18-34, 35-54 and ≥ 55 years) and maximum level of education was divided in two groups: higher education (professional higher technical course, bachelor's, master's and doctoral degree) and lower education (any level from elementary school to post-secondary education).

The following variables were recoded into:

- Sex: 0 ("male") and 1 ("female").
- Age: 1 ("18-34"), 2 ("35-54") and 3 ("≥ 55 years").
- Maximum level of education: 1 ("lower education") and 2 ("higher education").
- Length of the diet: 1 ("less than 6 months"), 2 ("6 months to 2 years"), 3 ("2 years to 5 years"), 4 ("More than 5 years") and 5 ("Since I was born").
- Frequency of consumption: 0 ("never"), 1 ("Less than once a month"), 2 ("1-3 days a month"), 3 ("1-3 times a week"), 4 ("4-6 times a week"), 5 ("Once a day") and 6 ("2 or more times a day").
- Meat consumption: -2 ("A lot less"), -1 ("Slightly less"), 0 ("No change"), 1 ("Slightly more") and 2 ("A lot more").
- Meat consumption groups: 1 ("Meat reducers", including flexitarian, pescetarian and vegetarian diets) and 2 ("omnivores").
- Weight status: 1 ("Normal weight") and 2 ("Overweight & obese").
- Intention: -2 ("I intend to consume less"), -1 ("I intend to consume a little less"), 0 ("I intend to consume the same"), 1 ("I intend to consume a little more") and 2 ("I intend to consume more").
- 7-point scales (barriers and sustainability scales): 0 ("Strongly disagree"), 1 ("Disagree"), 2 ("Somewhat disagree"), 3 ("Neither agree nor disagree"), 4 ("Somewhat agree"), 5 ("Agree") and 6 ("Strongly agree").

3.4.5. Statistical analysis

Descriptive statistics (frequencies, mean and standard deviation) were used to describe socio-demographic characteristics of the sample.

For eating behaviour group, crosstabs with frequencies were used in all analysis. Additionally, to interpret the relationship between diet type and other variables Fisher's Exact and Mann-Whitney test were applied. Fisher's Exact test (Fisher, 1922) was used for categorical variables, while Mann-Whitney test was applied for ordinal variables.

Cronbach's alfa interpretation was used to evaluate internal consistency and reliability of the barriers and the social, economic and environmental scale (Cronbach, 1951). Cronbach's alpha can range from 0 to 1, with higher values indicating greater interrelation between items (De Vet et al., 2011).

In light with previous research test-retest reliability and to analyse construct validity, Pearson's and Spearman's correlations were used (Dancey & Reidy, 2007; Hartmann & Siegrist, 2018). Pearson's was applied to the barriers scale to measure the strength of the relationship between continuous variables (with normal distribution), while Spearman's was used to measure it between continuous variables, with non-normal distribution (Coolidge, 2020). The correlation coefficients were interpreted based on the following classification system: weak (0.1–0.3), moderate (0.4–0.6) and strong correlation(≥0.7) (Dancey & Reidy, 2007).

To validate and compare the short version of the barriers with the long scale, Bland-Altman plot was used to assess agreement/ concordance between short and long barriers scale (Altman & Bland, 1983).

All statistical tests were applied at 95% confidence level. Data was analysed using Microsoft Excel, XLSTAT and IBM SPSS Statistics 27.

3.5. Results

3.5.1. Participants and socio-demographic characterization

In the 1st questionnaire administered via *LimeSurvey*, a total of 4481 clicks were recorded. Among these interactions, 4345 instances involved participants simply opening the survey link without proceeding to complete any of the survey items. Thus, from the 136 participants that effectively opened and did some parts of the questionnaire, 111 completed it of which 2 gave invalid answers, according to the exclusion criteria (valid answers of the first round, n=109). After answering Q1, 84 participants provided the email to continue participating in the study, and 67 participants completed Q2, with 66 valid answers.

Table 24 shows the sociodemographic characteristics of the participants. The sample is quite homogenous, particularly with 74.2% of the participants being females and 77.3% falling within the age group of 18-34 years old.

Table 24 - Participants' socio-demographic characteristics, N=66.

Characteristics		**Total** n = 66
Sex, n (%)	Female	49 (74.2)
	Male	17 (25.8)
Age, mean (sd)		31 (11)
Age Groups, n (%)	18-34	51 (77.3)
	35-54	10 (15.2)
	≥ 55	5 (7.6)
Level of education, n (%)	Lower education	10 (15.2)
	Higher education	56 (84.8)
Nationality, n (%)	Portuguese	59 (89.4)
	Brazilian	19 (10.6)
Municipality of residence, n (%)	Urban	49 (74.2)
	Semi-urban	12 (18.2)
	Rural	5 (7.6)
Geographical area, n (%)	North	58 (87.9)
	Centre	2 (3.0)
	South	5 (7.6)
	Archipelagos	1 (1.5)
Occupation, n (%)	Self-employed	4 (6.1)
	Employee	15 (22.7)
	Student	31 (47.0)
	Student-worker	11 (16.7)
	Unemployed	3 (4.5)
	Retired	2 (3.0)

Table 25 demonstrates the diet type of the participants, revealing that the largest group follows an omnivorous diet, followed by flexitarians. It also compares with weight status. These results make it impossible to use Chi-Square test, and Fisher's Exact Test is suitable for small sample sizes or when the expected counts are less than 5 (Fisher, 1922). *P*-value is 0.880, which means that diet and weight status are independent.

Table 25 - Frequencies of the relationship between diet and weigh status.

Diet (%) \ Weigh status	Normal weight, n (%)	Overweight & Obese, n (%)
Omnivore (72.7)	33 (70.2)	15 (78.9)
Flexitarian (13.6)	7 (14.9)	2 (10.5)
Vegan (7.6)	3 (6.4)	2 (10.5)
Lacto-ovo vegetarian (3.0)	2 (4.3)	-
Pescetarian (3.0)	2 (4.3)	-
Total (n)	47	19

Table 26 shows the distribution of diet groups concerning the duration of their respective diets. Mann-Whitney test has a *p*-value of <0.001, indicating a highly significant statistical difference in the length of the diet between individuals categorized as omnivores and those identified as meat reducers. Out of the total 48 participants identified as omnivores within the sample, 42 individuals always adhered to this dietary pattern. Among the meat reducer group, a total of 12 individuals transitioned to their current dietary pattern 2 to 5 years ago.

Table 26 - Frequencies of the relationship between diet and length of diet.

Diet (%) \ Length of diet	6 months to less than 2 years, n (%)	2 to 5 years, n (%)	More than 5 years, n (%)	Always, n (%)
Omnivores (72.7)	3 (50.0)	1 (7.7)	2 (40.0)	42 (100.0)
Meat reducers (27.3)	3 (50.0)	12 (92.3)	3 (60.0)	-

Table 27 illustrates the current meat consumption levels, compared to a year ago, among the participants categorized into two diet groups. Mann-Whitney test presents a *p*-value of 0.032, hence there is statistically significant differences in the current meat consumption levels compared to a year ago between the two diet groups. Among the omnivores, a total of 25 individuals are currently consuming slightly less meat compared to their consumption levels from a year ago.

Table 27 - Frequencies of the relationship between diet and current meat consumption levels.

Diet (%) \ Meat consumption change	Much less, n (%)	Slightly less, n (%)	No change, n (%)	Slightly more, n (%)
Omnivores (72.7)	3 (75.0)	25 (89.3)	18 (56.3)	2 (100.0)
Meat reducers (27.3)	1 (25.0)	3 (10.7)	14 (43.8)	-

Tables 28 and 29 present the participants' intentions regarding the modification of their meat and dairy consumption, respectively, over the upcoming 6 months. In terms of meat consumption, the Mann-Whitney test resulted in a *p*-value of 0.500, indicating no significant differences between meat reducers and omnivores. However, upon analysing Table 28, it is evident that omnivores express a higher intention to reduce their meat intake compared to meat reducers.

On the other hand, regarding dairy consumption intention, the Mann-Whitney test yielded a *p*-value of 0.042, suggesting statistically significant differences between meat reducers and omnivores. Specifically, omnivores intend to maintain their current dairy consumption levels.

