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Consumers' valuation of cultured beef Burger: A Multi-Country investigation using choice experiments

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ABSTRACT

This study investigates, for the first time, British, Spanish, and French consumers' willingness to pay (WTP) for cultured beef burger. Using a choice experiment (CE) involving beef burgers, our results show that Spanish and French consumers reject cultured beef burgers, while British consumers exhibit a more positive valuation for this new product. Furthermore, we found that younger consumers and those with a lower degree of neophobia towards new food technologies tend to be more accepting of cultured beef. Results also suggest that there is heterogeneity in consumers' valuation across different consumer groups. In each of the three countries, a segment of consumers willing to pay a premium price for cultured beef burger was identified: the United Kingdom has the largest segment of consumers (47%) willing to pay a premium price of 5.10 £/kg for cultured beef, followed by Spain (38% and 3.35 €/kg) and then France (30% and 2.68 €/kg). Our findings provide insights into the psychology of consumers' level of acceptance and attitudes, which can be useful in communicating the nature of the cultured meat to the public. They also have important implications for food practitioners and policy makers.

1. Introduction

Continued growth in world population, incomes, urbanization, and food security issues have significantly increased the demand for meat products (OECD-FAO, 2013). However, conventional meat production can cause environmental harms in terms of relatively larger greenhouse gas emissions (Xu et al., 2021) and requires the extensive use of land, energy and water. There are also increasing societal concerns about food safety and human health issues related to meat consumption, such as the risk of animal-transmitted pandemics and antibiotic resistance (Godfray et al., 2018; Reisch, 2021). Animal welfare is another concern since some conventional meat production systems are perceived to be conducted under inhumane conditions (Lymbery and Oakeshott, 2014).

For these reasons, there is increasing interest in novel livestock farming systems (Dumont et al., 2018) as well as in innovative alternatives to conventional meat. Among the different types of meat alternatives (e.g. plant-based food, mycoproteins, etc.), consumer desire for meat similar to conventional meat is pushing the development of what is termed 'cultured meat' (sometimes also called '*in-vitro* meat', "artificial meat", etc.) (Post and Hocquette, 2017). Cultured meat is the result of recent scientific advances in regenerative medicine techniques where muscle-specific stem cells are taken from an animal and then grown in large numbers until they form muscle tissues that can be considered edible meat (Post, 2012). One of the key advantages of cultured meat is that it can theoretically be produced in unlimited quantities, which would alleviate the increasing demand for meat, feed more people, and potentially be produced more sustainably in terms of lower greenhouse gas emissions and less intensive use of land and water (Mattick et al., 2015; Sinke & Odegard, 2021). Another advantage is that, from an animal welfare perspective, cultured meat technology could produce meat more ethically since the slaughter of animals is not required when cultured meat is produced without fetal calf serum (Chriki and Hocquette, 2020). Furthermore, it is speculated that cultured meat technology can produce meat without the use of antibiotics (Dempsey and Bryant, 2020) and can theoretically produce a great variety of meat products with different content and types of fat, B12 vitamin, etc.,

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allowing the product to be personalized to meet the preferences and needs of consumers (Treich, 2021).

In addition to the current challenges that cultured meat is facing, such as the cost of growth media, the industry scale-up of specific components of the cell culture process, the high costs of production, intellectual property sharing issues and regulatory hurdles (Warner, 2019), consumer acceptance is one of the most relevant barriers for the success of cultured meat (Sharma, Thind, and Kaur, 2015). A number of studies have investigated the consumer acceptance of cultured meat. To illustrate, Bryant and Barnett (2018, 2020) and Pakseresht, Kaliji, and Canavari (2021) provided three systematic reviews of a large number of empirical studies (14, 26 and 43, respectively) on consumers' acceptance of cultured meat. Some interesting outcomes were identified. First, a majority of consumers were at least willing to try cultured meat, while a substantial but lower number would consume it regularly or as a replacement for conventional meat (e.g. Weinrich, Strack, and Neugebauer, 2020; Gómez-Luciano et al., 2019). Second, consumers' acceptance of cultured meat increased when they were provided with positive and less technical information (e.g. Bekker et al., 2017; Rolland, Markus, and Post, 2020). In addition, message framing that emphasized both the societal and personal benefits of cultured meat or its similarity with conventional meat had a positive effect on consumer acceptance (e.g. Bryant and Dillard, 2019). Third, consumer acceptance of cultured meat varies among countries; for example, it is reported to be more accepted in India and China than in the United States (Bryant et al., 2019a). Fourth, cultured meat tends to appeal more to younger people (e.g. Zhang, Li, and Bai, 2020), urbanites (e.g. Shaw 2019), and higher-educated consumers (e.g. Weinrich, Strack, and Neugebauer, 2020), and sometimes, but not always, to males (e.g. Weinrich, Strack, and Neugebauer, 2020; Zhang, Li, and Bai, 2020), meat eaters (Arora, Brent, and Jaenicke, 2020), and consumers with higher meat attachment (Bryant et al., 2019a; Circus and Robison, 2019). Fifth, the findings about consumers' perceptions of the environmental benefits of cultured meat are ambiguous; some studies have reported that consumers perceived that cultured meat provided environmental benefits (e.g. Mancini and Antonioli, 2020), while other studies found that consumers perceived cultured meat as more harmful to the environment (e.g. Specht, Rumble, and Rhoades 2020). Sixth, some studies revealed that the reduction of animal suffering and death was a strong driver for cultured meat acceptance (e.g. Weinrich, Strack, and Neugebauer, 2020). Seventh, consumers could be open to cultured meat as a potential way to improve food safety (Gómez-Luciano et al., 2019) and to address global hunger (Mancini and Antonioli, 2019). Eighth, several studies identified some potential barriers towards consumer acceptance of cultured meat, including perceived unnaturalness (e.g. Weinrich, Strack, and Neugebauer, 2020), food safety concerns (e.g. Tucker, 2018; Shaw, 2019), disgust (e.g. Dupont and Fiebelkorn, 2020; Weinrich, Strack, and Neugebauer, 2020), nutrition concerns (e.g. Lupton and Turner, 2018), consumers' fears of novel food technologies (i.e. neophobia) (e.g. Bryant et al., 2019a; Dupont and Fiebelkorn, 2020), distrust in food scientists and food safety authorities (Zhang, Li, and Bai, 2020; Wilks and Phillips, 2017), economic anxiety about the impact of cultured meat on farming and rural communities (e.g. Circus and Robison, 2019), ethical concerns (e.g. Circus and Robison, 2019), and perceived high price (e.g. Gómez-Luciano et al., 2019).

