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FEP FACULDADE DE ECONOMIA
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Meat the Future - Lab-grown Meat and Its Social Acceptance

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Dissertation
Master in Services Management

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2025

Acknowledgements

I would like to express my gratitude to my supervisor, Professor Raquel Moutinho, for her support, guidance and patience throughout the development of this study.

I would also like to thank my family, namely my parents, grandparents and siblings, for their unwavering support and encouragement throughout my academic career.

Lastly, but most importantly, I would like to thank God. Through Christ all things are possible, and all my achievements belong to Him.

Abstract

The continuous growth of the global food market faced in the last few years raises concerns on several fronts. With this growth, businesses in the food industry face increasing competition and society faces environmental, ethical and health concerns. In the restaurant business, increased competition leads to a need for unique innovation in order to stand out. For customers, a restaurant needs to offer not just a product that satisfies their cravings, but also an experience they value as unique but does not go against their values. One possible solution for most of the previously mentioned concerns is in-vitro meat. A novel ingredient that has not yet been introduced to the general public in most of the world. This study investigates whether the Portuguese people are welcoming of in-vitro meat as a new ingredient in their diets, looking at this product from the perspective of a new technological product using a newly developed approach combining the Technology Acceptance Model (TAM) with the Unified theory of acceptance and use of technology (UTAUT2) model. Furthermore, it is the first study on social acceptance of in-vitro meat using this lens studying lab meat as an alternative to traditional meat. This study found that the Portuguese were welcoming of this new alternative, despite having some reservation, mostly regarding the regular consumption of it.

Resumo

O crescimento contínuo do mercado alimentar global enfrentado nos últimos anos levanta preocupações em várias frentes. Com este crescimento, as empresas do setor alimentar enfrentam uma concorrência cada vez maior e a sociedade enfrenta preocupações ambientais, éticas e de saúde. No setor da restauração, o aumento da concorrência leva à necessidade de inovação única para se destacar. Aos clientes, um restaurante precisa de oferecer não só um produto que satisfaça os seus desejos, mas também uma experiência que possa ser valorizada como única e que não vá contra os seus valores. Uma possível solução para a maioria das preocupações referidas anteriormente é a carne in-vitro. Um novo ingrediente que ainda não foi introduzido ao público em geral na maior parte do mundo. Este estudo irá investigar se os portugueses estão dispostos a acolher a carne in-vitro como um novo ingrediente nas suas dietas, ao analisar este produto sob a perspectiva de um novo produto tecnológico, utilizando uma abordagem recentemente desenvolvida

que combina o Modelo de Aceitação de Tecnologia (MAT) com o modelo da Teoria Unificada de Aceitação e Uso da Tecnologia (UTAUT2). É o primeiro estudo sobre a aceitação social da carne in vitro utilizando esta perspectiva, estudando a carne de laboratório como alternativa à carne tradicional. Este estudo constatou que os portugueses aceitam esta nova alternativa, apesar de terem algumas reservas, principalmente quanto ao seu consumo regular.

Keywords

Technology Acceptance Model (TAM); Unified theory of acceptance and use of technology (UTAUT2); In-vitro meat; Portuguese consumers; Social acceptance; Meat; Protein

Palavras-chave

Modelo de Aceitação de Tecnologia (TAM); Teoria unificada da aceitação e utilização da tecnologia (UTAUT2); Carne in vitro; Consumidores portugueses; Aceitação social; Carne; Proteína

Contents

Tables Index

Figures Index

Introduction

The global food market has been growing over the last few years and is expected to continue to grow through the foreseeable future (Gorade, 2025; Statista, 2025). With the growth of the market comes increasing competition. Namely, in the restaurant business, a sector highly impacted by the hedonic motivations of consumers, it is necessary to supply new demands and cravings to stay ahead of the competition. However, consumers are no longer looking for just something that satiates their cravings but also supports their environmental, ethical and health concerns (Ghvanidze et al., 2016). One popular ingredient in menus that has been subjected to multiple concerns regarding its impact on these three fronts is meat.

Sustainability and environmental concerns related to the meat industry have already led to scrutiny of its environmental impacts, such as deforestation, greenhouse gas emissions, and water usage. Animal meat production is also linked to a range of environmental issues, including habitat destruction and resource depletion (Hanna L. Tuomisto, 2011). Treating animals in industrial farming has also raised ethical concerns, which have already led to a higher demand for more humane and sustainable meat production methods (Animals). Lastly, the increasing awareness of the potential health risks associated with consuming red and processed meats has fueled interest in plant-based diets. Furthermore, evidence suggests that a diet rich in red and processed meats may be linked to an increased risk of health issues such as heart disease, strokes, and type 2 diabetes (Clark et al., 2019; Wein, 2012).

To address these environmental and ethical concerns, there is a growing trend towards alternative proteins, such as insect-based protein, plant-based meat substitutes and cultured or lab-grown meat (Talwar et al., 2024).

Insect-based protein sources, such as crickets and mealworms, offer a sustainable and protein-rich alternative to traditional meat. They require fewer resources for production, thus having a lower environmental impact (Rumpold & Schlüter, 2013). However, this alternative may face resistance in many Western societies, where insect consumption is hindered by cultural norms that associate insects with uncleanliness (Tan et al., 2015).

Plant-based meat substitutes are currently a well-known alternative to meat. However, they still remain unpopular among consumers who pursue meat-based meals for their sensory appeal (Fiorentini et al., 2020). Furthermore, plant production has also been subjected to

environmental criticism for the issues that arise with developing industrialized farming systems (Henchion et al., 2017).

The remaining alternative will be lab-grown or cultured meat, produced by cultivating animal cells in a lab, eliminating the need to raise and slaughter animals. It can potentially reduce the environmental and ethical concerns associated with traditional meat production (Bhat et al., 2017). Cultured meat is real animal meat produced by culturing animal cells in vitro, where they are fed a mixture of nutrients and growth factors to proliferate and differentiate into the end product (Choudhury et al., 2020). However, this option is not without its issues. Cultural and psychological factors can lead to resistance against lab-grown meat, as it challenges traditional perceptions of meat and its source, and some individuals may oppose the idea of cultured meat for cultural or religious reasons (C. Bryant et al., 2019). There are still health-related concerns about consuming meat. However, according to a review of lab-grown meat (Roy et al., 2021), the nutrient quality of in-vitro meat can be modified by changing the culture's ingredients, which could result in a healthier meat product.

While lab-grown meat could be considered a product to be sold for direct consumption, its existence would not be possible without highly specialized processes to develop it from the original cultures. From a more business-oriented perspective, while this study focuses on the user adoption of this product, it does so considering that adopting a novel food product based on technological development will greatly impact service-based businesses related to the food industry. The acceptance or rejection of this product could impact businesses such as restaurants, which are part of the tourism industry, food delivery services and supply chains related to the food industry.

This dissertation investigates "lab-grown" meat and its social acceptance. The proposed research question is "Are Portuguese people welcoming of a lab-grown alternative to meat?". The study aims to understand if lab-grown meat will become a new trend to which restaurants and other food industry-related businesses must be attentive.

The chosen methodology for this research is quantitative with a UTAUT2 basis, as this study wants to evaluate the potential adoption of a new technology in the consumer market. This study focuses on the Portuguese population and how they feel as food consumers daily. The structure of this dissertation can be summarized by a literature review section, where the

main concepts relating to this research's theme and framework are described and discussed, and the research hypotheses will be established. Following this section is Methodology, going further in detail on the data collection and analysis process discussion. Next, the Results section contains the data collected throughout the study, an analysis of it, and the structural model used, which hypotheses the obtained results allow to be confirmed or denied, what was not possible to confirm or deny and possible future research that could be done to deepen the level of knowledge on the approached subject in this research. The last section is Conclusion, in which the answer to the research question is presented, followed by the theoretical and practical implications of this research, its limitations and potential further studies.

2 Literature Review

As this research intends to answer the question, "Are Portuguese people welcoming of a lab-grown alternative to meat?" it is necessary first to understand what lab-grown meat is, why people might not be welcoming to it as an alternative and how this research will attempt to answer the question.

2.1 Lab-grown Meat

In 2011, livestock raised for meat consumption accounted for 18% of global greenhouse gas emissions while also being one of the main drivers behind deforestation and degradation of wildlife habitats. Furthermore, the levels of meat consumption not only exceed dietary protein requirements in many countries but are also unsustainable (Sievert et al., 2022; van der Weele et al., 2019). Modern animal agriculture is also known for contributing towards other issues, such as antibiotic resistance and animal suffering (C. J. Bryant et al., 2019). Furthermore, there is a consensus that reducing meat consumption will be essential for transitioning towards more sustainable food consumption (Hartmann & Siegrist, 2017).