Table 28 - Frequencies of the relationship between diet and the intention to change meat consumption.

Diet (%) \ Intention meat	I intend to consume less, n (%)	I intend to consume a little less, n (%)	I intend to consume the same, n (%)
Omnivores (72.7)	8 (61.5)	17 (94.4)	23 (65.7)
Meat reducers (27.3)	5 (38.5)	1 (5.6)	12 (34.3)

Table 29 - Frequencies of the relationship between diet and the intention to change dairy consumption.

Diet (%) \ Intention dairy	I intend to consume less, n (%)	I intend to consume a little less, n (%)	I intend to consume the same, n (%)	I intend to consume a little more, n (%)
Omnivores (72.7)	3 (50.0)	5 (55.6)	38 (77.6)	2 (100.0)
Meat reducers (27.3)	3 (50.0)	4 (44.4)	11 (22.4)	-

3.5.2. Short barriers scale

The Cronbach's alpha for the short barriers scale (n=66) is 0.721. This value indicates a satisfactory level of reliability and internal consistency (Taber, 2018). Additionally, the long barriers scale exhibits a high Cronbach's alpha of 0.871 for the same sample size (n=66), suggesting a strong correlation and good internal consistency among the scale items (Tavakol & Dennick, 2011).

Using Bland-Altman analysis, the agreement between the answers obtained from both scales (n=66) were evaluated. Bland-Altman plot (Figure 4) provides a visual

representation of the differences between both scales, plotted against the averages of the items. It shows that the short version of the scale is in good agreement with the long version, with only 4 points falling outside the limits of agreement. The quite narrow range of differences within the limits of agreement suggests good agreement. This statement is supported by the visual representation in the scatter plot (Figure 4), further associating the robustness of this analysis. Also, *p*-value of Bland-Altman test is 0.659, signifying that the null hypothesis is not rejected so, the difference between the means is equal to 0.

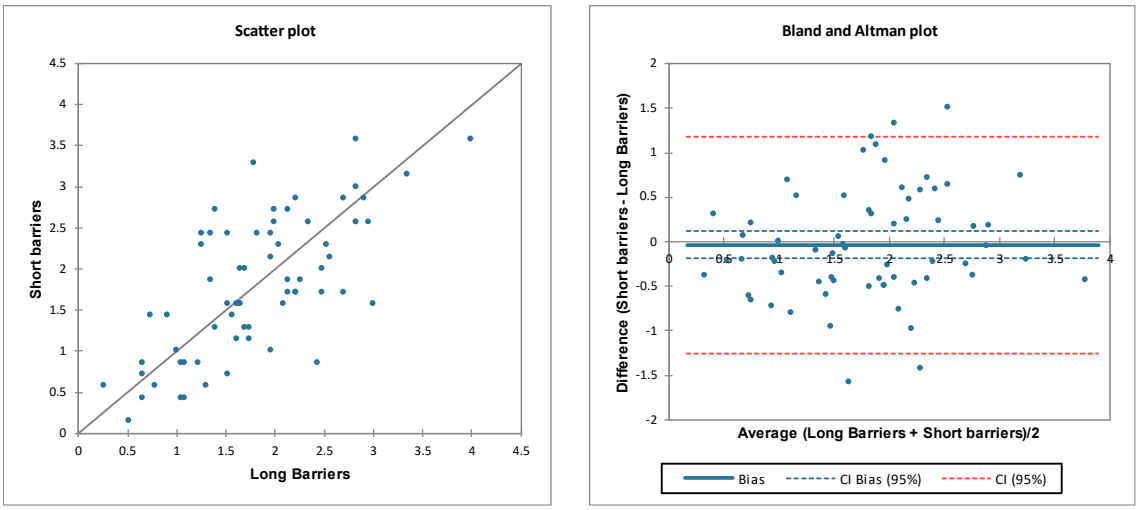

Figure 4 - Scatter plot between Long and Short Barriers (on the left). Bland and Altman plot between the average of the scales/2 and the difference between them (on the right).

The normal distribution of both scales was confirmed based on the Kolmogorov-Smirnov test results (long scale: p=0.973; short scale: p=0.728). Consequently, the Pearson correlation coefficient, which was found to be 0.701, was statistically significant ($p < 0.0001$), suggesting a moderately strong positive linear relationship between the scales.

3.5.3. Social, environmental and economic sustainability scale

In the test-retest analysis, the Cronbach's alpha for the 1st round (n=66) was 0.790, and for the 2nd round (n=66), it was 0.829. These values indicate a robust correlation and great internal consistency among the scale items, further affirming the scale's reliability.

The Kolmogorov-Smirnov test identified non-normal distribution (p=0.027) in one of the scales, leading to the use of Spearman correlation test. The Spearman correlation coefficient ($p < 0.0001$) measured 0.672, demonstrating a strong and consistent relationship between the test and retest scores. This Spearman correlation highlights the good test-retest reliability of the scale, indicating its stability and consistency over time.

3.6. Discussion

The validation of scientific scales tailored to consumer studies, specially focusing on attitudes and barriers related to plant-based foods, is a crucial step to develop intervention strategies that promote a more sustainable and healthy food system. In this sense, the main aim of this study is to validate two different scales, one about the barriers towards plant-based foods and other related to social, economic, and environmental sustainability.

According to Boateng et al. (2018), the development of a scale encompasses mainly three phases: item development, scale development and scale evaluation. In this study, the focus was on the third phase, the scale validation and, in this context, the statistical methods Cronbach's alpha (to test reliability), Spearman and Pearson correlation (for test–retest reliability and construct validity), and Bland-Altman (agreement of the scales), provide valuable insights into the quality and appropriateness of the scales (Altman & Bland, 1983; Boateng et al., 2018; Cronbach, 1951). For the barriers and "sustainability" scales analysed in this study, the analysis of each one was selected considering the appropriate methodology for each the objectives.

Regarding the barriers scale, a comparison between the short and the long version was conducted to assess their agreement and validity of the short version. In a different topic, but with the aim to shorten a scale, Sánchez et al. (2021) suggested to administer the long and short scales separately to the same sample, as was done in this study, with two questionnaires. This enables the evaluation of its performance and their comparison allow for an assessment of the extent to which the shorter scale provides comparable results to the longer scale in measuring the same construct. Similarly to Hartmann and Siegrist (2018) study, developing a short version of the Food Disgust Scale allowed a measurement of the items in a time-efficient way. The results of the present study, show that, the analysis of the plot revealed a quite small range of differences within the limits of agreement, indicating a moderate agreement between the short and long versions. Consequently, this result indicates that the short version has potential as a legitimate substitute for the long version, demonstrating adequate agreement, and supporting its use in similar assessments.

Moreover, the items exhibit a moderate level of correlation. The scale's reduction enhances its internal consistency, indicating that the items within the scale are interconnected and measure a consistent construct (BrckaLorenz et al., 2013). Likewise, our study's results demonstrate strong internal consistency for the social, economic, and environmental sustainability scale, affirming that the items are interrelated. This suggests

a high level of scale reliability, for both (BrckaLorenz et al., 2013). For the social, economic, and environmental sustainability scale, Spearman test shows a moderate correlation demonstrating that there may be some variability in the measurements when the scale is administered at different times to the same individuals. When validating a scale or any measurement tool, it is expected to verify a strong correlation between scores obtained in test-retest situations, even though, factors such as the sample size can influence the correlation (Coolidge, 2020). However, both "good" and "moderate" correlations can be described by correlation coefficients of 0.65, and, given that in this study the value for the coefficient of this scale is 0.672, it points to a positive indicator of reliability (Schober et al., 2018).