However, to the best of our knowledge, only a few studies have examined consumers' WTP for cultured meat. For example, Van Loo et al. (2020) investigated the preferences and attitudes of US consumers towards conventional, plant-based and cultured burgers and found that the latter has a potential market share of 5 %, while Asioli et al. (2022) found that US consumers were willing to pay a higher price for conventional chicken compared to cultured chicken. Carlsson et al. (2022) found that Swedish consumers were not willing to pay a premium price for cultured beef burger compared to conventional beef burger, while Zhang et al., (2020) found that Chinese consumers were willing to pay a premium price for cultured meat compared to conventional meat; however, this was not confirmed by a more recent study (Liu et al., 2021). Indeed, the majority of respondents of the same survey in China (86 %) and also in Brazil (71 %) were keen to pay less or much less for cultured meat than conventionally produced meat (or even nothing at all), compared to 10–25 % who were willing to pay the same price as conventional meat, whereas only less than 5 % were willing to pay more (Chriki et al., 2021; Liu et al., 2021). Rolland et al. (2020) examined Dutch consumers' WTP for cultured beef and found that, when information and sensory experience (taste)[1] were provided to consumers, most of them were willing to pay a premium price for cultured beef burgers compared to conventional beef burgers. In addition, it is important to note that there are only a few studies that compare consumers' preferences for cultured meat across different countries. For example, Bryant, et al. (2019b) compared consumer perception for cultured meat in the United States, India, and China. Gómez-Luciano et al. (2019) investigated consumers' willingness to purchase cultured meat in the United Kingdom, Spain, Brazil and the Dominican Republic. Siegrist & Hartmann (2020 investigated and compared perceived naturalness, disgust, trust and food neophobia for cultured meat acceptance in ten countries, such as Australia, China, England, France, Germany, Mexico, South Africa, Spain, Sweden and the United States. Grasso et al., 2019 compared consumer acceptance for cultured meat in several European countries.

No other known study however has examined consumer mWTP for cultured beef across different countries and tested labeling preferences. This information can provide useful information for producers aiming to sell cultured meat in different countries and policy makers to design new food policies. Our study fills this gap by using a hypothetical choice experiment (CE) to investigate and compare British, Spanish, and French consumers' preferences and WTP for hypothetical refrigerated, uncooked beef burgers, hereafter called 'beef burgers', that vary across four attributes (i.e. production method, Carbon Trust label, antibiotics use and price). Furthermore, we investigate consumer heterogeneity using the latent class modelling approach which can provide useful information for marketers and policy makers.

We chose beef burger for four main reasons: (i) beef is one of the most consumed meat products worldwide, and Europe is among the regions with the highest beef consumption (Henchion et al., 2021), (ii) the beef industry is one of the larger contributors to greenhouse gas (GHG) emissions (Clune et al., 2017; Xu et al., 2021) and thus, cultured beef can potentially contribute more to reducing environmental footprint, (iii) several large companies and startup businesses (e.g. Mosa Meat) are investing in cultured beef, and (iv) cultured beef burger is easier to produce using the cultured meat technologies compared to other cuts of meat (Chriki & Hocquette, 2020).

Our research differs from Van Loo et al. (2020) and Carlsson et al. (2022) for several reasons. First, we investigated three large potential markets (i.e. United Kingdom, Spain, and France) for cultured meat rather than just focusing on only one country. Second, we compared consumer mWTP for cultured meat across the three countries. Third, we tested consumer mWTP for carbon labeling and antibiotics use information which could potentially be important labeling information for cultured meat given that cultured meat is produced with reduced carbon footprint and without use of antibiotics. Finally, we identified several consumer segments and investigated individual differences for consumer mWTP for cultured meat based on consumer socio-demographics and attitudes which can be used by marketers to better target communication campaigns for such new product.

[1] This study only contained conventional meat samples (some labelled as 'cultured') since cultured meat is not yet available or approved for consumption in the EU.

2. Background

European Union (EU) policy makers have been stressed to address meat reduction and, at the same time, pushed the increasing production and consumption of meat alternatives in new food policies (Fortuna, 2020), including cultured meat (Commission & Innovation, 2018). This has been driven by the need of reducing the environmental impact of conventional meat as well as improving public health, and animal welfare (FAO, 2016). Several EU policies and initiatives are related to cultured meat which are important given the “very different social-legal regime” of meat alternatives compared to conventional meat (van der Weele et al., 2019). First, the new European Farm to Fork (F2F) strategy promises to make the EU food systems more sustainable and reduce negative impacts of meat consumption (European Commission, 2020). Second, the Food 2030 is the EU’s research and innovation policy aimed to transform food systems and ensure consumers have enough affordable, sustainable, nutritious food for a healthy life through 10 pathways (European Commission, 2021). More specifically, the pathway 4 “Alternative proteins and dietary shift” includes the potential role of meat alternatives in shifting from conventional meat diet to meat alternative diet. Third, another relevant policy linked to cultured meat is the European Green Deal focused on ensuring environmental sustainability within the EU (European Commission, 2022). Fourth, in Europe cultured meat is considered a novel food which follows the precautionary approach under the Novel Food Legislation (EU, 2015). The Novel Food Legislation offers a clear procedure on how to produce and market cultured meat, and thus is crucial for the development and the future commercialization of cultured meat products in the EU, but it needs to be further developed (Petetin, 2014). Furthermore, the European Food and Nutrition Action Plan aims to create healthy food environments and tackle diet-related non-communicable diseases (WHO Regional Office for Europe, 2015) which has pushed several EU countries to promote the reduction of meat consumption in their national guidelines in favour of meat alternatives (Willett et al., 2019). Practical examples of EU efforts on cultured meat have been the EU support of several projects for developing and marketing cultured meat (e.g. the Dutch cultured-meat “Mosa Meat” secured a €2 million EU grant, the Spanish company “BioTech Foods” got an EU-funded project to advance cultured-meat-production technology and improve market acceptance, etc.) (Proveg, 2022). However, the Common Agricultural Policy (CAP) and the EU’s food polices are still criticized with respect to biodiversity, soil, land degradation, climate, as well as socio-economic challenges (Pe’er et al., 2020). This is maybe due to the political challenges given that environmental concerns related to conventional meat production have often clashed with economical and political priorities linked to traditional livestock production (Rayner et al., 2008) which is one of the most important sectors of the EU economy. Indeed, the EU livestock sector continues to receive robust CAP subsidies (Peyraud & MacLeod, 2020) which clashes with the policies aimed to reduce conventional meat production.