As the world population continues to rise, so will the demand for food, namely, animal-based protein. This will likely lead to an increase in livestock meat production, which is expected to intensify pressure on land due to the need to produce more animal feed. This, in turn, will increase the conversion of forests, wetlands and natural grasslands into agricultural lands, thus leading to worsening consequences for GHG emissions, biodiversity and other important ecosystem services (McMichael et al., 2007). To further demonstrate this point, raising ruminant meats, such as beef and lamb, has been shown to produce emissions per gram of protein around 250 times higher than those of legumes (Tilman & Clark, 2014). A study performed in the United Kingdom suggests that greenhouse gas emissions associated with meat-eaters are roughly twice as high as those associated with vegans (Scarborough et al., 2014). However, most consumers are unaware of the huge impact the production and consumption of meat has on the environment (Hartmann & Siegrist, 2017). A statement that holds true for consumers in several Western countries, such as the USA, Germany, Netherlands, Portugal and Australia (author, year). Furthermore, the results of Hartmann and Siegrist (2017) indicate that only a minority of participants in the different studies are ready to reduce their meat consumption behavior for ecological reasons.

While meat consumption has been recognized as providing health benefits, over-consumption can negatively impact health. Furthermore, the International Agency for

Research on Cancer (IARC) has previously put out a report suggesting processed meat should be classified as "carcinogenic to humans". Additionally, red meat was classified as "probably carcinogenic to humans" (Henchion et al., 2017).

The evidence demonstrates that the over-consumption of meat contributes substantially to consumers' adverse environmental impacts and lifestyle diseases. To address these health and environmental challenges, a transition towards lower consumption of traditionally grown meat and an increased consumption of plant-based alternatives or others is key. Consumers can adopt more sustainable diets: becoming a vegan or a vegetarian, eating smaller amounts of meat, or eating meat less frequently.

As consuming meat raises several concerns, one of the options for a more sustainable diet is to substitute meat with alternative proteins, such as using a meat substitute, or alternative proteins like seaweed or beans (Onwezen et al., 2021).

Another possible solution to tackle the environmental impacts of livestock produced for human consumption is only growing the animal's muscle tissue in vitro (also known as "in-vitro meat", "lab-grown meat", or "cultured meat") (Hanna L. Tuomisto, 2011). The first cultured meat (beef) patty was created in 2013, which triggered great interest from the media and investors and led to a rise in the number of companies focusing on lab-grown meat. These companies aspired to provide the same meat options as their conventional counterparts (Choudhury et al., 2020). Livestock meat is a combination of muscle, fat and connective tissue, while, currently, most cultured meat tissues consist solely of muscle tissue. To reach the entire scope of livestock meat production, a more advanced tissue-engineering approach is needed to produce whole-thickness tissues (Post et al., 2020). Furthermore, for a meat substitute to be embraced by consumers, it needs to replicate or surpass conventional meat in terms of visual appearance, smell, texture, and taste (Post, 2012).

Humans, by nature, tend to be conservative when it comes to novel foods and, consequently, food technologies. Even if non-traditional foods become accepted, this does not mean people will change their established diets and might only increase the available food variety, depending on how conservative society is regarding their culturally defined dietary behavior (Siegrist & Hartmann, 2020). Variance in the past consumption of alternative proteins resulted in different levels of familiarity, attitudes, food neophobia, and social norms on acceptance (Onwezen et al., 2021).

When questioned on the subject, some consumers are not convinced that lab-grown meat should be seen as a viable alternative to conventional meat, even looking at it disgustingly (Wim Verbeke et al., 2015). However, studies show lab-grown meat could have potential as a viable alternative if consumers can transcend their disgust, see ethical advantages and find a sense of optimism on a global scale (Weinrich et al., 2020). There are still other factors recognized as interconnected determinants of consumer acceptance of lab-grown meat, such as awareness, risk-benefit perception, ethical and environmental concerns, emotions, personal factors, product properties, and availability of substitutes. However, knowledge, perceptions and personal traits seem stronger than environmental and ethical concerns alone (Pakseresht et al., 2022).

Several studies have shown that younger and more educated consumers are more inclined towards purchasing simulated meat (plant-based imitation of meat). Not considering demographics, two of the strongest predictors of willingness towards cultured meat consumption were the consumers' importance placed on the environment and their beliefs regarding the environmental impact of livestock production (Slade, 2018).

A previous study listed criteria for shaping consumer acceptance of cultured meat in the future, such as perceived risks and benefits related to the technology and the product, over trust in science, society and regulation, public involvement in the product development and media coverage about the issue (W. Verbeke et al., 2015). Interestingly, consumers' associations and attitudes towards cultured meat vary depending on the associations elicited by using different product names (Bryant & Barnett, 2019).

2.2 Theoretical Models and Studied Hypothesis

In this section, a detailed overview of the characteristics and development of the Theoretical Model used is given, as well as the established hypotheses this study aims to test.

2.2.1 TAM

The Technology Acceptance Model (TAM) was created to explain and predict an individual's acceptance of Information Technology (IT). It is based on the Fishbein and Ajzen (1975) Theory of Reasoned Action (TRA), that suggests social behavior is motivated by an individual's attitude towards carrying out that behavior. According to this theory,

behavior is determined directly by the intention to act, as humans, in general, behave as they intend to, within the context and time available to them (Moon & Kim, 2001).

One of the main purposes of TAM is to provide a base for following the impact of external variables on internal beliefs, attitudes, and intentions. It suggests that Perceived Ease of Use (PEoU), and Perceived Usefulness (PU) are the two most important factors when explaining system use (Legris et al., 2003). As stated by Moon and Kim (2001), Davis (1993) defined PU as "the degree of which a person believes that using a particular system would enhance his or her job performance" (p.320) and PEoU as "the degree of which a person believes that using a particular system would be free of effort" (p.320). Also according to Moon and Kim (2001) the users' beliefs determine the Attitudes toward using a system, while Behavioral Intentions to Use, in turn, are determined by these attitudes toward using the system, with Behavioral Intentions to Use leading to actual system use.

PeoU and PU and the relation between Attitude and Behavioral Intention is the fundamental point of this approach and considered of essence for this study, as, currently, there is no public commercialization of in-vitro meat in Portugal, it is only possible to study the Attitude and Behavioral Intention towards this innovation.

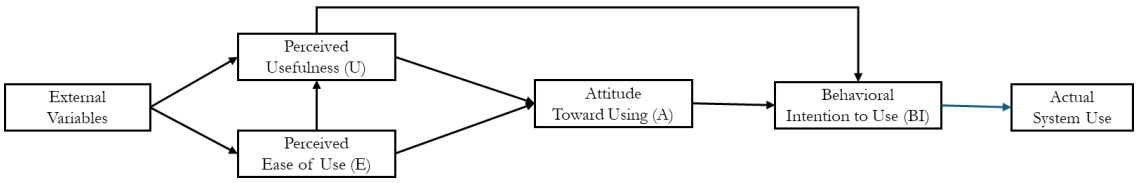

Figure 1: Technology Acceptance Model

Attitude and Behavioral Intention

A new "Attitude" section, based on the Technology Acceptance Model (TAM) was added to the UTAUT2 model to gauge the participants' attitude towards consuming in-vitro meat regularly once it becomes available, taking the place of Behavioral Intention in the original UTAUT2 model. The Behavioral Intention section will then replace UTAUT2's Use Behavior section, as it is not possible to gauge it at the time of this study due to in-vitro meat not being a product that is commercially available to the Portuguese public. This model was chosen to combine with the UTAUT2 model due to TAM having accumulated theoretical

and empirical support when it comes to explaining and predicting user acceptance of new technologies (Venkatesh & Davis, 2000). Thus, the following hypothesis is raised:

H1: Attitude has a positive impact on Behavioral Intention

2.2.2 UTAUT2

In past efforts to understand individual technology acceptance and use, researchers have applied and extended UTAUT2 through a variety of settings, which could be grouped into six categories: different types of users, different types of organizations, different types of technology, different task types, different times and different locations (Tamilmani et al., 2021). The third group, which focused on different types of technology, has previously examined the use of diverse types of technologies such as mobile internet and social networking sites (SNS), mobile payments, music as a service, and wearable healthcare technology, cloud-based e-learning and pervasive information systems (Google Glass) (Tamilmani et al., 2021). Following a review of the usage of UTAUT2, there has been a marked increase in UTAUT2 utilization, which can be attributed to Information Technologies (IT) permeating every aspect of society across the globe. Consequently, this leads to a rise of various individuals using IT in different contexts, while UTAUT2 is focused on the consumer context (Tamilmani et al., 2017). UTAUT2 as a research model (Figure 2) includes constructs such as Performance Expectancy, Facilitating Conditions, Effort Expectancy, Social Influence, Facilitating Conditions, Hedonic Motivation, Price Value and Habit, as well as moderators such as Age, Gender and Experience (Venkatesh et al., 2012). As lab-grown meat is a product resulting from a new technology developed in the food industry, UTAUT2 presents itself as an adequate model for understanding the factors that influence its acceptance by consumers.

In the context of this study, behavioral intention concerns the intentions of the consumer regarding their personal consumption of lab-grown meat.