This validated scale evaluates consumer attitudes towards social, economic, and environmental sustainability, filling a gap in existing research, that often focuses on environmental sustainability alone (Dimitrova et al., 2022; Dunlap et al., 2000; Kaiser & Wilson, 2004; Milfont & Duckitt, 2010), consequently offering valuable insights into the importance consumers assign to these interconnected sustainability dimensions. Having a generic scale that evaluates consumer attitudes towards social, economic, and environmental sustainability is crucial in consumer sciences related to the adoption of plant-based foods, because it allows for a comprehensive assessment of sustainability perceptions beyond environmental concerns alone. This broader evaluation sheds light on the diverse motivations and attitudes of consumers towards sustainability, aiding in understanding the multi-faceted factors influencing their adoption or reluctance towards plant-based food choices. By encompassing social and economic aspects, this scale offers a holistic view of sustainability preferences, contributing to the development of targeted strategies and interventions that promote the uptake of plant-based diets in a sustainable and socially conscious manner.

In sum, the validation process affirmed the efficacy of a shortened barriers scale, indicating its potential as a legitimate substitute for the longer version. Additionally, the validated social, economic, and environmental sustainability scale demonstrates good internal consistency and offers a comprehensive assessment of consumer attitudes, filling a significant gap in existing research. These validated measurement tools are instrumental in comprehending consumer perceptions and are essential for shaping targeted interventions to foster sustainable food choices crucial in an era of climate emergency.

Despite the conclusions of this study, it's important to acknowledge certain limitations that could impact the robustness of the findings. One significant limitation is the small

sample size, that translates into a few information of the data. It might have restricted the representativeness of the results and potentially affected the statistical power, making it challenging to draw broader conclusions. Additionally, the incoherent results obtained from the factor analysis (not included in the study), which led to the exclusion of the scale reduction component, pose another limitation. This decision was made to ensure the quality and accuracy of the data analysis, even though it deviated from methodologies employed in other studies that successfully validated scales using this approach. Factor analysis is a type of validity that is very dependent on sample size, and according to the literature, a minimum of approximately 100 individuals are needed in order to conduct this analysis (De Vet et al., 2011). Future research with larger sample sizes and a deeper exploration of alternative scale validation methods is recommended to enhance the reliability and validity of the findings.

3.7. Conclusions

In the context of evolving dietary preferences and growing environmental awareness, investigating consumer attitudes and barriers towards plant-based foods has become increasingly critical. Plant-based foods are recognized for their potential to reduce GHG emissions, conserve natural resources, and promote health. Understanding the barriers that delay the adoption of plant-based diets, and comprehending consumer attitudes toward various dimensions of sustainability, including social, economic, and environmental factors, provides essential insights for different actors. This study recognized the need to validate scales tailored to measure these attitudes and barriers, aligning with the urgent need for sustainable and health-conscious dietary shifts.

The findings of this study hold significant implications for consumer sciences and sustainability research. The validation process of the barriers scale revealed that a shortened version may substitute the longer version, offering a time-efficient and valid measurement tool. Additionally, the validated social, economic, and environmental sustainability scale had good internal consistency, demonstrating its reliability in assessing consumer attitudes across these interconnected sustainability dimensions.

In summary, this study contributes to the field by providing possible validated measurement tools, essential for investigating consumers' perceptions and behaviours related to plant-based diets and sustainability. These scales offer researchers a reliable instrument to explore consumer attitudes, supporting the development of targeted strategies and interventions to encourage sustainable dietary choices. The two scales, facilitate a more nuanced understanding of factors influencing consumer choices, crucial in promoting sustainable and conscious food adoptions.

4. Overall conclusions

This dissertation synthesizes critical insights from two different, yet interrelated, studies focused on consumers' perspectives towards innovative and sustainable plant-based food products.

The first study showed that nature is highly associated to algae, and Asian food is mentioned within the concepts algae and food. The results indicated that the seventeen algae food products load in three main groups of food categories, and that the acceptance of algae is divided in four different consumer segments: Rejecters, Moderate critics, Moderate admirers and Acceptors. Pasta and dry seasonings are the food products with higher acceptance to integrate algae as food. Determinants such as dietary pattern, healthiness of the diet, frequency of consumption of ethnic foods, familiarity, food neophobia, green consumption values and trust in NGOs, have influence on the acceptance of food product categories incorporating algae.

The second study suggests that the short version may substitute the longer version of the barriers scale. The social, economic, and environmental sustainability scale demonstrated reliability in assessing consumer attitudes across different sustainability dimensions. This study highlights the importance of validating scales to measure attitudes and barriers, aligning with the need for sustainable dietary shifts.

In conclusion, understanding consumers' perspectives on innovative and sustainable plant-based food products, as demonstrated through these two studies, is fundamental for fostering their widespread adoption and promoting a more sustainable food system.

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6. Annexes

6.1. Annex 1: JuniFEUP social media post

6.2. Annex 2: MC SONAE poster

6.3. Annex 3: Algae study' questionnaire

Consumer Science Study on Innovative Food Products

Informed Consent Statement for Study Participation

Welcome!

As part of a research project for a Master's degree in Consumer Sciences and Nutrition from the Faculty of Sciences of the University of Porto, and in collaboration with MC SONAE (a Portuguese food retail (Portuguese food retail company) and GreenUPorto (Research Center for Sustainable Sustainable Agro-Food Production), I hereby invite you to participate in a study on innovative food products.

If you agree to participate in this study, you will be directed to answer the online questionnaire which will take approximately 8 minutes to complete.

Responses to the questionnaire will not allow researchers to reveal the identity of the people who complete the questionnaire. Confidentiality and anonymity of the data will be guaranteed, and the data collected will be used exclusively for this study and kept in a protected database for up to 7 months for further analysis. Records of survey responses do not contain any information about your identity.

The decision to participate is voluntary, and you can withdraw at any time.

Should you require any additional information about this questionnaire, please contact the student Inês Magalhães (up201803425@up.pt) or the project advisor Prof. Luís Miguel Cunha (lmcunha.inqueritosUP@gmail.com).

Thank you for your willingness to participate in this study, which is fundamental for the realization of the present project.

If you agree to participate, please check the alternative below. By agreeing, you will confirm that you are 18 years of age or older and participating voluntarily.

Please select all that apply:

◯ I understand the procedures described above.

◯ I agree to participate in this study. I give permission for the information collected to be published for scientific purposes.

Group 1 - Conceptualizing of the use of algae

Part 1

Please name the first three words that come to mind when you think of algae:

_____

Please indicate how you rate the 1st word you wrote:

◯ Positive

◯ Neither positive nor negative

◯ Negative

Please indicate how you rate the 2nd word you wrote:

◯ Positive

◯ Neither positive nor negative

◯ Negative

Please indicate how you rate the 3rd word you wrote:

◯ Positive

◯ Neither positive nor negative

◯ Negative

Part 2

Please name the first three words that come to mind when you think of algae and food:

_____

Please indicate how you rate the 1st word you wrote:

◯ Positive

◯ Neither positive nor negative

◯ Negative

Please indicate how you rate the 2nd word you wrote:

◯ Positive

◯ Neither positive nor negative

◯ Negative

Please indicate how you rate the 3rd word you wrote:

◯ Positive

◯ Neither positive nor negative

◯ Negative

Group 2 - Acceptance and willingness to consume

Please indicate the situation that best describes how often you would consume the following algae-incorporated products if they were available on the market, using the following scale:

(1) I would eat this if I were forced to.

(2) I would eat this only if there were no other food choices.

(3) I would hardly ever eat this.

(4) I don't like it but would eat it on an occasion.

(5) I would eat this if available but would not go out of my way.

(6) I like this and would eat it now and then.

(7) I would frequently eat this.

(8) I would eat this very often.

(9) I would eat this every opportunity I had.