Thus, to meet the above mentioned EU polices, it is important to reduce meat consumption and at the same time favor the incorporation of meat alternatives in consumer everyday life (Van Loo et al., 2020), including cultured meat (Treich, 2021). At the same time, recent research has shown a large increase of meat alternatives consumption in Europe (EU, 2022), and a further increase of consumption is expected over the next years (Euronews, 2022). In this context, cultured meat can represent an important meat alternative able to meet the EU policies because of its environmental, animal welfare and public health advantages also including the reduction of antibiotics use in animal production (Kumar et al., 2015). In this context more research is needed to investigate consumers’ acceptance for cultured meat in Europe (Froggatt & Wellesley, 2019).

3. Materials and methods

3.1. Choice experiment design

In the CE, four attributes were used to describe the different types of beef burgers: production method, Carbon Trust label, antibiotics use, and price (Table 1). First, we included production method because the main aim of the study is to investigate consumers’ WTP for beef burgers produced using different production methods. Thus, two levels of production methods were specified: conventional or cultured. Second, we included Carbon Trust label as an attribute, referring to the environmental impact of food production and transportation and the impact of the food product in terms of GHG emissions. We included information about the environmental impact of meat production because it is currently-one of the top concerns related to conventional meat production method (Godfray et al., 2018). Thus, the two levels of this attribute were i) use of the Carbon Trust label or ii) no label used at all. Third, we included information about antibiotics use given that antibiotics might be used during beef burger production (Chriki and Hocquette, 2020), and this information is a top concern when consumers are purchasing meat (Boyer et al., 2017). Therefore, the two levels of antibiotics use were i) use of the label ‘No antibiotics ever’ and ii) no information about antibiotics use. Lastly, four price levels were specified based partly on the current market prices for refrigerated, uncooked beef burgers in retail stores in the United Kingdom (£3.20/kg, £7.70/kg, £12.30/kg and £16.80/kg) and the equivalent for Spain and France (3.50€/kg, 8.50€/kg, 13.50€/kg and 18.50€/kg).[2]

The selected attributes and their levels were used to generate an orthogonal fractional factorial design using Ngene 1.2.1 (ChoiceMetrics, Sidney, Australia) to collect preliminary data (i.e. a pilot study) among a small number of consumers (i.e. 75) not selected for the final study. The pilot study was performed and provided the prior parameters necessary to generate the final Bayesian optimal choice design, which resulted in the creation of 18 choice sets. Then, the 18 choice sets were divided into two blocks of nine choice tasks each to prevent respondents’ fatigue. The Bayesian sequential design was developed as recommended by the current state of practice (Scarpa et al., 2007). Each choice task was composed of two product alternatives (options A and B) and an ‘opt-out’ option (option C) (see an example in Appendix A). The choice tasks

Table 1
Attributes and levels.

ATTRIBUTES		LEVELS	
Production method		‘Conventional’ ‘Cultured’	
Carbon Trust label		No label provided reducing with the Carbon Trust CO2	
Antibiotics use		No information provided ‘No antibiotics ever’ label	
Price	**United Kingdom**	**Spain**	**France**
	£3.20/kg £7.70/kg £12.30/kg £16.80/kg	3.50€/kg 8.50€/kg 13.50€/kg 18.50€/kg	3.50€/kg 8.50€/kg 13.50€/kg 18.50€/kg

[2] The prices for beef burgers were based on prices recorded in different stores in the United Kingdom, Spain and France, including grocery stores, farmers’ markets, specialty stores, organic stores and supercentres.

within each block were randomly presented to consumers.

The CE was introduced to the consumers with an explanation and clear description of the attributes and levels. Before the choice tasks, respondents were asked to read a cheap talk (CT) script in an attempt to mitigate possible hypothetical bias that typically affects consumers' WTP estimates in stated preference studies (Cummings and Taylor, 1999) (see Appendix B for the CT script). Upon completion of the choice tasks, the respondents were asked to complete a questionnaire to collect information on their socio-demographics, habits, and attitudes. The complete questionnaire is available in Appendix C.

The existing literature indicates that several socio-demographic and attitudinal factors may shape consumers' preferences related to cultured meat. For this reason, we also investigated the effect of several socio-demographic and attitudinal factors in respondents' WTP formation for the different beef burgers. We particularly focused on the following:

(i) The effect of gender (GENDER): in line with prior research (e.g. Zhang, Li, and Bai, 2020), our hypothesis is that males have a higher WTP for cultured beef burger compared to females;
(ii) The effect of age (AGE): in line with previous studies (e.g. Slade 2018), our hypothesis is that younger consumers have a higher WTP for cultured meat compared to older ones;
(iii) The effect of education (EDUCATION): in line with past studies (e.g. Gómez-Luciano et al., 2019), our hypothesis is that more educated consumers have a higher WTP for cultured meat compared to less educated consumers;
(iv) The effect of having heard or not heard about cultured meat (HEARING) prior to the study: following past studies, our hypothesis is that consumers who have heard the term 'cultured meat' prior to the study have a higher WTP for cultured meat than consumers who have not previously heard this term;
(v) The effect of pro-animal welfare attitude (AAS): our hypothesis is that consumers who have a stronger pro-animal welfare attitude have a higher WTP for cultured meat because cultured meat is produced without slaughtering animals and because previous consumer research found that animal welfare is one of the most important perceived benefits of cultured meat (Bryant & Barnett, 2018);
(vi) The effect of a pro-environmental attitude (NEP): some researchers have reported that environmental benefits are one of the major perceived benefits of cultured meat (Bryant & Barnett, 2018), while other authors found that consumers perceive that cultured meat can harm the environment (e.g. Specht, Rumble, and Rhoades. 2020). Our hypothesis is that consumers who have a stronger pro-environmental attitude have a higher WTP for cultured meat;
(vii) The effect of the degree of neophobia towards new food technologies (FTNS): prior research shows ambiguous results (Dupont and Fiebelkorn, 2020; Gómez-Luciano et al., 2019) about the effect of the degree of neophobia towards new food technologies on consumers' WTP for cultured meat;
(viii) The effect of religious orientation (RELIGION): prior research has shown that religion could affect consumers' acceptance of cultured meat. Indeed, Marcu et al. (2014) found that some consumers characterized cultured meat as 'playing God', while other authors found that, in principle, religious people were open to cultured meat if it comes from animal species allowed in their religion (Bryant, 2020).