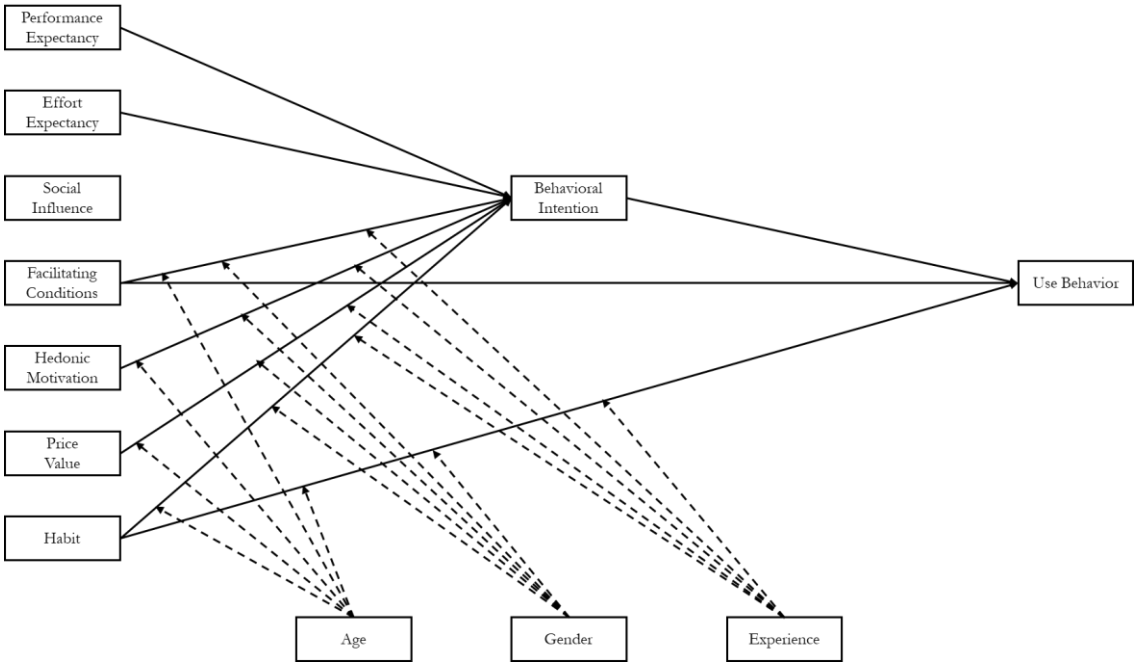

Figure 2: UTAUT2 Model

Note: (Venkatesh et al., 2012) (p.160)

Performance Expectancy

Performance Expectancy, under the context of UTAUT2 can be defined as the degree to which an individual believes that adopting a technology will benefit them (Venkatesh et al., 2003). One of the reasons alternative proteins are being sought after is the rising concern with global warming and greenhouse gas emissions tied to traditional livestock production. It is not yet known whether cultured meat will present itself as a more climatically sustainable alternative, as its environmental impacts depend on the decarbonized energy used in its production (Lynch & Pierrehumbert, 2019). A study has also shown that cultured meat production emits substantially less greenhouse gas emissions and requires only a fraction of land and water compared to conventionally produced meat in Europe while having lower energy requirements than beef, sheep, and pork meat (Hanna L. Tuomisto, 2011). Another previous study found that, while most of the enquired consumers hesitate when asked if they would be willing to try cultured meat in the future, only a small minority rejected the idea. The same consumers perceived benefits in terms of sustainability of cultured meat relative to traditional meat, and that providing information that stresses those benefits increased consumers' claimed willingness to try, purchase, and, to a lesser degree, pay for cultured meat

in the future (W. Verbeke et al., 2015). One of the expected benefits of cultured meat consumption is a reduced environmental footprint, so consumers will be motivated to pursue the product. As such, the following hypothesis are raised:

H2: Performance Expectancy has a positive impact on Attitude

Effort Expectancy

UTAUT2 considers Effort Expectancy as the level of ease associated with the use of a new technology (Venkatesh et al., 2003).

This section related to the consumer's perceptions of the simplicity and ease of use of the researched technology (Venkatesh et al., 2012). The expected effort will depend on factors such as price, availability and the differences in the preparation methods for consumption between cultured meat and conventional meat. Previous experiments have shown that fears of novel food technologies are a critical psychological barrier to clean meat acceptance, just as it was shown to be a significant predictor of negative attitudes towards foods produced using other formerly novel technologies, such as genetic modification, pasteurization, and nanotechnology (Krings et al., 2022). Since consuming cultured meat will raise the need to adapt to a new product, this may substantially impact how it is cooked and how and where it is eaten compared to traditional meat. The increase in expected effort (level of ease associated with the use) by consumers should positively impact their intentions to consume in-vitro meat since a higher perceived ease of use or consumption of an item is expected to cause a better attitude towards that item.

H3: Effort Expectancy has a positive impact on Attitude

Social Influence

Social Influence in the context of UTAUT2, is the degree to which an individual perceives that people seen as important to the individual believe should use the new technology (Venkatesh et al., 2003).

A study (C. J. Bryant et al., 2019) on the perceptions of naturalness of cultured meat found that of three tested messages, only the one describing "conventional meat is unnatural" was

accepted by their readers. While the other two messages, describing naturalness as unimportant and clean meat being natural, failed to convince the participants (C. J. Bryant et al., 2019). As society's perceived social acceptance of a product increases, more consumers who are generally indecisive will be inclined towards having a better attitude on consuming such a product due to influence from their peers.

H4: Social Influence has a positive impact on Attitude

Facilitating Conditions

According to Venkatesh et al. (2012), facilitating conditions refer to the consumers' perceptions of available resources and support for performing a behavior. The more consumers perceive that a product or service is supported by its provider, the more they will be inclined to trust and consume it. This should extend not only towards a consumers' attitude towards trying in-vitro meat but also to an intention of consuming it repeatedly, in the same manner, a consumer orders the same dish at a restaurant or chooses the same delivery service on order, based on previous experiences.

These result in two hypotheses:

H5: Facilitating Conditions have a positive impact on Attitude

H6: Facilitating Conditions have a positive impact on Behavioral Intention

Hedonic Motivation

Under UTAUT2, Hedonic Motivation is defined as the fun or pleasure an individual obtains from adopting a new technology (Venkatesh et al., 2012).

Consumers may be detracted from consuming cultured meat by its lack of taste and/or texture (Choudhury et al., 2020). In past studies, participants displayed mostly emotional first reactions of disgust and fear at the thought of eating cultured meat, going so far as to label it as "scary", "frightening", and "weird" (Wim Verbeke et al., 2015). Even when accepting cultured meat as a concept, consumers will not be willing to accept compromises regarding food safety, taste or other attributes (Chriki & Hocquette, 2020). The feedback from these consumers aligns with the conclusions from a UTAUT2-focused review where the usage of hedonic motivation as a construct for research focused on hedonic outcomes when the

consumer performs a task for the novelty and pleasure derived from it was deemed "appropriate" (Tamilmani et al., 2019). The consumption of not only meat products but also food products and related services, in general, by a large part of consumers is deeply impacted by personal tastes and desires. As such, it is fair to assume hedonic motivations will impact the behavioral intentions of these same consumers towards consuming in-vitro meat. Thus, the following hypothesis is considered:

H7: Hedonic Motivations have a positive impact on Attitude

Price Value

Like all new technologies, cultured meat still presents a high price. However, its production costs will probably decrease in the future (Chriki & Hocquette, 2020). As with most products, the more value a consumer perceives in an item, the more positive their attitude towards it will be and the more they will be willing to pay for it. This means that consumers' perceived value of in-vitro meat should positively influence their attitude towards the product and their intentions towards consuming it.

H8: Price Value has a positive impact on Attitude

H9: Price Value has a positive impact on Behavioral Intention

Habit

As "habit" can be defined as the extent to which people will gravitate to develop specific behaviors based on previous learning (Venkatesh et al., 2012), the level of similarity in the preparation and consumption of in-vitro meat compared to traditional meat affects consumers' habits in the sense that consumers will have to change some of their routine habits to execute these processes. Since habit is a result of internalized repeated behaviors, they are directly related to the behavioral intention of an individual and their attitude towards it, as such, it is expected that those who are not used to consuming meat regularly will not miss it and look for such a product. Those who are used to regularly consuming meat will likely be interested in consuming in-vitro meat. Furthermore, when questioned on their willingness to consume alternative proteins, consumers with high meat consumption habits appear to be more receptive to cultured meat and products that are similar to meat than to plant-based proteins (Onwezen et al., 2021). Thus, resulting in the following hypothesis:

H10: Habit has a positive impact on Attitude

Moderating Factors: Age, Gender, Experience and Voluntariness

As "lab-grown" meat is developed using new technologies, it is possible to explore all the points this model provides. There is both political and economic motivation for it to perform to a certain level. Studies have found that the acceptance of cultured meat is impacted by moderating factors such as gender, age and experience: it seems to be higher amongst men compared to women, among younger people compared to older people, and among omnivores compared to vegetarians, with the latter point being influenced by a general aversion to meat being developed by vegetarians, as cultured meat circumvents the primary ethical and environmental motivations of this group (Post et al., 2020). In a different study, two-thirds of the participants demonstrated a willingness to try cultured meat if it was available on the market (W. Verbeke et al., 2015). People who are more knowledgeable about cultured meat might also have fewer concerns about possible adverse health effects or its nutritional quality (Krings et al., 2022). Thus, these moderating factors should impact some of the points that will be analyzed.