Please select the appropriate position for each element:

	(1) I would eat this if I were forced to.	(2) I would eat this only if there were no other food choices.	(3) I would hardly ever eat this.	(4) I don't like it but would eat it on an occasion.	(5) I would eat this if available but would not go out of my way.	(6) I like this and would eat it now and then.	(7) I would frequently eat this.	(8) I would eat this very often.	(9) I would eat this every opportunity I had.
Dehydrated algae – e.g.: algae sheets for making sushi.									
Pre-prepared meals – e.g.: hamburger or vegetarian nugget with algae.									
Canned meals – e.g.: vegetable									

soup with algae; canned vegetables and/or legumes with algae sauce.									
Fresh ready meals (takeaway) – e.g.: sandwich with algae pâté; wrap with algae filling.									
Instant meals – e.g.: instant oatmeal with algae, powdered.									
Pâtés/pastes – e.g.: pâté with algae; hummus with algae.									
Sauces – e.g.: pesto with algae; mayonnaise with algae.									
Dry seasonings – e.g.: algae granules for seasoning (as an alternative to salt).									
Snacks – e.g.: salty snack with algae; snacks/chips seasoned with algae.									
Bakery – e.g.: toast or bread with dried algae.									
Salty pastries – e.g.: veggie pie or rissole with algae.									
Sweet pastries – e.g.: rice cake with algae; croissant with algae.									
Crackers – e.g.: cracker									

with algae; corn tortitas with algae.									
Frozen Vegetables – e.g.: sauté mix of vegetables and algae.									
Pasta – e.g.: fusilli pasta or spaghetti pasta with algae incorporation.									
Dairy products – e.g.: butter with algae; cream cheese with algae.									
Beverages – e.g.: fruit and algae smoothies; oatmeal and algae vegetable drink.									

Group 3 - Eating Behavior

Please select which type of eating pattern fits best with your lifestyle:

- Omnivore (includes both animal and plant foods)
- Flexitarian (mostly vegetarian, but meat may be eaten occasionally)
- Vegan (excludes every animal-based foods)
- Lacto-ovo vegetarian (excludes meat and fish, allows eggs and dairy products)
- Lacto-vegetarian (excludes meat, fish and eggs, allows dairy products)
- Ovo-vegetarian (excludes meat, fish and dairy products, allows eggs
- Other (_____)

Please indicate how you rate your eating pattern with regard to the following aspect:

	Poor	Fair	Good	Very good	Excellent
In general, how healthy is your diet? Would you say it is:					

To answer the following question, think about a typical week in the last 12 months, and select on how many days of the month or week you consumed the following meals:

	Never	< 1 day/ month	1-3 days/month	1 day/week	2-3 days/week	4-5 days/week	6-7 days/week
Sushi							

Miso soup							

To answer the following question, think about a typical week in the last 12 months, and select on how many days of the month or week you consumed algae products:

	Never	< 1 day/ month	1-3 days/month	1 day/week	2-3 days/week	4-5 days/week	6-7 days/week
Meal/food product with algae.							

Regarding meals/food products with algae, please indicate the option that best characterizes your knowledge:

◯ Unknown

◯ I know about it, but I have never eaten it

◯ I know and have used it

Group 4

Regarding your eating behaviours, please indicate to what extent do you agree with the following statements?

(Using the following scale from 1 to 7, with 1 being "strongly disagree" and 7 being "strongly agree")

	1- Strongly disagree	2	3	4	5	6	7- Strongly agree
I am constantly sampling new and different foods.							
I don't trust new foods.							
If I don't know what is in a food, I won't try it.							
I like foods from different countries.							
Ethnic food looks too weird to eat.							
At dinner parties, I will try a new food.							

I am afraid to eat things I have never had before.							
I am very particular about the foods I will eat.							
I will eat almost anything.							
I like to try new ethnic restaurants.							

Regarding your behaviours about global sustainability, please indicate your level of agreement with the following items/phrases:

(using the following scale from 1 to 7, with 1 being "strongly disagree" and 7 being "agree strongly agree")

	1- Strongly disagree	2	3	4	5	6	7- Strongly agree
It is important to me that the products I use do not harm the environment.							
I consider the potential environmental impact of my actions when making many of my decisions.							
My purchase habits are affected by my concern for our environment.							
I am concerned about wasting the resources of our planet.							
I would describe myself as environmentally responsible.							
I am willing to be inconvenienced in order to take actions that are more environmentally friendly.							

Please indicate your degree of confidence in the following food system actors with respect to food safety:

	Totally distrust	Slightly distrust	Slightly trust	Totally trust
Farmers (producing plants and animals for human consumption)				
Food manufacturers (preparing, preserving, and packaging food)				
Retailers (supermarkets, markets, food stores)				
Authorities (government agencies at national and EU level)				
Non-governmental organizations (non-profit organizations)				

Group 5 - Socio-Demographic Profile

Please indicate your gender:

◯ Female

◯ Male

◯ I do not identify with the binary classification

◯ I prefer not to answer

Please indicate your age:

_____

Please indicate the highest level of education you have completed.

- Primary school 1st cycle (current 4th grade/former primary school/4th grade)
- Elementary school 2nd cycle (current 6th grade/preparatory school)
- Elementary school 3rd cycle (current 9th grade/former high school)
- Secondary education (current 12th grade/former 7th grade/preparatory year)
- Post-secondary education (non-higher technological specialization courses)
- Professional higher technical course
- Bachelor's degree
- Master's degree
- Doctoral degree

Please indicate your nationality:

_____

Please indicate your county of residence:

_____

Please indicate your legal marital status:

◯ Single

◯ Married

◯ Widow(er)

◯ Divorced

Please indicate the number of household members, including yourself:

_____

Please indicate the household's net monthly income:

◯ Less than 560€

◯ 560€ a 790€

◯ 790€ a 1010€

◯ 1010€ a 1260€

◯ 1260€ a 1530€

◯ 1530€ a 1780€

◯ 1780€ a 2120€

◯ 2120€ a 2610€

◯ 2610€ a 3440€

◯ More than 3440 €

Please indicate your current employment status:

◯ Self-employed

◯ Employee

◯ Student

◯ Student Worker

◯ Unemployed

◯ Retired

◯ Other (which?) _____

Thank you very much for your participation!

6.4. Annex 4: Ethical approval by Ethical Commission of the Faculty of Sciences of the University of Porto

U.PORTO

FACULDADE DE CIÊNCIAS
UNIVERSIDADE DO PORTO
Comissão de Ética

Parecer

Ref.: Proc. CE2023/p45

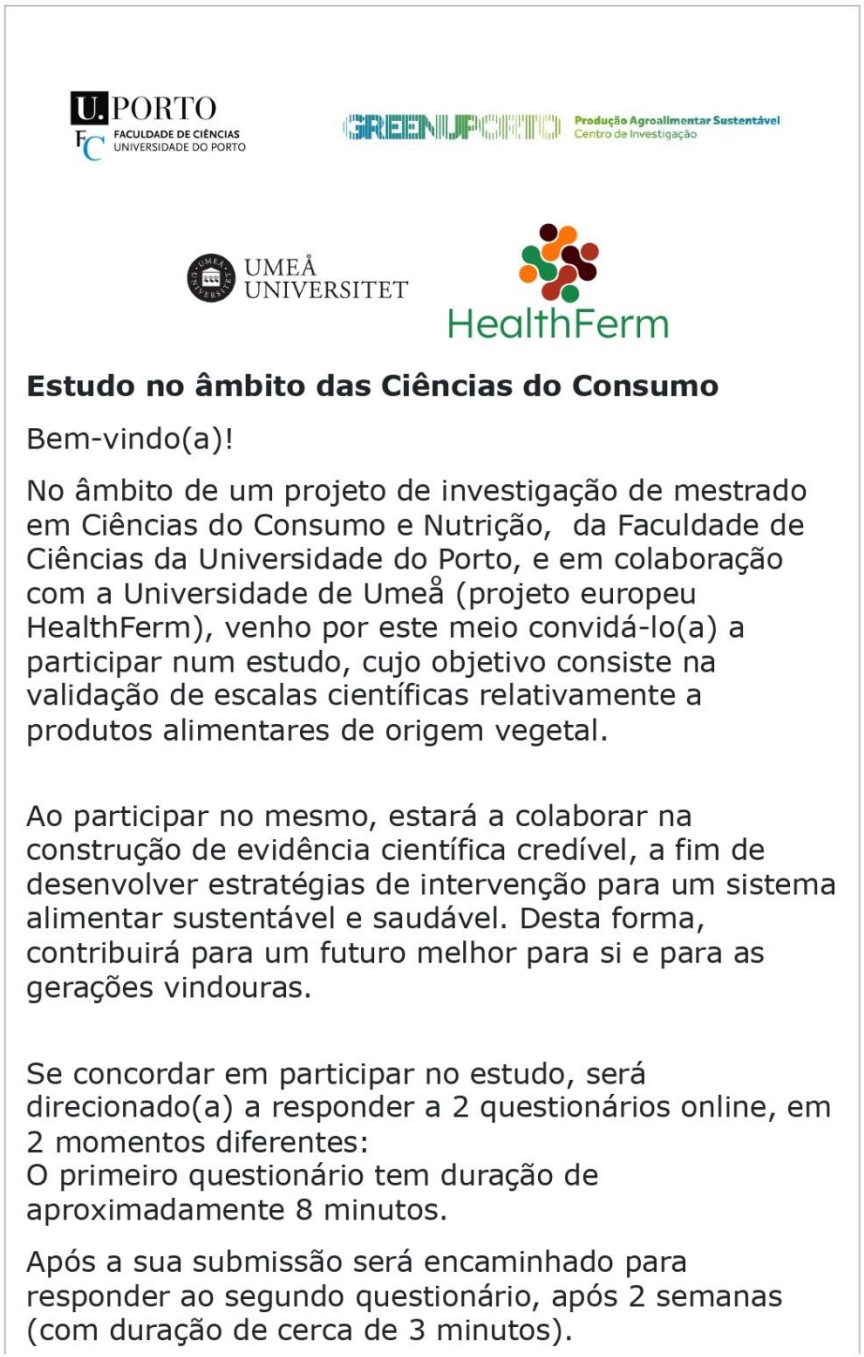
A Comissão de Ética nada tem a opor à aplicação de um questionário a maiores de idade sobre a aceitação de produtos alimentares com algas edíveis, pela estudante de mestrado Inês Filipa Pereira Magalhães, no âmbito da sua dissertação do Mestrado em Ciências do Consumo e Nutrição, uma vez que está garantido o anonimato e confidencialidade dos dados solicitados, bem como o consentimento informado dos inquiridos.