3.2. Data

The data used in this study are drawn from an online survey conducted in summer 2020 involving 648 consumers located in the United Kingdom (216 consumers), Spain (216 consumers) and France (216 consumers) using the online platform Qualtrics LLC (Provo, US). Consumers were recruited by Qualtrics using sampling quotas in terms of age (50 % between 18 and 46 years old and 50 % between 47 and 75 years old) and gender (50 % males and 50 % females). Only consumers who were at least 18 years old and who are responsible for food shopping in their household always or sometimes were included in the study. We obtained informed consent from all respondents in the study, and our study was approved by an institutional ethical clearance board.

To ensure data quality, we took two steps. First, before presenting the series of choice tasks, we asked respondents whether they had 'devoted [their] full attention to the questions so far' and whether, in their honest opinion, they believed that we should use their responses for the study (see questionnaire in Appendix C). This 'attention check' question has been shown by Meade and Craig (2012) to stimulate respondents to pay extra attention to the subsequent questions (it is not used to detect dishonest replies). We strategically placed this question right before the most important questions such as the choice tasks. Second, we included in the study only consumers who took more than one-third of the median time duration to complete the survey.

The results show that the hypotheses of equality of means between socio-demographic characteristics across the three countries were not rejected at the 5 % significance level (see Table D1 in appendix D) for gender, age, and income. Spanish consumers were more educated and have larger families than the British and French respondents. Given the quota sampling, the final samples in each country consisted of 50 % females and 50 % males, which is very similar to the most recent census data from the United Kingdom (Office for National Statistics, 2019), Spain (INE, 2022) and France (INSEE, 2020) (see Table D2 in appendix D). In terms of age, in the United Kingdom, 26.39 % of respondents were 18–32 years old, 25.93 % were 33–47 years old, 39.35 % were 48–62 years old and 8.33 % were 63 + years old, which is similar to the census population (Office for National Statistics, 2019). In Spain, 22.22 % of the respondents were 18–32 years old, 30.09 % were 33–47 years old, 37.50 % were 48–62 years old and 10.19 % were 63 + years old, which is similar to the census population (INE, 2022). In France, 23.15 % of the respondents were 18–32 years old, 31.48 % were 33–47 years old, 37.50 % were 48–62 years old and 7.87 % were 63 + years old, which is similar to the census population (INSEE, 2020). In all three countries, respondents between 48 and 62 years old were slightly over-represented, while consumers 63 + years old were slightly under-represented compared to the census population.

After the choice tasks, we included in the questionnaire questions that will allow us to test our hypotheses concerning attitudinal factors. Specifically, we included questions about (i) whether respondents had heard or not heard (i.e. HEARING) the term 'cultured meat' prior to the study; (ii) whether respondents had a pro-animal welfare attitude using the animal attitude scale (AAS) (Herzog et al., 2015); (iii) respondents' degree of neophobia towards the adoption of new food technologies using the food technology neophobia scale (FTNS) (Cox & Evans, 2008), iv) respondents' pro-environmental attitude using the new environmental paradigm (NEP) scale (Dunlap et al., 2000), and v) respondents' religious orientation.

Next, we investigated the descriptive statistics of the attitudinal factors (see Table E1 in Appendix E). We found that there was no statistically significant differences for HEARING and pro-environmental attitude (NEP) across the three countries, while British respondents had a higher pro-animal attitude (AAS) compared to the French and Spanish respondents. In addition, the French respondents also had a higher degree of food neophobia towards new food technologies (FTNS) compared to the Spanish and British respondents, while the Spanish respondents were more religious than the British and French ones.

4. Econometric analysis

Data collected from CE can be estimated using the so-called discrete choice models (DCMs) (Train, 2009). Consistent with the Lancaster Theory (Lancaster, 1966), DCMs assume that the total utility consumers derive from a product can be segregated into the marginal utilities given by the design attributes of a product. Furthermore, DCMs are consistent with random utility theory (McFadden, 1974), which states that the utility of an individual n of choosing alternative j in choice situation t can be represented as:

$$U_{njt} = \beta^{'} x_{njt} + \varepsilon_{njt} \tag{1}$$

where x_{njt} is a vector of the observed variables relating to an individual n of choosing alternative j in choice situation t; β' is a vector of the structural taste parameters which characterize choices; and ε_{njt} is the unobserved error term, which is assumed to be independent of the vectors β and x.

In this study, we used the mixed logit (MIXL) model with specification of the utility function in the WTP space, which provides estimates directly in WTP terms (i.e. currencies such as £ for United Kingdom, and € for Spain and France).

We analyzed the data in three steps. First, we investigated consumers' marginal WTP (mWTP) for beef burgers, considering the design attributes' main effects only. As such, the specification of the utility (*U*) function in our study can be defined as follows:

$$U_{njt} = \alpha_n(ASC - PRICE_{njt} + \theta_{n1}PRODUCT_{njt} + \theta_{n2}CARBON_{njt} + \theta_{n3}ANTIBIOTICS_{njt}) + \in_{njt} \tag{2}$$

where *n* refers to individual, *j* denotes each of the three alternatives available in the choice set, *t* is the number of choice occasions, and α_n is the price scale parameter, which is assumed to be random and to follow a log-normal distribution. The ASC is the alternative constant, indicating the selection of the opt-out option. The price ($PRICE_{njt}$) attribute is represented by four experimentally defined price levels. $PRODUCT_{njt}$ is a dummy variable representing the production method of beef burger, taking the value of 0 if the production method is 'conventional' and 1 if it is 'cultured'. $CARBON_{njt}$ is a dummy variable representing the 'Carbon Trust label', taking the value of 0 if no label is reported and 1 if the Carbon Trust label is reported. $ANTIBIOTICS_{njt}$ is a dummy variable for information about antibiotics use, taking the value of 0 if no information is reported and 1 if the label 'No antibiotics ever' is reported. θ_{n1}, θ_{n2} and θ_{n3} are the coefficients of the estimated mWTP values for the production method, the Carbon Trust label and the 'No antibiotics ever' label, respectively. $\in_{njt}$ is an unobserved random term that is distributed following an extreme value type I (Gumbel) distribution, independent and identically distributed (i.i.d.) over alternatives. The parameters corresponding to the three non-price attributes were modelled as random parameters assumed to follow a normal distribution, while the opt-out parameter was modelled as a fixed parameter.