M1: How Attitude affects BI is moderated by Age

M2: How EE affects Attitude is moderated by Age

M3: How FC affects Attitude is moderated by Age

M4: How Habit affects Attitude is moderated by Age

M5: How HM affects Attitude is moderated by Age

M6: How PE affects Attitude is moderated by Age

M7: How PV affects Attitude is moderated by Age

M8: How SI affects Attitude is moderated by Age

M9: How PV affects Attitude is moderated by Financial Independence

M10: How Attitude affects BI is moderated by Experience

M11: How EE affects Attitude is moderated by Experience

M12: How HM affects Attitude is moderated by Experience

M13: How PE affects Attitude is moderated by Experience

M14: How PV affects Attitude is moderated by Experience

M15: How SI affects Attitude is moderated by Experience

M16: How Attitude affects BI is moderated by Gender

M17: How EE affects Attitude is moderated by Gender

M18: How Habit affects Attitude is moderated by Gender

M19: How PE affects Attitude is moderated by Gender

M20: How PV affects Attitude is moderated by Gender

M21: How SI affects Attitude is moderated by Gender

2.3 UTAUT - Unified Theory of Acceptance and Use of Technology

The updated model featured in figure 3 represents the combination of TAM with UTAUT2 used in this study with Attitude and Behavioral Intention replacing, respectively, Behavioral Intention and Use Behavior from the original UTAUT2 model. Furthermore, the model also represents the proposed hypotheses and moderating factors of this study, with the solid lines representing the connections established by the proposed hypotheses and the dotted lines representing the connections established by the proposed moderating factors.

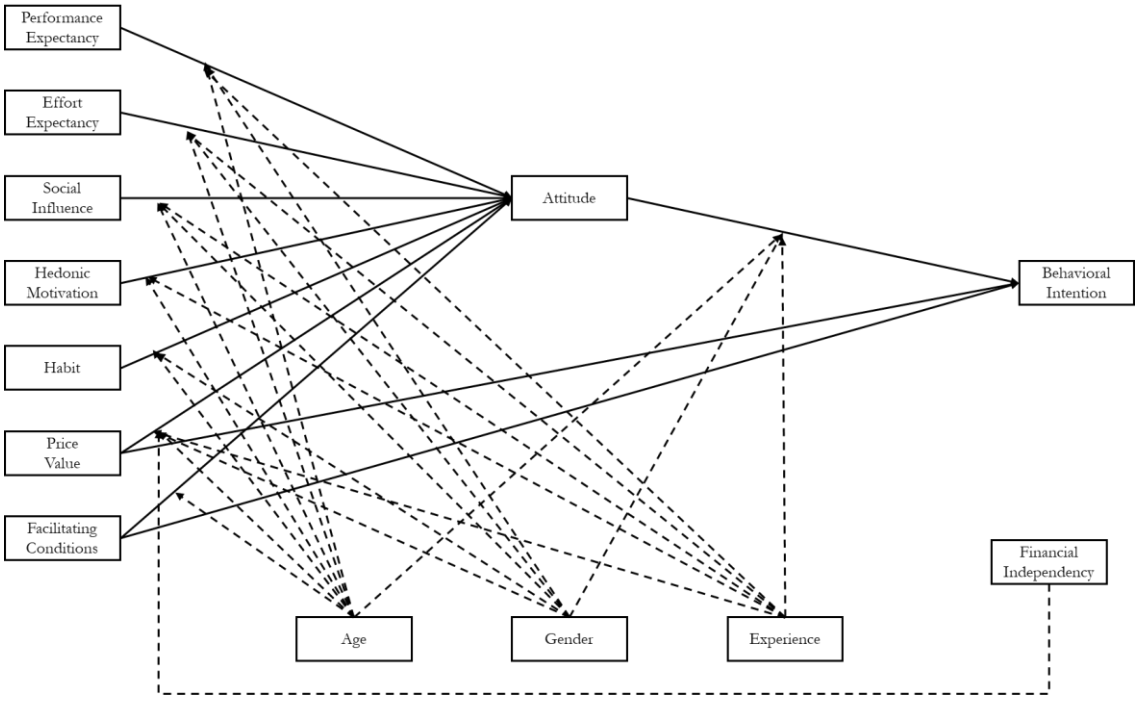

Figure 3: Adjusted UTAUT2 Model

3. Methodology

This research adopted a quantitative methodology to measure and analyze statistical data variables. This data was then validated through Partial Least Squares Structural Equation Modeling (PLS-SEM). The PLS-SEM method is widely recognized by many researchers as a model that allows for estimations of complex models with many constructs, indicator variables and structural paths without imposing distributional assumptions on the data. It is also a causal-predictive approach to SEM focusing on prediction in estimating statistical models, whose structures are designed to provide causal explanations (Hair et al., 2019). 3.1 Data Collection

To gather the data, a questionnaire was hosted on the Microsoft Forms platform and distributed via link sharing. For the Portuguese version, the link was shared across multiple social media and digital communication platforms. The data collection process took place between the 15th of April and the 27th of May 2024.

Questionnaire

The questionnaire begins with a request made to the participant to choose one of two options at random before proceeding. Depending on the choice, the participant will either be shown an AI-generated image of what appears to be a raw steak on a petri dish or no image at all will be shown (Figure 4). This variable was added to verify if the presence of the image would change how the participants would respond as images could affect responses to survey questions in many ways, such as changing the range of objects implied by a question, affection the mood or emotion of the participant, making certain vague ideas more concrete and even clarify or obfuscate the meaning of a question or designation (Couper, 2008). In this research, this image aims to make certain vague ideas more concrete, which supposedly impacts respondents' reactions. So, before the study of the proposed model, we tested two hypotheses:

H11: Seeing the image has a positive effect on Attitude

H12: Seeing the image has a positive effect on Behavioral Intention

Figure 4: AI generated image of in-vitro meat

The first section of the questionnaire contains questions regarding the sociodemographic characteristics of the participants (age, gender, country and level of education). A 5-point Likert scale was also used to measure the level of self-measured knowledge on the topic of in-vitro meat, in order to account for Experience in the final model, as the product is still not available for commercial use to the Portuguese public. Then followed the Financial Independency section, which was gauged through the scale used by (Mittal & Griskevicius, 2016). To determine the prevalence of conventional meat in the participants' dietary habits and their personal perception of knowledge they had on in-vitro meat, some open questions were asked. Lastly, UTAUT2 section of the questionnaire was gauged through

the scale used by several researchers (Alalwan et al., 2017; Bryant & Barnett, 2019; Rosenfeld & Burrow, 2018; Tamilmani et al., 2019; Venkatesh et al., 2012) and measured with a 5-point Likert scale. The questionnaire is presented in Table 1.

Table 1: English questionnaire

Scale	Items
Financial Sufficiency (FS)	I have enough money to buy the things I want. **(FS1)**
	I don't need to worry too much about paying my bills. **(FS2)**
	I feel relatively wealthy these days. **(FS3)**
Meat Consumption Habits	Do you eat meat?
	Why not? (skip if previous answer was "yes")
	Do you plan to reduce your meat consumption in the future? (skip if previous question was answered)
	Why? (skip if previous question was not answered)
UTAUT2 Section	
Performance Expectancy (PE)	Eating in-vitro meat would contribute towards reducing my environmental footprint. **(PE1)**
	Eating in-vitro meat would be healthier than eating traditional meat. **(PE2)**
	I would eat in-vitro meat as a way of making the world a better place for others. **(PE3)**
	I feel motivated to eat in-vitro meat because I am concerned about the effects of my food choices on other beings. **(PE4)**
	Adding in-vitro meat to my dietary pattern would improve my life. **(PE5)**
	People who would eat in-vitro meat will tend to be good people. **(PE6)****
Effort Expectancy (EE)	Cooking in vitro meat will be just as easy as cooking traditional meat. **(EE1)****
	I will need to learn how to cook with in-vitro meat. **(EE2)****
	Consuming in-vitro meat will require the same efforts as consuming traditional meat. **(EE3)****
	In-vitro meat's cooking requirements will be more consistent than traditional meat. **(EE4)****
	I will acquire in-vitro meat in the same places where traditional meat is acquired **(EE5)**
	In-vitro meat will be available in most of the same restaurants where traditional meat is now served **(EE6)**
Social Influence (SI)	I will consume in-vitro meat if people who are important to me think that I should. **(SI1)****