Faculdade de Ciências da Universidade do Porto, 6 de maio de 2023

A Presidente da Comissão de Ética

Sabine Broda
(Prof. Doutora Sabine Broda)

6.5. Annex 5: Q1' questionnaire



U.PORTO
FACULDADE DE CIÊNCIAS
UNIVERSIDADE DO PORTO

GREENUP
Produção Agroalimentar Sustentável
Centro de Investigação

UMEÅ UNIVERSITET

HealthFerm

Estudo no âmbito das Ciências do Consumo

Bem-vindo(a)!

No âmbito de um projeto de investigação de mestrado em Ciências do Consumo e Nutrição, da Faculdade de Ciências da Universidade do Porto, e em colaboração com a Universidade de Umeå (projeto europeu HealthFerm), venho por este meio convidá-lo(a) a participar num estudo, cujo objetivo consiste na validação de escalas científicas relativamente a produtos alimentares de origem vegetal.

Ao participar no mesmo, estará a colaborar na construção de evidência científica credível, a fim de desenvolver estratégias de intervenção para um sistema alimentar sustentável e saudável. Desta forma, contribuirá para um futuro melhor para si e para as gerações vindouras.

Se concordar em participar no estudo, será direcionado(a) a responder a 2 questionários online, em 2 momentos diferentes:
O primeiro questionário tem duração de aproximadamente 8 minutos.

Após a sua submissão será encaminhado para responder ao segundo questionário, após 2 semanas (com duração de cerca de 3 minutos).

As respostas ao questionário não permitem aos investigadores chegar à identidade das pessoas que o preencherem. A confidencialidade e anonimato dos dados serão garantidos, sendo que os dados recolhidos serão usados exclusivamente para o presente estudo e mantidos numa base de dados protegida até, mas não depois, 01/09/2035. Os registos das respostas ao inquérito não contêm qualquer informação sobre a sua identidade.
A decisão de participar é voluntária, podendo desistir a qualquer momento.

Caso pretenda alguma informação adicional sobre o presente questionário, por favor entre em contacto com a estudante Inês Magalhães (up201803425@up.pt) ou com o orientador do projeto, Prof. Doutor Luís Miguel Cunha (lmcunha.inqueritosUP@gmail.com).
Se concordar em participar, por favor assinale a alternativa abaixo.

*

Assinale todas as que se aplicam
Por favor, selecione **todas** as que se aplicam:

☐ Sim, confirmo que tenho 18 anos ou mais e que participo voluntariamente.
Compreendi os procedimentos descritos acima e concordo em participar neste estudo.
Dou permissão para que a informação recolhida seja publicada para fins científicos.

Dados demográficos

Por favor indique qual o seu sexo: *

Escolha uma das seguintes respostas
Por favor, selecione **apenas uma** das seguintes opções:

- ◯ Feminino
- ◯ Masculino
- ◯ Outro
- ◯ Prefiro não dizer

Por favor indique qual a sua idade: *

Por favor, escreva aqui a sua resposta:

Por favor indique qual o seu peso em quilogramas (kg): *

Por favor, escreva aqui a sua resposta:

Por favor indique qual a sua altura em centímetros (cm), por exemplo se mede 1 metro e 60 cm, escreva 160. *

Por favor, escreva aqui a sua resposta:

Por favor indique a sua nacionalidade: *

Escolha uma das seguintes respostas
Por favor, selecione **apenas uma** das seguintes opções:

◯ Portuguesa
◯ Outro

Por favor indique como caracteriza o seu lugar de residência:

(escolha a opção que melhor se adequa)

*

Escolha uma das seguintes respostas
Por favor, selecione **apenas uma** das seguintes opções:

◯ Urbano
◯ Semi-urbano
◯ Rural

Por favor indique o seu estado profissional atual: *

Escolha uma das seguintes respostas
Por favor, selecione **apenas uma** das seguintes opções:

- ◯ Trabalhador por conta própria
- ◯ Trabalhador por conta de outrém
- ◯ Estudante
- ◯ Trabalhador-Estudante
- ◯ Desempregado
- ◯ Reformado/aposentado
- ◯ Outro

Por favor indique o nível de escolaridade mais elevado que completou: *

Escolha uma das seguintes respostas
Por favor, selecione **apenas uma** das seguintes opções:

- ◯ Ensino básico 1º ciclo (atual 4º ano/antiga instrução primária/4ª classe)
- ◯ Ensino básico 2º ciclo (atual 6º ano/antigo ciclo preparatório)
- ◯ Ensino básico 3º ciclo (atual 9º ano/antigo 5º liceal)
- ◯ Ensino secundário (atual 12º ano/antigo 7º liceal/ano propedêutico)
- ◯ Ensino pós-secundário (Cursos de especialização tecnológica não superior)
- ◯ Curso técnico superior profissional
- ◯ Bacharelato (inclui antigos cursos médios)
- ◯ Licenciatura
- ◯ Mestrado
- ◯ Doutoramento

Por favor indique a cidade onde atualmente reside: *

Por favor, escreva aqui a sua resposta:

Estilo de vida alimentar

Qual das seguintes opções melhor representa o seu estilo de vida alimentar? *

Escolha uma das seguintes respostas
Por favor, selecione **apenas uma** das seguintes opções:

◯ Omnívoro (inclui alimentos de origem animal e vegetal)

◯ Flexitariano (maioritariamente vegetariano, mas a carne pode ser consumida ocasionalmente)

◯ Pescetariano (inclui pescado, mas exclui outro tipo de carne)

◯ Ovolactovegetariano (exclui carne e pescado, permite ovos e lacticínios)

◯ Lactovegetariano (exclui carne, pescado e ovos, permite lacticínios)

◯ Ovovegetariano (exclui carne, pescado e lacticínios, permite ovos)

◯ Vegano (exclui todos os alimentos de origem animal, bem como ingredientes de origem animal)

Há quanto tempo segue o seu estilo de vida alimentar atual? *

Escolha uma das seguintes respostas
Por favor, selecione **apenas uma** das seguintes opções:

- ◯ Menos de 6 meses
- ◯ De 6 meses a menos de 2 anos
- ◯ 2 anos a 5 anos
- ◯ Mais de 5 anos
- ◯ Sempre, toda a vida, desde que me recorde