Second, we investigated consumers' mWTP for beef burgers considering the design attributes main effects plus the interactions with several consumer characteristics with the attribute PRODUCT to test whether consumer mWTP for beef burgers is affected by those characteristics. As such, the specification of the utility (*U*) function in our study can be defined as follows:

$$U_{njt} = \alpha_n(ASC - PRICE_{njt} + \theta_{n1}PRODUCT_{njt} + \theta_{n2}CARBON_{njt} + \theta_{n3}ANTIBIOTICS_{njt} + \theta_4 PRODUCT_{jt} X\, GENDER_n + \theta_5 PRODUCT_{jt}\, X\, AGE_n + \theta_6 PRODUCT_{jt} X\, EDUCATION_n + \theta_7 PRODUCT_{jt} X\, RELIGION_n + \theta_8 PRODUCT_{jt}\, X\, HEARING_n + \theta_9 PRODUCT_{jt} X\, AAS_n + \theta_{10} PRODUCT_{jt}\, XFTNS_n + \theta_{11} PRODUCT_{jt}\, X\, NEP_n) + \in_{njt} \tag{3}$$

where θ_4, θ_5, θ_6, θ_7, θ_8, θ_9, θ_{10} and θ_{11} are the coefficients of the interaction terms between the attribute PRODUCT and the consumer characteristics. Specifically, GENDER is a dummy variable representing the gender of the consumer, taking the value of 0 for females and 1 for males. AGE is a continuous variable representing the age of the consumer in years. EDUCATION is an ordinal variable representing the education level of the consumer, taking the value of 1 for primary school, 2 for secondary/middle school, 3 for high school/college qualification (e.g. diploma) and 4 for university degree. RELIGION is a dummy variable representing whether the consumer is religious or not, taking the value of 1 for religious and 0 otherwise. HEARING is a dummy variable representing whether the consumer has heard the term 'cultured meat' (or 'lab-grown meat', 'artificial meat', 'clean meat', 'in-vitro meat' or 'synthetic meat') prior to the study, taking the value of 1 if the consumer has heard such a term and 0 otherwise. AAS is a variable representing the pro-animal welfare attitude of the consumers, assessed on a 5-point scale from 1 (strongly disagree) to 5 (strongly agree). FTNS is a variable representing the degree of neophobia towards new food technologies of the consumers, assessed on a 7-point scale from 1 (strongly disagree) to 7 (strongly agree). NEP is a variable representing the pro-environmental attitude of the consumers, assessed on a 5-point scale from 1 (strongly disagree) to 5 (strongly agree). The rest of the variables are specified as in Eq. (2). The parameters corresponding to the three non-price attributes were modelled as random parameters assumed to follow a normal distribution, while the opt-out and the interactions of PRODUCT with consumer characteristics (i.e. GENDER, AGE, EDUCATION, RELIGION, HEARING, AAS, FTNS and NEP) parameters were modelled as fixed parameters.

The MIXL model in the WTP space was estimated using the Stata module *mixlogitwtp.* (Hole, 2007)We ran different MIXL models using different number of draws, both with correlated and not correlated variables. Based on logL, AIC and BIC parameters, the best model was five hundred Halton draws with correlated variables that were used in the simulations.

Third, we investigated consumers' heterogeneity by calculating the distribution of the individual-level coefficients (i.e. mWTP) for PRODUCT, CARBON and ANTIBIOTICS using the kernel density estimation across individuals with the *kdensity* command in Stata. Next, based on the results from the distribution of the individual-level coefficients, which indicate the presence of consumer clusters, we performed the latent class logit (LCL) model in preference space (Greene and Hensher, 2003) to identify consumer clusters. The LCL model assumes that the overall population can be divided into two or more clusters by assuming constant model parameters within each group, capturing consumer heterogeneity by assuming a mixed distribution for the clusters (Greene and Hensher, 2003). The probability of class membership *s* depends on individual *n* choosing alternative *j* at time *t*, which consists of a certain set of observable attributes *x*' (Greene & Hensher, 2003):

$$Prob_{jnt|s} = \frac{exp(\boldsymbol{x'}_{ntj}\boldsymbol{\beta}_s)}{\sum_{j=1}^{Jn} exp(\boldsymbol{x'}_{ntj}\boldsymbol{\beta}_s)} \tag{4}$$

where $s = 1, \ldots S$ represents the number of classes, β'_s is the fixed (constant) parameter vector associated with class *s* and x_{njt} is a vector of attributes associated with each product. To establish the likelihood, these choice probabilities have to be multiplied across the choice sets and finally combined across all individuals.

To estimate the LCL model, we used the expectation–maximization (EM) algorithm, which allows for a good numerical stability and good performance in terms of runtime (Train 2008)(Bhat, 1997; Pacifico & Yoo, 2013; Train, 2008). The LCL model was estimated using the modules *lclogit2, lclogitml2* and *lclogitwtp* (Hong Il, 2020) on Stata.

All the models were estimated using Stata 16.1 software (Stata-Corp

Table 2
Estimated mWTP space from MIXL models with correlated variables for main effects in the United Kingdom, Spain, and France.

ATTRIBUTE	United Kingdom (N = 216)		Spain (N = 216)		France (N = 216)	
	mWTP (£/kg) (SE)	*p-value*	mWTP (€/kg) (SE)	*p-value*	mWTP (€/kg) (SE)	*p-value*
Product	0.59 (0.68)	0.39	−4.18 (0.64)	0.00	−5.27 (1.31)	0.00
Carbon	8.92 (1.25)	0.00	6.47 (0.78)	0.00	17.71 (2.60)	0.00
Antibiotics	7.36 (0.95)	0.00	9.43 (1.11)	0.00	20.61 (3.27)	0.00
Price	−1.59 (0.15)	0.00	−1.70 (0.10)	0.00	−2.48 (0.13)	0.00
Optout	−9.50 (0.62)	0.00	−13.17 (0.60)	0.00	−14.69 (1.32)	0.00
N. obs.	5832		5832		5832	
Wald chi2	515.95		933.75		528.37	
Prob > chi2	0.00		0.00		0.00	
logL	−1579.66		−1585.60		−1655.14	
df	15		15		15	
AIC	3189.33		3201.21		3340.29	
BIC	3289.40		3301.28		3440.35	

mWTP = marginal willingness to pay.
SE = standard error.
N. obs = number of observations.
Wald chi2 = Wald test.
logL = log likelihood function.
df = degree of freedom.
AIC = Akaike's information criterion.
BIC = Bayesian information criterion.