	I will consume in-vitro meat if people who influence my behaviour think that I should. **(SI2)****
	I will consume in-vitro meat if people whose opinions I value prefer that I do. **(SI3)**
	I will consume in-vitro meat if people who are important to me consume it. **(SI4)**
	I will consume in-vitro meat if people who influence my behaviour consume it. **(SI5)**
	I will consume in-vitro meat if people whose opinions I value will consume it. **(SI6)**
Facilitating Conditions (FC)	I believe I have the resources necessary to consume in-vitro meat. **(FC1)**
	I believe I have the knowledge necessary to consume in-vitro meat. **(FC2)****
	I believe in-vitro meat is compatible with other foods I consume. **(FC3)**
	I believe I can get help from others when I have difficulties consuming in-vitro meat. **(FC4)**
Hedonic Motivation (HM)	Consuming in-vitro meat would be fun. **(HM1)**
	Consuming in-vitro meat would be enjoyable. **(HM2)**
	Consuming in-vitro meat would be entertaining. (**HM3)**
	In-vitro meat will be tasty. **(HM4)**
Price Value (PV)	In-vitro meat should be reasonably priced. **(PV1)**
	In-vitro meat will be good value for the money. **(PV2)**
Attitude (AT)	Eating in-vitro meat should become natural to me. **(AT1)**
	Eating in-vitro meat will not interfere with my chosen dietary habits. **(AT2)**
	I will resist consuming in-vitro meat in order to not interfere with my daily habits. **(AT3)*** **
Behavioural Intention (BI)	I intend to consume in-vitro meat in the future. **(BI1)**
	I will always try to consume in vitro meat in my daily life. **(BI2)**
	I plan to consume in-vitro meat in future. **(BI3)**
	I predict I would consume in-vitro meat in the future. **(BI4)** **
Habit (HA)	How often (on average) per week do you consume meat-based meals? **(HA1)**

Note * Likert-scale was inverted due to question's negative structure; ** Question was discarded during analysis for lack of validity

3.2 Data Analysis

Structural equation modelling is particularly useful when studying complex relationships between variables that cannot be directly measured, as it includes two components: the measurement model and the structural model. In this way, a structural model mirrors the hypothesis and the measurement models that relate the latent variables with their respective manifestations.

3.2.1 Measurement Models

The first step is always to validate the measurement models. In this study, there are only reflective models, which will firstly be analyzed by measuring the Outer Loading and determining if the values of the constructs are all above 0.708, as recommended by (Hair et al., 2019), since this would indicate the constructs explains more than 50% of the indicator's variance.

Regarding the internal consistency reliability, while Cronbach's alpha is a less precise measure of reliability, due to its items being unweighted, composite reliability's items are weighted based on the construct indicator's individual loadings, thus presenting a higher reliability. However, while the first method is sometimes considered too conservative, the second one is also sometimes considered too liberal, with the construct's actual reliability being considered within the two extreme values (Hair et al., 2019). A new alternative, rho_a, was proposed as an approximately exact measure of construct reliability that usually lies between Cronbach's alpha and composite reliability (Dijkstra & Henseler, 2015). Higher values are usually indicative of higher levels of reliability, with values between 0.60 and 0.70 being considered "acceptable in exploratory research", values between 0.70 and 0.90 being deemed from "satisfactory to good" and values of 0.95 and higher being problematic due to indicating possible redundance (Diamantopoulos et al., 2012; Drolet & Morrison, 2001) or possible undesired response patterns, such as straight lining (Hair et al., 2019).

As for the convergent validity of each construct measure, defined as the extent to which the construct converges to explain the variance of its items, it is measured by the average variance extracted (AVE) for all items on each construct. An acceptable AVE is 0.50 or higher, which indicates the construct explains at least 50 per cent of the variance of its items (Hair et al., 2019).

To assess discriminant validity, defined as the extent to which a construct is empirically distinct from other constructs in the structural model, Fornell and Larcker (1981) proposed the traditional metric and suggested that each construct's Average Variance Extracted (AVE) should be compared to the squared inter-construct correlation (as a measure of shared variance) of that same construct and all other reflectively measured constructs in the structural model and that the shared variance for all model constructs should not be larger than their AVEs (Hair et al., 2019).

3.2.2 Hypothesis testing

To compare the results between participants who viewed the figure and those who did not, we used the Student's t-test for independent samples, suitable for assessing differences between two means. This test assumes that the variables are continuous, that the observations are independent, that the populations follow a normal distribution, and that they present homogeneous variances (Malhotra & Dash, 2019).

In this study, the assumptions were considered met for the following reasons:

(i) the subsamples are independent, as each respondent chose only one version of the questionnaire and did not have access to the other, which prevents any overlap between the groups;

(ii) the variables analyzed are continuous, resulting from the calculation of latent variables obtained through modeling in SmartPLS;

(iii) Because both subsamples had more than 30 observations, the Central Limit Theorem was applied, which guarantees that the distribution of the sample mean tends to approach normality as the sample size increases, even if the population distribution is not normal (Malhotra & Dash, 2019). For this reason, a formal normality test was not performed.

Additionally, Levene's test was performed to verify the assumption of homogeneity of variances, and the results are presented together with those of the Student's t-test.

3.2.3 Structural Model

To validate the structural model, this study applied a Bootstrapping based validation with 10,000 samples, as the approach is non-parametric and, thus, not as demanding. As such, it was not necessary to guarantee that the variables follow a normal distribution. However,

there are issues that can stem from multicollinearity, so the Variance Inflation Factor (VIF) was used to evaluate the collinearity (Hair et al., 2019).

The p-value was used to determine the statistical relevance of the relations in the model. To assess the strength of these relations, the β was calculated. As recommended by Cohen (1988) to assess the magnitude of effects, the f^2 effect index was calculated to quantify the contribution of an additional explanatory variable to the model.

4 – Results

4.1 Descriptive Analysis

After the exclusion of 19 invalid or incomplete responses, the final and analyzed sample consists of 146 individuals of Portuguese origin, 43% of whom identified themselves as being female, 56% as male and <1% (1 individual) as other. The ages of the participants ranged from 20 to 74 years old, with a distribution of less than 1% for Boomers I (one individual), 6% for Boomers II, 32% for Gen X, 35% for Millenials, the largest generational group of participants, and 26% for Gen Z. Most participants, 83%, claimed to have a higher level of education and the remaining 17% claimed a secondary level of education. This demographic information provides a clearer context for the interpretation of the findings related to the participants' opinions on in-vitro meat. This information is also laid out in Table 2.

While only 2.7% (4 individuals) claimed to not consume meat, 40% claimed they were planning to reduce the consumption of meat in their regular diets.

When asked to react to the statement "I would be willing to try in-vitro meat.", 51% responded positively with 38.36% selecting the "Agree" option and 13.01% choosing "Completely agree". 25% gave negative feedback with 14.38% answering "Disagree" and 10.27% answering "Completely Disagree". 23.97% of the participants chose the "Neutral" option. Following this statement, the participants that answered in a positive or neutral form to the previous statement were asked to provide their feedback on two other statements: "I would be willing to eat in-vitro meat regularly" and "I would recommend meat eaters to eat in-vitro meat instead of conventional meat". On the willingness to eat in-vitro meat regularly, 26% responded positively with 16.36% selecting the "Agree" option and 10.00% choosing "Completely agree". 17% gave negative feedback with

10.00% answering "Disagree" and 7.27% answering "Completely Disagree". 56.36% of the participants chose the "Neutral" option.

When asked if they would recommend meat eaters to choose eating in-vitro meat over conventional meat, 24% responded positively with 12.73% selecting the "Agree" option and 10.91% choosing "Completely agree". 17% gave negative feedback with 10.91% answering "Disagree" and 6.36% answering "Completely Disagree". 59.09% of the participants chose the "Neutral" option.

Table 2: Profile of participants

Characteristics	Items	Frequency	Percentage
Gender	Female	63	43.15%
	Male	82	56.16%
	Other	1	0.68%
Age	Gen Z	38	26.03%
	Millenials	51	34.93%
	Gen X	47	32.19%
	Boomers II	9	6.16%
	Boomers I	1	0.68%
Country	Portugal	146	100%
Education	Primary	0	0%
	Secondary	25	17.12%
	Higher	121	82.88%

4.2 Measurement Models

In the measurement models, as shown on table 3, the Outer Loadings are all above 0.708, as recommended by Hair et al. (2019), except the one regarding FC1 which sits at 0.700. Due to the exploratory nature of this research and how close this value sits to the recommended threshold, it was considered within the limits of acceptable reliability.

The values associated with rho_a are all within the "satisfactory to good" range and higher, with the values related to BI and SI being slightly above 0.95, which could be deemed as possibly redundant but are still close enough to be considered acceptable in exploratory research (Dijkstra & Henseler, 2015).

On the convergent validity of each construct measure, measured by the AVE, all of the measured values are well above the acceptable threshold of 0.50 (Fornell & Larcker, 1981) and were considered validated as such.