Qual das seguintes afirmações melhor descreve a frequência com que consumiu os seguintes alimentos nos últimos 12 meses? *

Por favor, selecione a posição apropriada para cada elemento:

	Nunca	Menos de uma vez por mês	1-3 vezes por mês	1-3 vezes por semana	4-6 vezes por semana	Uma vez por dia	2 ou mais vezes por dia
Cereais e derivados (p. ex., cereais e grãos: arroz, cuscuz, bulgur, quinoa, trigo sarraceno, aveia, centeio, etc.; produtos derivados: massas, pão, etc.)	◯	◯	◯	◯	◯	◯	◯
Frutas (p. ex., maçãs, cerejas, frutos tropicais, etc.)	◯	◯	◯	◯	◯	◯	◯
Hortícolas (p. ex., cenouras, couves, etc.)	◯	◯	◯	◯	◯	◯	◯
Leguminosas (p. ex., feijão, lentilhas, etc.)	◯	◯	◯	◯	◯	◯	◯
Frutos secos, gordos e sementes (p. ex., amendoins, amêndoas, nozes, avelãs, etc.)	◯	◯	◯	◯	◯	◯	◯
Gorduras e óleos (p. ex., óleo de girassol, manteiga, azeite, colza, etc.)	◯	◯	◯	◯	◯	◯	◯

	Nunca	Menos de uma vez por mês	1-3 vezes por mês	1-3 vezes por semana	4-6 vezes por semana	Uma vez por dia	2 ou mais vezes por dia
Batatas e outros tubérculos (p. ex., batata, batata-doce, mandioca, etc.)	◯	◯	◯	◯	◯	◯	◯
Lacticínios (p. ex., leite, queijo, iogurte, etc.)	◯	◯	◯	◯	◯	◯	◯
Ovos	◯	◯	◯	◯	◯	◯	◯
Carne vermelha (p. ex., carne de vaca, porco, borrego, vitela, etc.)	◯	◯	◯	◯	◯	◯	◯
Carne branca (p. ex., frango, peru, coelho, etc.)	◯	◯	◯	◯	◯	◯	◯
Carne processada (p. ex., salsichas, fiambre, chouriço, etc.)	◯	◯	◯	◯	◯	◯	◯
Pescado (p. ex., salmão, atum, lagosta, polvo, etc.)	◯	◯	◯	◯	◯	◯	◯
Refeições congeladas e pré-preparadas (p. ex., lasanha, sopas enlatadas, etc.)	◯	◯	◯	◯	◯	◯	◯
Alternativas à carne de origem vegetal (p. ex., hambúrgueres vegetarianos,	◯	◯	◯	◯	◯	◯	◯

	Nunca	Menos de uma vez por mês	1-3 vezes por mês	1-3 vezes por semana	4-6 vezes por semana	Uma vez por dia	2 ou mais vezes por dia
almôndegas vegetarianas, etc.)							
Bebidas vegetais (p. ex., bebida vegetal de soja/amêndoa/aveia e outros)	◯	◯	◯	◯	◯	◯	◯
Alternativas ao queijo e iogurtes de origem vegetal (p. ex., queijo creme à base de plantas, iogurte de soja, etc.)	◯	◯	◯	◯	◯	◯	◯
Tofu	◯	◯	◯	◯	◯	◯	◯

Em comparação com há um ano atrás, quanta carne (vaca, porco, frango, etc.) consome atualmente, no seu dia-a-dia? *

Escolha uma das seguintes respostas
Por favor, selecione **apenas uma** das seguintes opções:

◯ Muito menos
◯ Um pouco menos
◯ Sem alteração
◯ Um pouco mais
◯ Muito mais

Barreiras e atitudes face à importância da sustentabilidade social, ambiental e económica

Nas perguntas que se seguem, quando há referência a produtos de origem vegetal (*plant-based*) refere-se a produtos feitos à base de hortícolas, leguminosas (grão-de-bico, feijão, lentilhas, etc.), cereais (trigo, cevada, aveia, etc.), tanto na sua forma natural, como processada (bebida de soja, bebida de amêndoa, hambúrgueres de soja, almôndegas de soja, etc.).

Indique o seu grau de concordância ou discordância em relação a cada uma das seguintes afirmações, numa escala de "Discordo totalmente" a "Concordo totalmente":

*

Por favor, selecione a posição apropriada para cada elemento:

	Discordo totalmente	Discordo	Discordo ligeiramente	Não concordo nem discordo	Concordo ligeiramente	Concordo	Concordo totalmente
Os alimentos de origem vegetal são nutricionalmente suficientes (em proteínas, ferro, cálcio, vitamina B12, etc.) para uma dieta saudável e equilibrada.	○	○	○	○	○	○	○
Os alimentos de origem vegetal satisfazem e saciam as minhas necessidades energéticas.	○	○	○	○	○	○	○
Os alimentos de origem vegetal são	○	○	○	○	○	○	○

saborosos e agradáveis.							
Os alimentos de origem vegetal são convenientes.	◯	◯	◯	◯	◯	◯	◯
Os alimentos de origem vegetal são acessíveis e estão disponíveis em supermercados e serviços de restauração.	◯	◯	◯	◯	◯	◯	◯
Sei como e o que preparar numa refeição que inclua alimentos de origem vegetal.	◯	◯	◯	◯	◯	◯	◯
Seria fácil para mim incluir mais alimentos de origem vegetal na minha alimentação.	◯	◯	◯	◯	◯	◯	◯
Os alimentos de origem vegetal ajudam numa possível transição alimentar sustentável e saudável.	◯	◯	◯	◯	◯	◯	◯

Sustentabilidade

Tenciona aumentar ou reduzir o consumo das seguintes categorias de alimentos nos próximos 6 meses? *

Por favor, selecione a posição apropriada para cada elemento:

	Tenciono consumir menos	Tenciono consumir um pouco menos	Tenciono consumir o mesmo	Tenciono consumir um pouco mais	Tenciono consumir mais
Lacticínios (p.ex., leite, iogurte, queijo, etc.)	◯	◯	◯	◯	◯
Produtos cárneos (p.ex., vaca, porco, fiambre, frango, etc.)	◯	◯	◯	◯	◯

Para as seguintes afirmações sobre a sustentabilidade social, ambiental e económica, p.f., avalie o seu grau de concordância com as mesmas, utilizando uma escala desde "Discordo totalmente" a "Concordo totalmente": *

Por favor, selecione a posição apropriada para cada elemento:

	Discordo totalmente	Discordo	Discordo ligeiramente	Não concordo nem discordo	Concordo ligeiramente	Concordo	Concordo totalmente
Todos devem ter igual acesso à educação, aos cuidados de saúde e aos direitos humanos fundamentais.	◯	◯	◯	◯	◯	◯	◯
As comunidades devem ser inclusivas e diversificadas.	◯	◯	◯	◯	◯	◯	◯
As políticas devem promover a equidade social, como as ações afirmativas e a tributação progressiva.	◯	◯	◯	◯	◯	◯	◯
As empresas devem contribuir de forma positiva para a sociedade e apoiar as comunidades locais.	◯	◯	◯	◯	◯	◯	◯
O crescimento económico deve ser equilibrado com a protecção do ambiente e a equidade social.	◯	◯	◯	◯	◯	◯	◯

Devem ser promovidas práticas empresariais sustentáveis, como os modelos de economia circular e a gestão responsável da cadeia de abastecimento.	◯	◯	◯	◯	◯	◯	◯
As políticas económicas devem dar prioridade ao bem-estar das pessoas e do planeta em detrimento dos lucros das empresas.	◯	◯	◯	◯	◯	◯	◯
Devem ser promovidos sistemas económicos alternativos, como a economia colaborativa e as cooperativas.	◯	◯	◯	◯	◯	◯	◯
As alterações climáticas são uma questão premente que exigem uma ação imediata.	◯	◯	◯	◯	◯	◯	◯
As políticas devem promover a utilização de fontes de energia renováveis e reduzir as emissões de gases com efeito de estufa.	◯	◯	◯	◯	◯	◯	◯
As empresas devem reduzir o seu impacto	◯	◯	◯	◯	◯	◯	◯

ambiental e promover práticas sustentáveis.							
Deve ser dada prioridade aos esforços de conservação, como a proteção dos habitats naturais e a preservação da biodiversidade.	○	○	○	○	○	○	○

Convite a participar em 2ª ronda

Desde já agradecemos o seu envolvimento neste estudo e as respostas dadas ao questionário.