LP, College Station, USA).

5. Results

5.1. WTP Estimates: Main effects

The results of the estimation of the MIXL models using Eq. (2) in the WTP space using the main effects for the three countries are exhibited in Table 2. Specifically, we report the estimates (mWTP) for production method, Carbon Trust label, antibiotics use, price, and opt-out parameters as well as the corresponding standard errors (SEs) and significances for the attributes (*p-values*).

In all three countries, the mean estimate of mWTP for the opt-out option was negative and significant, suggesting that consumers tended to prefer one of the two product alternatives in a choice set as opposed to the 'opt-out' option. The results show that, on average, consumers in France (mWTP: −5.27 €/kg, *p-value*: 0.00) and Spain (mWTP: −4.18 €/kg, *p-value*: 0.00) tended to prefer the conventional beef burger, while British consumers did not show a particular preference for either conventional or cultured beef (mWTP: 0.59 £/kg, *p-value*: 0.39). In addition, in all three countries, consumers preferred beef burger with the Carbon Trust label and carrying the label 'No antibiotics ever'.

5.2. WTP Estimates: Main effects and interactions with consumer characteristics

The results from the estimation of the MIXL models using Eq. (3) in the WTP space using the main effects and interactions with consumer characteristics for the three countries are exhibited in Table 3. Specifically, we report the estimates for the main effects and the interactions of consumer characteristics with production method and opt-out parameters as well as the corresponding standard errors (SEs) and significances for the attributes (*p-values*).

The results show that across the three countries, the degree of

Table 3
Estimated mWTP space from MIXL models with correlated variables for main effects and interactions with consumer characteristics for the United Kingdom, Spain and France.

ATTRIBUTE	United Kingdom (N = 216)		Spain (N = 216)		France (N = 216)	
	mWTP (£/kg) (SE)	*p-value*	mWTP (€kg) (SE)	*p-value*	mWTP (€/kg) (SE)	*p-value*
Product	21.77 (6.34)	0.00	34.40 (13.03)	0.01	66.51 (14.67)	0.00
Carbon	8.63 (0.93)	0.00	7.24 (1.07)	0.00	15.49 (8.87)	0.00
Antibiotics	7.90 (0.91)	0.00	9.56 (1.29)	0.00	18.43 (2.94)	0.00
Price	−1.51 (0.11)	0.00	−1.81 (0.10)	0.00	−2.33 (0.14)	0.00
Optout	−9.15 (0.61)	0.00	−14.37 (1.06)	0.00	−14.04 (1.37)	0.00
Product X Gender	0.00 (1.25)	0.99	1.53 (2.16)	0.48	0.46 (2.37)	0.85
Product X Age	−0.07 (0.04)	0.09	−0.36 (0.08)	0.00	−0.49 (0.10)	0.00
Product X Education	−0.26 (0.63)	0.68	1.53 (2.16)	0.18	0.30 (1.88)	0.87
Product X Religion	0.22 (1.53)	0.89	−2.18 (2.02)	0.28	−3.76 (6.41)	0.56
Product X Hearing	1.13 (1.28)	0.38	−3.09 (2.18)	0.16	−4.81 (2.99)	0.11
Product X AAS	0.20 (0.86)	0.81	1.33 (1.57)	0.40	0.61 (3.07)	0.84
Product X FTNS	−3.22 (0.73)	0.00	−5.34 (1.24)	0.00	−5.65 (1.60)	0.00
Product X NEP	−1.51 (1.22)	0.22	−2.57 (1.79)	0.15	−6.77 (2.53)	0.01
N. obs.	5805		5832		5697	
Wald chi2	743.27		541.97		516.52	
Prob > chi2	0.00		0.00		0.00	
logL	−1549.51		−1568.17		−1597.43	
df	23		23		23	
AIC	3145.02		3182.34		3240.85	
BIC	3298.35		3335.77		3393.75	

mWTP = marginal willingness to pay.
SE = standard error.
N. obs = number of observations.
Wald chi2 = Wald test.
logL = log likelihood function.
df = degree of freedom.
AIC = Akaike's information criterion.
BIC = Bayesian information criterion.

neophobia towards new food technologies (FTNS) strongly negatively affected consumers' WTP for cultured beef burger, with a larger magnitude in France (mWTP: −5.65 €/kg, *p-value*: 0.00) and Spain (mWTP: −5.34 €/kg, *p-value*: 0.00), followed by the United Kingdom (mWTP: −3.22 £/kg, *p-value*: 0.00). Furthermore, AGE had a negative influence on consumers' WTP for cultured beef burger in France (mWTP: −0.49 €/kg, *p-value*: 0.00) and Spain (mWTP: −0.36 €/kg, *p-value*: 0.00). Thus, young consumers were willing to pay higher prices for cultured beef burger in Spain and France but not in the United Kingdom. In addition, we found that in France, consumers with a higher degree of pro-environmental attitude (NEP) were more likely to reject cultured beef (mWTP: −6.67 €/kg, *p-value*: 0.01).