Table 3: Outer Loadings, Cronbach's Alpha, Composite reliability (rho_a and rho_c) and Average Variance Extracted

Construct	Item	Outer loadings	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
BI	BI1	0.967	0.963	0.964	0.976	0.931
	BI3	0.969				
	BI4	0.959				
EE	EE5	0.909	0.690	0.728	0.864	0.760
	EE6	0.833				
FC	FC1	0.700	0.691	0.757	0.825	0.614
	FC3	0.881				
	FC4	0.758				
FI	FI1	0.886	0.741	0.743	0.885	0.794
	FI3	0.897				
HM	HM1	0.839	0.902	0.907	0.931	0.772
	HM2	0.900				
	HM3	0.889				
	HM4	0.886				
Attitude	AT1	0.927	0.757	0.804	0.890	0.802
	AT2	0.863				
PE	PE1	0.806	0.901	0.907	0.927	0.718
	PE2	0.803				
	PE3	0.911				
	PE4	0.881				
	PE5	0.829				
PV	PV1	0.944	0.856	0.869	0.933	0.874
	PV2	0.925				
SI	SI3	0.909	0.953	0.955	0.966	0.876
	SI4	0.942				
	SI5	0.955				
	SI6	0.937				

The discriminant validity analysis did not return any issues (table 4).

Table 4: Fornell-Larcker

	BI	EE	FC	FI	HM	AT	PE	PV	SI
BI	**0.965**								
EE	0.539	**0.737**							
FC	0.584	0.284	**0.783**						
FI	0.143	-0.073	0.153	**0.889**					
HM	0.803	0.534	0.526	0.012	**0.879**				
AT	0.721	0.463	0.623	0.126	0.664	**0.894**			
PE	0.745	0.518	0.554	0.057	0.644	0.677	**0.856**		
PV	0.533	0.398	0.506	0.011	0.451	0.495	0.478	**0.935**	
SI	0.375	0.267	0.249	0.022	0.348	0.322	0.418	0.177	**0.925**

4.3 Hypothesis Testing

Table 5: T-test results

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	**Sig.**	**t**	**Two-Sided p Significance**
LV scores - Attitude	Equal variances assumed	0.0008	0.9769	-1.5431	0.1250
	Equal variances not assumed			-1.5364	0.1268
LV scores - BI	Equal variances assumed	0.8976	0.3450	-0.3603	0.7192
	Equal variances not assumed			-0.3583	0.7207

As shown on table 5, no significant differences were found between the participants who were shown the AI-generated image of in-vitro mean and those that were not shown any image as the values fall below the minimum threshold for a small effect (0.2) (Cohen, 1988). The provided image was expected to cause a reaction or effect on the responses of the participants due to it being a product not currently available to the public and, thus, not having a defined visual idea present in the minds of the participants. However, as no significant differences were found, it can be concluded that showing the image, or not, provided no relevant effect on the answers of the participants.

4. 4 Structural Model

Considering multicollinearity, no significant issues were identified (Table 6). All VIF values, except one, are below 3, which is generally considered ideal for validation purposes. Although values between 3 and 5 may suggest potential collinearity concerns, the VIF associated with HM and PE versus Attitude are only slightly above 3 (3.030 and 3.330). Therefore, for research purposes, these values were deemed acceptable (Hair Jr et al., 2023).

Table 6: Variable Inflation Factor (VIF)

Construct	Variable Inflation Factor (VIF)
Age -> Attitude	1.483
Age -> BI	1.062
Attitude -> BI	1.856
EE -> Attitude	1.783
FC -> Attitude	2.156
FC -> BI	1.886
Financial Independency -> Attitude	1.522
HM -> Attitude	3.030
Habit -> Attitude	1.563
Experience -> Attitude	1.892
Experience -> BI	1.132
PE -> Attitude	3.330
PV -> Attitude	2.457
PV -> BI	1.595
SI -> Attitude	1.700
Gender -> Attitude	1.773
Gender -> BI	1.077
Financial Independency x PV -> Attitude	1.857

R-square

According to Hair et al. (2019), values of 0.75 and 0.50 are considered, respectively, substantial and moderate. Table 5 shows us the values of R-square for Attitude and Behavioral Intention, both of which fall within the interval of values between substantial and moderate, as shown in table 5.

Table 7: R-square Results

	R-square	R-square adjusted
Attitude	0.721	0.632
BI	0.585	0.558

Statistical significance of weights can be evaluated through the P-values and accepted when these are under 0.05 (Hair et al., 2019). To assess the magnitude of effects, (Cohen, 1988) proposed the use of the f^2 effect index, which allows quantifying the contribution of an additional explanatory variable to the model. According to Cohen's guidelines, f^2 values can be interpreted as follows: $f^2 = 0.02 \rightarrow$ small effect; $f^2 = 0.15 \rightarrow$ medium effect; $f^2 = 0.35 \rightarrow$ large effect. These thresholds serve as rules of interpretation for the magnitude of the effect, allowing researchers to assess the practical relevance of the results obtained. As shown in table 6, Performance Expectancy (PE) has a positive effect on Attitude ($f^2 = 0.047$; $\beta = 0.284$; p-value = 0.005), Hedonic Motivation (HM) has a positive effect on Attitude ($f^2 = 0.127$; $\beta = 0.234$; p-value = 0.006), Attitude has a positive effect on Behavioral Intention (BI) ($f^2 = 0.308$; $\beta = 0.499$; p-value = 0.000), Price Value (PV) has a positive effect on Attitude ($f^2 = 0.064$; $\beta = 0.139$; p-value = 0.049) and Behavioral Intention (BI) ($f^2 = 0.068$; $\beta = 0.220$; p-value = 0.001), Facilitating Conditions (FC) has a positive effect on Attitude ($f^2 = 0.093$; $\beta = 0.217$; p-value = 0.001) and Behavioral Intention (BI) ($f^2 = 0.040$; $\beta = 0.201$; p-value = 0.006) and Gender has a modifying effect on how Price Value (PV) effects Attitude ($f^2 = 0.163$; $\beta = -0.225$; p-value = 0.001). Although it wasn't possible to validate that Effort Expectancy (EE) had an effect on Attitude ($\beta = 0.028$; p-value = 0.664), the results suggest that the gender of the participant would have a modifying effect on this hypothetical relation ($\beta = 0.183$; p-value = 0.009).

Table 8: Structural Model Results – Path Coefficients

	f-squared	β	T statistics	P values
Age x Attitude -> BI		0.032	0.815	0.415
Age x EE -> Attitude		-0.001	0.022	0.982
Age x FC -> Attitude		0.001	0.020	0.984
Age x Habit -> Attitude		-0.013	0.308	0.758
Age x HM -> Attitude		0.010	0.115	0.908
Age x PE -> Attitude		0.003	0.034	0.973
Age x PV -> Attitude		-0.004	0.062	0.951
Age x SI -> Attitude		0.043	0.745	0.456
Attitude -> BI	0.308	0.499	5.593	0.000

EE -> Attitude		0.028	0.435	0.664
FC -> Attitude	0.093	0.217	3.325	0.001
FC -> BI	0.040	0.201	2.762	0.006
Financial Independency x PV -> Attitude		-0.022	0.497	0.619
Habit -> Attitude		0.010	0.245	0.807
HM -> Attitude	0.127	0.234	2.769	0.006
Experience x Attitude -> BI		-0.008	0.172	0.863
Experience x EE -> Attitude		0.035	0.493	0.622
Experience x HM -> Attitude		-0.040	0.431	0.666
Experience x PE -> Attitude		-0.062	0.634	0.526
Experience x PV -> Attitude		-0.053	0.711	0.477
Experience x SI -> Attitude		0.090	1.036	0.300
PE -> Attitude	0.047	0.284	2.813	0.005
PV -> Attitude	0.064	0.139	1.965	0.049
PV -> BI	0.068	0.220	3.315	0.001
Gender x Attitude -> BI		0.028	0.686	0.493
Gender x EE -> Attitude		0.183	2.628	0.009
Gender x Habit -> Attitude		-0.004	0.092	0.927
Gender x PE -> Attitude		-0.018	0.202	0.840
Gender x PV -> Attitude	0.163	-0.225	3.208	0.001
Gender x SI -> Attitude		0.019	0.292	0.771
SI -> Attitude		0.042	0.527	0.598

Following the f^2 results obtained, the only effect that comes close to being a large effect is how Attitude affects Behavioral Intention. Gender has medium effect on how it moderates the effect Price Value has on Attitude. Hedonic Motivation also has a small, albeit somewhat close to medium Effect on Attitude. The remaining verified effects (Facilitating Conditions on Attitude, Price Value on Attitude and Behavioral Intention, Performance Expectancy on Attitude and Facilitating Conditions on Behavioral Intention) were all deemed small as they were between 0.040 and 0.093.

Table 9 presents the total indirect effects and table 10 the total effects.

Attitude has a mediating effect on the relationship between Performance Expectancy (PE) and Behavioral Intention (BI), and between Hedonic Motivation (HM) and BI, as the effect of these variables on BI is indirect. Thus, these variables have a positive effect on how this labmeat is perceived by the consumers which then affects the consumers' purchase intent.