Para efeitos de validação do mesmo, vimos convidá-lo/a a participar numa segunda ronda.

De modo a garantir que mantemos a participação anónima e confidencial, pedimos que registe um código correspondente às iniciais do seu primeiro e último nome, seguidas do seu ano de nascimento (formato aaaa).

Ex.1: **M**aria Antónia **S**ilva, nascida a **1994**: MA1994

Ex.2: **J**oão Santos **O**liveira, nascido a **2001**: JO2001

Convite a participar em 2ª ronda

Desde já agradecemos o seu envolvimento neste estudo e as respostas dadas ao questionário.

Para efeitos de validação do estudo, vimos convidá-lo/a a participar numa segunda ronda.

De modo a garantir que mantemos a participação anónima e confidencial, pedimos que registe um código correspondente às iniciais do seu primeiro e último nome, seguidas do seu ano de nascimento (formato aaaa).

Ex.1: **M**aria Antónia **S**ilva, nascida a **1994**: MA1994

Ex.2: **J**oão Santos **O**liveira, nascido a **2001**: JO2001

Na página seguinte será apresentado um link, com um novo inquérito, onde apenas terá de fornecer o seu e-mail, para que num prazo de duas a três semanas lhe possamos enviar convite para participar na segunda fase deste estudo.

Desde já agradecemos a sua disponibilidade.

P.f., introduza a inicial do seu primeiro nome *

Por favor, escreva aqui a sua resposta:

P.f., introduza a inicial do seu último nome *

Por favor, escreva aqui a sua resposta:

P.f., introduza o seu ano de nascimento (formato aaaa)

Neste campo só é possível introduzir números.
A resposta deve estar entre 1910 e 2005
Por favor, escreva aqui a sua resposta:

Antes de finalizar este questionário, por favor, clique no seguinte **link**, para fornecimento de e-mail, onde receberá convite para a 2ª ronda deste estudo (**só assim é possível dar continuidade ao estudo**):

https://inqueritos.up.pt/6/index.php/747563?lang=pt

Poderá, em alternativa, utilizar o seguinte QR-code, no seu telemóvel:

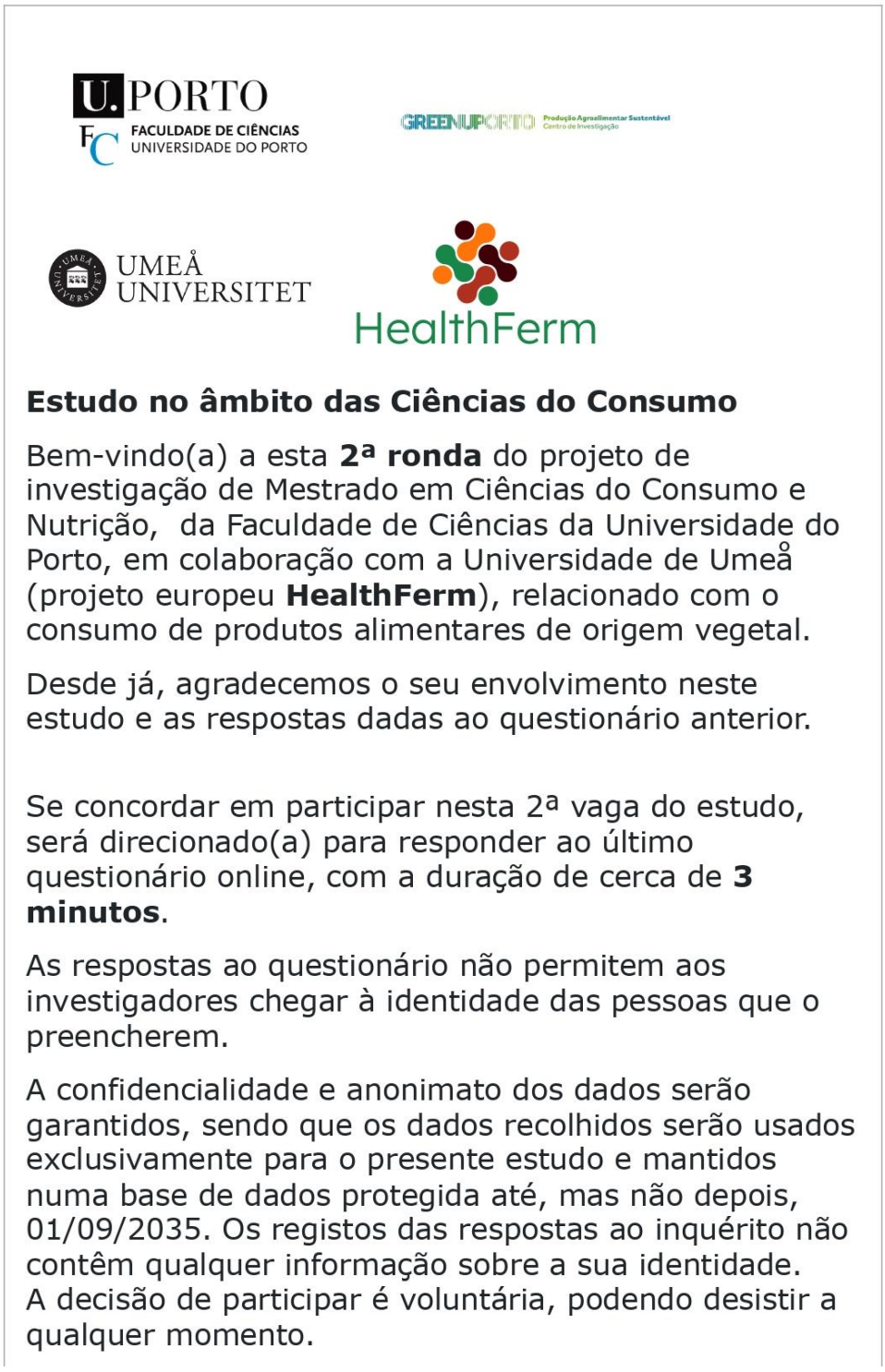
Para terminar a sua participação neste inquérito, p.f., clique no botão **Submeter**

Por favor, selecione **apenas uma** das seguintes opções:

◯ Obrigado pela sua participação!

Submeta o seu inquérito.
Obrigado por ter concluído este inquérito.

6.6. Annex 6: Q2' questionnaire



U.PORTO
FACULDADE DE CIÊNCIAS
UNIVERSIDADE DO PORTO

GREENUPORTO Produção Agroalimentar Sustentável Centro de Investigação

UMEÅ UNIVERSITET

HealthFerm

Estudo no âmbito das Ciências do Consumo

Bem-vindo(a) a esta **2ª ronda** do projeto de investigação de Mestrado em Ciências do Consumo e Nutrição, da Faculdade de Ciências da Universidade do Porto, em colaboração com a Universidade de Umeå (projeto europeu **HealthFerm**), relacionado com o consumo de produtos alimentares de origem vegetal.

Desde já, agradecemos o seu envolvimento neste estudo e as respostas dadas ao questionário anterior.

Se concordar em participar nesta 2ª vaga do estudo, será direcionado(a) para responder ao último questionário online, com a duração de cerca de **3 minutos**.

As respostas ao questionário não permitem aos investigadores chegar à identidade das pessoas que o preencherem.

A confidencialidade e anonimato dos dados serão garantidos, sendo que os dados recolhidos serão usados exclusivamente para o presente estudo e mantidos numa base de dados protegida até, mas não depois, 01/09/2035. Os registos das respostas ao inquérito não contêm qualquer informação sobre a sua identidade.
A decisão de participar é voluntária, podendo desistir a qualquer momento.