5.3. WTP estimates: Distribution of individual mWTP values

Fig. 1 presents the distribution of mWTP values across individuals (kernel density estimates). Not only did the mean values for each mWTP differ, but some mWTP distributions were considerably more diffused than others. Specifically, for PRODUCT, British consumers' individual mWTP distribution was much more concentrated, indicating the

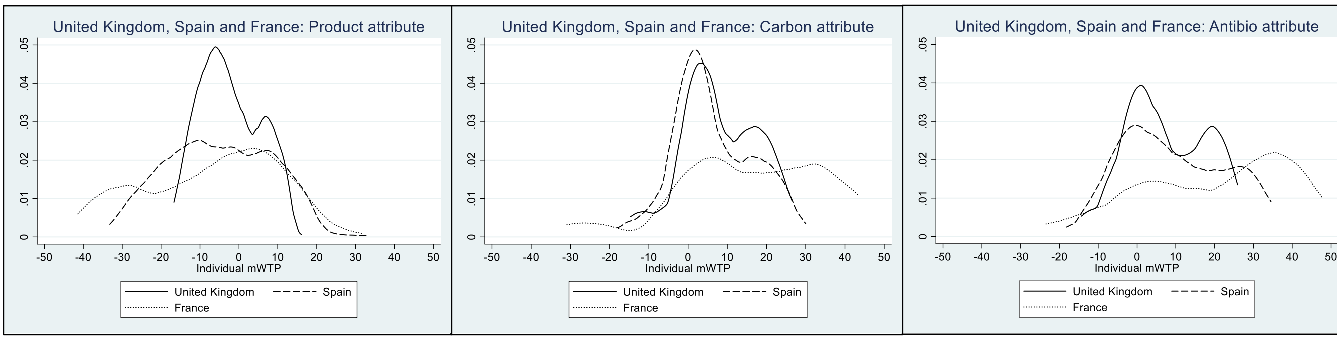

Fig. 1. Distributions of mWTP across individuals for the attributes PRODUCT (**left-side**), CARBON (**middle-side)** and ANTIBIOTICS (**right-side)** for the United Kingdom, Spain, and France.

presence of two possible homogeneous clusters of consumers, while for Spanish and French consumers, the distributions are more heterogenous. For the attributes CARBON and ANTIBIOTICS, for the British and Spanish consumers, the individual mWTP distributions show two possible consumer clusters, both with positive mWTP, while for French consumers, the distribution is much more diffused but with a large segment at high mWTP values.

5.4. *WTP Estimates: Latent class logit (LCL) model*

In view of the multimodality of some of the attributes within the MIXL model, as shown in the previous section, we now investigate the possibility that there are distinct clusters of consumers. To investigate this form of consumer heterogeneity, we estimated the LCL models for each country.

Based on the BIC values and the size of the segments, we choose the three-clusters solution for all the countries.

For the United Kingdom, the results of the LCL model with the three-clusters solution are reported in Table 4, including the mWTP for production method, Carbon Trust label, antibiotics use, price, and opt-out parameters as well as the corresponding standard errors (SEs) and significances for the attributes (*p-values*). Groups 1 ('Traditionalists': 44 consumers, 20 % of the sample) and 2 ('Undecided': 71 consumers, 33 % of the sample) include consumers who do not show a particular significant preference for any of the attributes investigated, although the first one present larger coefficients pointing out that those consumers tend to prefer beef burgers produced with a conventional production method, branded with the Carbon Trust label, and labelled with the claim 'No antibiotics ever'. Group 3 ('Innovators': 101 consumers, 47 % of the sample) is the largest group of consumers; they are willing to pay a premium price for cultured beef burger (5.10 £/kg, *p-value*: 0.00) without the claim 'No antibiotics ever' (-2.06 £/kg, *p-value*: 0.04).

The results of the LCL model for Spain with the three-clusters solution are reported in Table 5. Group 1 ('Undecided': 69 consumers, 32 % of the sample) includes consumers who do not show a particular preference for any of the attributes investigated. Group 2 ('Traditionalists': 66 consumers, 30 % of the sample) consumers prefer beef burgers produced by the conventional method (-13.76 €/kg, *p-value*: 0.00) and labelled with the claim 'no antibiotics ever' (3.83 €/kg, *p-value*: 0.00).

Table 4
Estimated mWTPs from the LCL model for the United Kingdom.

ATTRIBUTE	GROUP 1 Traditionalists (*N = 44*)		GROUP 2 Undecided (*N = 71*)		GROUP 3 Innovators (*N = 101*)	
	mWTP (£/kg) (SE)	*p-value*	mWTP (£/kg) (SE)	*p-value*	mWTP (£/kg) (SE)	*p-value*
Product	–23.17		−1.10		5.10	
	(23.13)	0.11	(0.59)	0.06	(1.11)	0.00
Carbon	49.52		0.91		0.64	
	(29.04)	0.09	(0.62)	0.14	(0.93)	0.49
Antibiotic	45.84		0.89		−2.06	
	(25.76)	0.08	(0.59)	0.13	(0.99)	0.04
Optout	−63.49		−3.55		−14.84	
	(35.49)	0.07	(0.59)	0.00	(1.20)	0.00
BIC	3084.8					

mWTP = marginal willingness to pay.
SE = standard error.
BIC = Bayesian information criterion.

Table 5
Estimated mWTPs for LCL model for Spain.

ATTRIBUTE	GROUP 1 Undecided (*N = 69*)		GROUP 2 Traditionalists (*N = 66*)		GROUP 3 Innovators (*N = 81*)	
	mWTP (€/kg) (SE)	*p-value*	mWTP (€kg) (SE)	*p-value*	mWTP (€/kg) (SE)	*p-value*
Product	0.41		−13.76		3.35	
	(5.02)	0.94	(2.14)	0.00	(0.80)	0.00
Carbon	−28.00		2.40		0.86	
	(14.62)	0.06	(1.26)	0.06	(0.78)	0.27
Antibiotic	−38.36		3.83		−0.59	
	(20.02)	0.06	(1.30)	0.03	(0.79)	0.46
Optout	43.40		−7.15		−15.13	
	(23.96)	0.07	(1.22)	0.00	(1.06)	0.00
BIC	3129.57					

mWTP = marginal willingness to pay.
SE = standard error.
BIC = Bayesian information criterion.

Table 6
Estimated mWTPs from the LCL model for France.

ATTRIBUTE	GROUP 1 Innovators (*N = 64*)		GROUP 2 Undecided (*N = 88*)		GROUP 3 Traditionalists (*N = 64*)	
	mWTP (€/kg) (SE)	*p-value*	mWTP (€kg) (SE)	*p-value*	mWTP (€/kg) (SE)	*p-value*
Product	2.68		−0.48		–22.49	
	(1.10)	0.02	(2.38)	0.84	(5.14)	0.00
Carbon	2.50		−17.16		6.13	
	(0.95)	0.01	(5.50)	0.00	(2.38)	0.01
Antibiotic	−0.48		−18.64		12.23	
	(1.09)	0.66	(6.16)	0.00	(3.02)	0.00
Optout	−20.38		10.65		2.73	
	(2.19)	0.00	(6.47)	1.00	(3.22)	0.40
BIC	3281.71					

mWTP = marginal willingness to pay.
SE = standard error.
BIC = Bayesian information criterion.