Price Value (PV) and Facilitating Conditions (FC), however, present both indirect and direct effects, resulting in a higher total effect. This implies that the perceived financial

value of the product and ease with which the consumer can access not only affects the attitude towards the product but also the actual intention of consuming the product (Hair et al., 2019).

Total indirect effects

Table 9: Mean, STDEV, T values, p values

	β	T statistics	P values
FC -> BI	0.109	2.828	0.005
HM -> BI	0.117	2.377	0.017
PE -> BI	0.142	2.485	0.013
Gender x EE -> BI	0.091	2.468	0.014
Gender x PV -> BI	-0.112	2.933	0.003

Total effects

Table 10: Mean, STDEV, T values, p values

	β	T statistics	P values
Attitude -> BI	0.499	5.593	0.000
FC -> Attitude	0.217	3.325	0.001
FC -> BI	0.31	4.646	0.000
HM -> Attitude	0.234	2.769	0.006
HM -> BI	0.117	2.377	0.017
PE -> Attitude	0.284	2.813	0.005

4.3 Discussion

From the data gathered, it was possible to reach several conclusions on the perception and acceptance of in-vitro meat among the participating individuals. While the percentage of participants who were vegetarian or vegan was low (only 2.7% do not consume meat), a large section of the sample is interested in reducing their meat consumption (40%). From this, we can gather that, even amongst meat consumers, there is interest in changing dietary habits, contrary to what was understood in previous studies that pointed towards only smaller minorities in western countries being interested in reducing their consumption of red meat, namely younger and more educated consumers, being the ones inclined towards

purchasing plant-based alternatives (Slade, 2018). There is a solid initial receptiveness towards in-vitro meat. Most participants (51%) are willing to try in-vitro meat, indicating curiosity and openness towards food innovation and only 25% of the individuals questioned considered themselves against it as 24% were neutral on it. This openness towards lab-made meat reveals a window of opportunity for both established businesses and entrepreneur initiatives to adapt or create new culinary experiences with in-vitro meat as a base ingredient, as one of the distinguishing factors in the food industry is the ability to provide new and unique experiences.

Although many are willing to try in-vitro meat, there is some hesitation about regular consumption, as only 26% of the people questioned showed openness towards it. However, only 17% claimed to be against eating lab made meat regularly, with most individuals (56.4%) giving neutral feedback. These sentiments may be linked to concerns about taste, safety, price, or cultural values, as a previous review identified awareness, risk-benefit perception, ethical and environmental concerns, emotions, personal factors, product properties, and availability of substitutes as interconnected determinants of consumer acceptance of lab-grown meat (Pakseresht et al., 2022). These results should be faced as a challenge towards the insertion of this new product in the market, which could potentially be diminished by improving the product's appeal by developing unique approaches.

Recommendation to others is also scarce. Most (59%) remained neutral on this, and even among those who accept in-vitro meat there is some resistance to actively promoting it, as only 24% would recommend it to other meat eaters and 17% opposed the idea, which may indicate a still superficial or conditional acceptance. Aligning with previous studies (Weinrich et al., 2020) that have shown lab-grown meat could have potential as a viable alternative if consumers can get past their disgust and find ethical advantages and a sense of optimism and considering there is considerable reluctance to recommend in-vitro meat to other consumers, businesses adopting this novel ingredient would need to focus on providing experiences with enough perceived value to overcome any reluctance or lack of trust.

Although most participants still consume meat, there is a clear movement toward reducing consumption of traditional meat and significant curiosity about alternatives such as in vitro meat. However, regular adoption and active promotion still face barriers, suggesting that

awareness campaigns, product testing, and technological improvements may be required to increase acceptance.

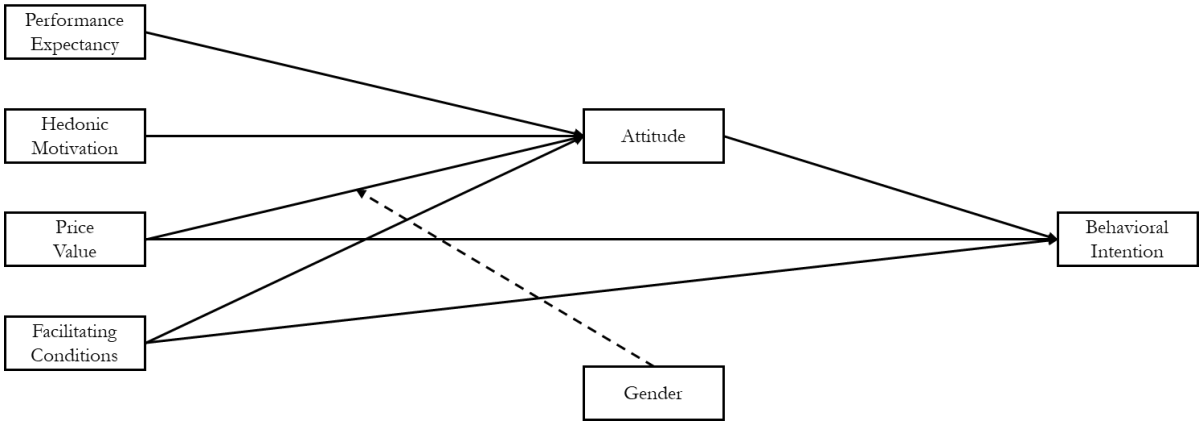

Figure 5: Validated Constructs Model

The validated hypotheses allow us to conclude that Performance Expectancy (PE) has a positive effect on Attitude (AT), Hedonic Motivation (HM) has a positive effect on Attitude, Attitude has a positive effect on Behavioral Intention (BI), Price Value (PV) has a positive effect on Attitude and Behavioral Intention (BI), Facilitating Conditions (FC) has a positive effect on Attitude and Behavioral Intention (BI) and Gender has a modifying effect on how Price Value (PV) effects Attitude, thus validating hypothesis H1, H2, H5, H6, H7, H8 and H9. Furthermore, the moderating effect, M20, was also validated. The validated constructs are represented in Figure 5.

From the observed high impact of Facilitating Conditions and Price Value, we can deduce that for the Portuguese consumer, the price and accessibility of the product will have a high influence on their considerations of the product itself and whether they are willing to consume it.

As HM proved to have an effect on Attitude, investors in lab-made meat should aim at making its consumption a unique and pleasurable experience. In a similar way, the observed effects PE has on AT indicates that this product should also be promoted to the consumers for its possible positive attributes, such as nutrition, sustainability and

accessibility. As Attitude also has a positive effect on Behavioral Intention, this makes it a key indicator for a consumer's intentions towards actually consuming the product, which means influencing a consumer's attitude towards in-vitro meat in a positive way will enhance the probability of them consuming it in the future.

5 Conclusion

As per the evidence presented, we can consider the Portuguese people welcoming of a lab-grown alternative to meat. Although with a certain number of reservations. While the idea of experiencing in-vitro meat is appealing to most of the participants, the same cannot be said when it comes to consuming it regularly.

Combining the UTAUT2 model and Technological Acceptance Model proved to be a good idea, as it allowed a deeper look into a novel technology that is not yet accessible to most of the public. Furthermore, as technology is rapidly evolving and embedding itself to a bigger degree in both day-to-day public life as well as at an industrial level, looking at in-vitro meat as a novel technology instead of as just a newly discovered ingredient allowed for a better perspective on it as an industry disruptor.

From the analysis performed in this study, we can conclude that the more an individual believes that consuming in-vitro meat will be of benefit to them, whether it be for its hedonic experience, recognized value, ease of use or access, the more positive their attitude towards it will be. In a similar manner, this study also found that the more fun or pleasure an individual believes they will obtain from consuming in-vitro meat, the more positive their attitude towards it will be. Furthermore, the results show the more value a consumer sees in consuming lab-made meat, they will feel more inclined towards consuming. An effect, according to this study, exacerbated in female participants. This study also found that the more a consumer thinks that in-vitro meat will be supported by its provider, the more they will feel trusting and consuming towards it. Lastly, this study also found that the more positive a consumer's attitude towards consuming lab-made meat is, the more they intend to actually consume it. Overall, as Performance Expectancy, Hedonic Motivation, Price Value and Facilitating Conditions all have positive effects on Attitude and Attitude has a proven positive effect on Behavioral Intention shared with Price Value and Facilitating Conditions, there is an open window of opportunity for tailored intertwined strategies that focus on two or more of these relationships for better results. In sum, those looking to bring this new food item to the Portuguese people will need to focus on making it an alternative that is tasty, unique, reasonably priced, easy to find and cook or a combination of these, for the Portuguese to be more inclined towards consuming it regularly.

This study finds that, in general, the Portuguese people are open to a lab-made alternative of meat as a novel ingredient in the food industry, despite not finding it as appealing as a new staple of their dietary habits.

Theoretical Implications

The results obtained from this study point towards the current theoretical models being insufficient to gauge the acceptance of novel technology items in more complex contexts. While combining the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) with the Technology Acceptance Model (TAM) for the purposes of this research proved useful, and thus providing a new base model that already accounts for situations in which a novel technology or technological product has already been developed but has still not been made widely available to the general product, as one had not previously been be developed.