Caso pretenda alguma informação adicional sobre o presente questionário, por favor entre em contacto com a estudante Inês Magalhães (up201803425@up.pt) ou com o orientador do projeto, Prof. Doutor Luís Miguel Cunha (lmcunha.inqueritosUP@gmail.com).
Se concordar em participar, por favor assinale a alternativa abaixo.

*

Por favor, selecione **todas** as que se aplicam:

☐ Sim, confirmo que tenho 18 anos ou mais e que participo voluntariamente.
Compreendi os procedimentos descritos acima e concordo em participar neste estudo.
Dou permissão para que a informação recolhida seja publicada para fins científicos.

Interligação das 2 rondas

Convite a participar em 2ª ronda

Agradecemos, mais uma vez, o seu envolvimento neste estudo e as respostas dadas ao questionário anterior.

Como as respostas são anónimas, pedimos-lhe que introduza a seguinte informação, que nos permitirá cruzar as respostas a ambos os questionários.

De modo a garantir que mantemos a participação anónima e confidencial, pedimos que registe um código correspondente às iniciais do seu primeiro e último nome, seguidas do seu ano de nascimento (formato aaaa).

Ex.1: **M**aria Antónia **S**ilva, nascida a **1994**: MA1994

Ex.2: **J**oão Santos **O**liveira, nascido a **2001**: JO2001

P.f., introduza a inicial do seu primeiro nome *

Por favor, escreva aqui a sua resposta:

P.f., introduza a inicial do seu último nome *

Por favor, escreva aqui a sua resposta:

P.f., introduza o seu ano de nascimento (formato aaaa) *

Por favor, escreva aqui a sua resposta:

Dados demográficos

Por favor indique qual o seu sexo: *

Por favor, selecione **apenas uma** das seguintes opções:

- ◯ Feminino
- ◯ Masculino
- ◯ Outro
- ◯ Prefiro não dizer

Por favor indique qual a sua idade: *

Por favor, escreva aqui a sua resposta:

Por favor indique a cidade onde atualmente reside: *

Por favor, escreva aqui a sua resposta:

Barreiras e atitudes face à importância da sustentabilidade social, ambiental e económica

Nas perguntas que se seguem, quando há referência a produtos de origem vegetal (*plant-based*), refere-se a produtos que incluem hortícolas, leguminosas (grão-de-bico, lentilhas, feijão, etc.), cereais (trigo, cevada, aveia, quinoa, amaranto, etc.), tanto na sua forma natural, como processada (bebida de soja, bebida de amêndoa; hambúrgueres de soja, almôndegas de soja, etc.).

Indique o seu grau de concordância ou discordância em relação a cada uma das seguintes afirmações, numa escala de "Discordo totalmente" a "Concordo totalmente":

*

Por favor, selecione a posição apropriada para cada elemento:

	Discordo totalmente	Discordo	Discordo ligeiramente	Não concordo nem discordo	Concordo ligeiramente	Concordo	Concordo totalmente
Não há proteínas suficientes nos produtos alimentares de origem vegetal.	◯	◯	◯	◯	◯	◯	◯
Não existe ferro suficiente nos produtos alimentares de origem vegetal.	◯	◯	◯	◯	◯	◯	◯
Estaria preocupado com a minha saúde (p. ex., vit. B12, cálcio) se comesse apenas produtos alimentares de origem vegetal.	◯	◯	◯	◯	◯	◯	◯
Eu ficaria com indigestão, inchaço, gases ou flatulência	◯	◯	◯	◯	◯	◯	◯

com o consumo de produtos alimentares de origem vegetal.							
Não conseguiria obter energia ou força suficientes através de produtos alimentares de origem vegetal.	◯	◯	◯	◯	◯	◯	◯
Teria de comer uma grande quantidade de alimentos de origem vegetal para me sentir satisfeito.	◯	◯	◯	◯	◯	◯	◯
Os produtos alimentares de origem vegetal não seriam suficientemente saciantes.	◯	◯	◯	◯	◯	◯	◯
Eu acho que os seres humanos estão destinados a comer muita carne (produtos alimentares de origem animal).	◯	◯	◯	◯	◯	◯	◯
Os produtos alimentares de origem vegetal não são suficientemente saborosos.	◯	◯	◯	◯	◯	◯	◯
Os produtos alimentares de origem vegetal parecem demasiado invulgares.	◯	◯	◯	◯	◯	◯	◯

Os produtos alimentares de origem vegetal são inconvenientes.	◯	◯	◯	◯	◯	◯	◯
Não gosto de comer produtos alimentares de origem vegetal.	◯	◯	◯	◯	◯	◯	◯
Os produtos alimentares de origem vegetal não parecem apetitosos ou apelativos.	◯	◯	◯	◯	◯	◯	◯
Não quero mudar os meus hábitos alimentares nem a minha rotina.	◯	◯	◯	◯	◯	◯	◯
A minha família/parceiro(a) não quer comer produtos alimentares de origem vegetal.	◯	◯	◯	◯	◯	◯	◯
Os alimentos de origem vegetal não são seguros.	◯	◯	◯	◯	◯	◯	◯
Quando como fora de casa, não há muitas opções de alimentos de origem vegetal.	◯	◯	◯	◯	◯	◯	◯
Não encontro refeições ou snacks de origem vegetal quando como fora de casa.	◯	◯	◯	◯	◯	◯	◯

Preciso de mais informações sobre produtos alimentares de origem vegetal.	○	○	○	○	○	○	○
Os alimentos de origem vegetal que necessito não estão disponíveis nos locais onde faço compras ou quando como fora.	○	○	○	○	○	○	○
Os alimentos de origem vegetal não são acessíveis.	○	○	○	○	○	○	○
Não sei como preparar refeições de origem vegetal.	○	○	○	○	○	○	○
Não sei o que comer em vez de muita carne (produtos alimentares de origem animal).	○	○	○	○	○	○	○

Sustentabilidade

Para as seguintes afirmações sobre sustentabilidade social, ambiental e económica, p.f., avalie o seu grau de concordância com as mesmas, utilizando uma escala desde "Discordo totalmente" a "Concordo totalmente": *

Por favor, selecione a posição apropriada para cada elemento:

	Discordo totalmente	Discordo	Discordo ligeiramente	Não concordo nem discordo	Concordo ligeiramente	Concordo	Concordo totalmente
Todos devem ter igual acesso à educação, aos cuidados de saúde e aos direitos humanos fundamentais.	◯	◯	◯	◯	◯	◯	◯
As comunidades devem ser inclusivas e diversificadas.	◯	◯	◯	◯	◯	◯	◯
As políticas devem promover a equidade social, como as ações afirmativas e a tributação progressiva.	◯	◯	◯	◯	◯	◯	◯
As empresas devem contribuir de forma positiva para a sociedade e apoiar as comunidades locais.	◯	◯	◯	◯	◯	◯	◯
O crescimento económico deve ser equilibrado com a protecção do ambiente e a equidade social.	◯	◯	◯	◯	◯	◯	◯

Devem ser promovidas práticas empresariais sustentáveis, como os modelos de economia circular e a gestão responsável da cadeia de abastecimento.	◯	◯	◯	◯	◯	◯	◯
As políticas económicas devem dar prioridade ao bem-estar das pessoas e do planeta em detrimento dos lucros das empresas.	◯	◯	◯	◯	◯	◯	◯
Devem ser promovidos sistemas económicos alternativos, como a economia colaborativa e as cooperativas.	◯	◯	◯	◯	◯	◯	◯
As alterações climáticas são uma questão premente que exigem uma acção imediata.	◯	◯	◯	◯	◯	◯	◯
As políticas devem promover a utilização de fontes de energia renováveis e reduzir as emissões de gases com efeito de estufa.	◯	◯	◯	◯	◯	◯	◯
As empresas devem reduzir o seu impacto	◯	◯	◯	◯	◯	◯	◯

ambiental e promover práticas sustentáveis.							
Deve ser dada prioridade aos esforços de conservação, como a protecção dos habitats naturais e a preservação da biodiversidade.	○	○	○	○	○	○	○

Obrigado pela sua disponibilidade para participar neste estudo.

Submeta o seu inquérito.
Obrigado por ter concluído este inquérito.