Practical Implications

The findings in this research prove there is room for in-vitro meat in the Portuguese consumer market and can be of practical use for in-vitro meat producing companies that want to find a better way of penetrating the market once they are able to make their products widely available. It can also be used by businesses in the restaurant industry that are looking to provide novel experiences for their customers and how to market them to stand out from their competitors.

This research bridges the gap between the previously existing academic research and future investment opportunities for this novel product in real-world situations in the Portuguese food industry and/or market by the insights it provides on the thoughts of real people in an academic framework basis using technology acceptance models.

Limitations and possibilities for future research

There are multiple limitations in this study that can be seen as opportunities for future research. The study had a sample pool of people mostly residing in the northern regions of

Portugal while it also consisted of exclusively Portuguese people, which could limit the ability to apply these results to the whole country. As such, collecting data from people residing in other Portuguese regions could prove advantageous for a more accurate perspective of the general population of Portugal as it would also be an opportunity to collect data on the perspectives of both Portuguese and non-Portuguese people residing in the different regions of the country, so that a more tailored approach could be prepared for the businesses of each region. As Portugal is, at the time of this study, a member of the European Union, this study could also be replicated across other member countries to assess marketing and promotion opportunities for in-vitro meat at a larger scale.

Further studies could be done towards the types of "cuts" of in-vitro meat that consumers would prefer, or what meals with this product as a main ingredient they would be more open to eat regularly. Studies that going deeper into specific demographics, such as a generational level (focusing on the younger generations) or even generations across different nationalities could be done to better understand the sentiments, and their causes, across more specific groups.

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Appendix

Table 11: Cross Loadings

	Attitude	BI	EE	FC	FI	HM	PE	PV	SI
Hab1	**0.927**	0.761	0.425	0.561	0.123	0.660	0.703	0.446	0.330
Hab2	**0.863**	0.483	0.332	0.559	0.101	0.511	0.465	0.446	0.192
BI1	0.672	**0.967**	0.444	0.547	0.159	0.789	0.733	0.503	0.352
BI3	0.700	**0.969**	0.465	0.536	0.113	0.780	0.706	0.534	0.357
BI4	0.695	**0.959**	0.450	0.600	0.129	0.756	0.719	0.504	0.334
EE5	0.420	0.454	**0.909**	0.297	-0.066	0.457	0.455	0.406	0.252
EE6	0.316	0.356	**0.833**	0.158	0.066	0.369	0.384	0.245	0.140
FC1	0.377	0.295	0.039	**0.700**	0.206	0.255	0.228	0.267	0.130
FC3	0.603	0.601	0.340	**0.881**	0.152	0.522	0.549	0.459	0.246
FC4	0.443	0.405	0.181	**0.758**	0.017	0.405	0.386	0.427	0.152
FI1	0.110	0.145	-0.110	0.144	**0.886**	0.019	0.035	0.033	0.023
FI3	0.115	0.102	0.085	0.132	**0.897**	0.002	0.084	-0.022	-0.014
HM1	0.505	0.667	0.378	0.358	-0.043	**0.839**	0.552	0.353	0.336
HM2	0.598	0.711	0.373	0.513	0.050	**0.900**	0.578	0.367	0.251
HM3	0.584	0.738	0.345	0.473	0.014	**0.889**	0.549	0.428	0.320
HM4	0.633	0.706	0.572	0.489	0.012	**0.886**	0.587	0.434	0.255
PE1	0.587	0.633	0.411	0.524	0.161	0.521	**0.806**	0.443	0.327
PE2	0.481	0.538	0.410	0.284	0.010	0.442	**0.803**	0.325	0.424
PE3	0.614	0.694	0.431	0.495	0.102	0.619	**0.911**	0.428	0.429
PE4	0.610	0.682	0.357	0.512	0.044	0.576	**0.881**	0.397	0.398
PE5	0.524	0.591	0.452	0.371	-0.055	0.558	**0.829**	0.387	0.326
PV1	0.491	0.534	0.358	0.525	0.004	0.444	0.442	**0.944**	0.130
PV2	0.433	0.457	0.363	0.408	0.006	0.398	0.438	**0.925**	0.188
SI3	0.279	0.371	0.240	0.241	0.042	0.364	0.420	0.176	**0.909**
SI4	0.259	0.303	0.175	0.185	0.000	0.274	0.406	0.133	**0.942**
SI5	0.285	0.321	0.202	0.210	-0.002	0.270	0.410	0.126	**0.955**
SI6	0.301	0.349	0.247	0.242	-0.021	0.314	0.442	0.189	**0.937**

Table 12: Portuguese Questionnaire

Scale	Items
Independência Financeira (FS)	Possuo dinheiro suficiente para comprar as coisas que quero. **(FS1)**
	Não preciso de me preocupar muito com as contas que tenho de pagar. **(FS2)**
	Actualmente, sinto-me relativamente próspero(a). **(FS3)**
Hábitos de consumo de carne	Consome carne?
	Porque não? (saltar se a resposta prévia for "sim")
	Planeia reduzir o seu consumo de carne no futuro? (saltar se a pergunta prévia tiver sido respondida)
	Porquê? (saltar se a pergunta prévia não tiver sido respondida)
UTAUT2 Section	
Expectativa de Desempenho (PE)	Comer carne in- vitro contribuiria para reduzir a minha pegada ambiental. **(PE1)**
	Comer carne in- vitro seria mais saudável do que comer carne convencional. **(PE2)**
	Eu comeria carne in-vitro como um meio de tornar o mundo um local melhor para os outros. **(PE3)**
	Sinto-me motivado(a) para comer carne in-vitro porque me preocupo com os efeitos das minhas escolhas alimentares noutros seres. **(PE4)**
	Adicionar carne in-vitro à minha dieta regular iria melhorar a minha vida. **(PE5)**
	Pessoas que comerem carne in-vitro provavelmente são boas pessoas. **(PE6)**
Expectativa de Esforço (EE)	Cozinhar carne in-vitro será tão fácil como cozinhar carne convencional. **(EE1)**
	Terei de aprender a cozinhar carne in-vitro. **(EE2)**
	Consumir carne in-vitro irá requerer tanto esforço como consumir carne convencional. **(EE3)**
	Os requisitos para cozinhar carne in-vitro serão mais consistentes do que os da carne convencional. **(EE4)**
	Irei adquirir carne in-vitro nos mesmos locais onde adquiro carne convencional. **(EE5)**
	Carne in-vitro será oferecida na maioria dos restaurantes onde hoje se oferece carne convencional. **(EE6)**
Influência Social (SI)	Irei consumir carne in-vitro se pessoas que são importantes para mim pensarem que o devo fazer. **(SI1)****
	Irei consumir carne in-vitro se pessoas que influenciam o meu comportament o pensarem que o devo fazer. **(SI2)**
	Irei consumir carne in-vitro se pessoas cuja opinião eu valorizo pensarem que o devo fazer. **(SI3)**

	Irei consumir carne in-vitro se pessoas que são importantes para mim o fizerem.**(SI4)**
	Irei consumir carne in-vitro se pessoas que influenciam o meu comportament o o fizerem. **(SI5)**
	Irei consumir carne in-vitro se pessoas cujas opiniões eu valorizo o fizerem. **(SI6)**
Condições Facilitadoras (FC)	Acredito ter todos os recursos necessários para consumir carne in-vitro. **(FC1)**
	Acredito ter o conhecimento necessário para consumir carne in-vitro. **(FC2)**
	Acredito que a carne in-vitro é compatível com os outros alimentos que consumo. **(FC3)**
	Acredito que consigo obter ajuda de outros quando tiver dificuldades no consumo de carne in-vitro. **(FC4)**
Motivação Hedónica (HM)	Consumir carne in-vitro seria divertido. **(HM1)**
	Consumir carne in-vitro seria agradável. **(HM2)**
	Consumir carne in-vitro seria entusiasmante. **(HM3)**
	A carne in-vitro vai ser saborosa. **(HM4)**
Valor do Preço (PV)	A carne in-vitro deve ter um preço razoável. **(PV1)**
	A carne in-vitro irá representar um bom valor para o preço. **(PV2)**
Atitude (AT)	Comer carne in-vitro deverá tornar-se natural para mim. **(AT1)**
	Comer carne in- vitro não irá interferir com a minha dieta regular. **(AT2)**
	Irei resistir ao consumo de carne in-vitro de forma a não interferir com os meus hábitos diários. **(AT3)**
Intenção Comportamental (BI)	Tenho intenção de consumir carne in-vitro no futuro. **(BI1)**
	Tentarei consumir carne in-vitro na minha vida diária. **(BI2)**
	Planeio consumir carne in-vitro no futuro. **(BI3)**
	Prevejo que irei consumir carne in-vitro no futuro. **(BI4)**
Hábito (HA)	Quantas refeições de carne consome por semana (em média)? **(HA1)**