Group 3 ('Innovators': 81 consumers, 38 % of the sample) is the largest group of consumers; they are willing to pay a premium price for cultured beef burger (3.35 €/kg, *p-value*: 0.00).

The results of the LCL model for France with the three-clusters solution are reported in Table 6. Group 1 ('Innovators': 64 consumers, 30 % of the sample) consumers are willing to pay a premium price for cultured beef burger (2.68 €/kg, *p-value*: 0.02) branded with the Carbon Trust label (2.50 €/kg, *p-value*: 0.01). Group 2 ('Undecided': 88 consumers, 40 % of the sample) includes consumers who do not show a particular preference for production method, but they dislike beef burgers branded with the Carbon Trust label (-17.16 €/kg, *p-value*: 0.00) and labelled with the claim 'No antibiotics ever' (-18.64 €/kg, *p-value*: 0.00). Group 3 ('Traditionalists': 64 consumers, 30 % of the sample) includes consumers who prefer beef burgers produced with the conventional method (–22.49 €/kg, *p-value*: 0.00), branded with the Carbon Trust label (6.13 €/kg, *p-value*: 0.01) and labelled with the claim 'No antibiotics ever' (12.23 €/kg, *p-value*: 0.00).

6. Discussion

This study investigated and compared, for the first time, British, Spanish, and French consumers' preferences and WTP for hypothetical cultured beef burgers. Several main results were identified. First, our results suggest that the United Kingdom is the most promising market for cultured beef burgers given the more positive acceptance of this new product from the British respondents than from the Spanish and French respondents. Second, in each country, we found a potential market segment of consumers (i.e. innovators) who are willing to pay a premium price for cultured beef burger - up to 47 % in the British sample, 38 % in the Spanish sample and 30 % in the French sample. These findings are corroborated by previous studies (for example, Siegrist and Hartmann 2020; Gómez-Luciano et al. 2019; Verbeke, Sans, and Van Loo 2015) which show that British and Spanish consumers are more enthusiastic than French consumers towards cultured meat. This finding is also in line with previous research showing that French consumers have more negative attitudes (vs Germans) towards cultured meat (Bryant et al., 2020). However, our results differ from Gómez-Luciano et al.'s (2019) finding that Spanish consumers are more willing to buy cultured meat than British consumers. Third, we found that, on average, consumers prefer cultured beef burger that carries the Carbon Trust label and is labelled with the claim 'No antibiotics ever'. This finding is corroborated by Asioli et al. (2022) in a study about cultured chicken in the United States. Furthermore, we found that the segments of consumers who are willing to pay a premium price for cultured beef burger (i.e. innovators) differ in their labeling preferences across countries. Specifically, British consumers prefer cultured beef burgers labelled without the claim 'No antibiotics ever', Spanish consumers do not care for the Carbon Trust label and the claim 'No antibiotics ever', while French consumers prefer cultured beef burgers branded with the Carbon Trust label. Fourth, we found that younger consumers tend to accept cultured beef more than do older consumers. This finding is corroborated by Slade (2018), Zhang et al. (2020) and Chriki et al. (2021), who found that younger consumers had a more positive attitude than older consumers towards cultured beef. Fifth, we found that consumers with a higher degree of neophobia towards new food technologies strongly reject cultured beef. This finding is corroborated by previous research (Bryant, et al., 2019b; Wilks et al., 2019). Sixth, we found that French consumers are more likely to reject cultured meat if they had higher pro-environmental attitudes which could be due to the fact that they are misinformed about the environmental impact of cultured meat compared to conventional meat. Interestingly, we found that a group of French consumers dislike the Carbon Trust label. Speculatively, this could be due to the misinformation about the environmental impact of cultured meat or lack of familiarity or understanding of such type of carbon footprint label (Hocquette et al., 2022; Rondoni & Grasso, 2021; Sirieix et al., 2012). Seventh, we found that similar to Van Loo et al. (2020) in the United States and Carlsson et al. (2022) in Sweden, majority of consumers prefer conventional over cultured beef burger and that younger consumers tend to prefer cultured meat. We found however that gender and education do not affect consumer acceptance for cultured meat.

These findings have important implications for food businesses. First, since the United Kingdom seems to represent a larger potential market for cultured beef compared to Spain and France, global cultured beef producers could target the initial launch of this new product in the United Kingdom. However, smaller potential markets for cultured beef can also be identified in Spain and France. Hence, for Spanish or French cultured beef producers, an effective strategy might be to target both markets (i.e. France and Spain), for instance, by setting up alliances with retailers in both countries. Second, food businesses could also benefit from the marketing of cultured beef burger branded with the Carbon Trust label and labelled with the claim 'no antibiotics ever' if the latter is technologically feasible. Third, companies who wish to enter the cultured meat market could enhance the path of building a responsible and inclusive technology, by supporting depopulated areas or meat subsectors in decline or with environmental problems (Chiles et al., 2021; Eastwood et al., 2021). These approaches may support the development of a technology more involved with the problems of today's society and could at least partially lessen some perceptions of cultured meat as artificial food (Weinrich et al., 2020) or detached from rural areas (Hebinck et al., 2018). In addition, cultured beef producers should target the launch of the new product to younger people and consumers with a low degree of new food technology neophobia since these might be the early adopters of cultured beef burgers.

Further research is needed to test the robustness of our findings with other cuts of cultured beef and other types of meat (i.e. chicken, pork, and lamb). Similar studies should also be conducted in other countries given the expected increase in demand for cultured meat in many parts of the world. Future studies should further investigate consumers' WTP by conducting non-hypothetical experiments using experimental auctions (Canavari et al., 2019) or real choice experiments (RCE) (Gilmour et al., 2019) combined with sensory evaluations (Asioli et al., 2017) of cultured meat to test the robustness of our findings. Moreover, future research should investigate heterogeneity in trust of carbon labeling across consumers.

7. Policy implications & conclusions

Several policy implications can be derived from this study. First, the differences observed in consumer WTP for cultured meat among the United Kingdom, Spain, and France suggest that the potential for shifting to more sustainable and health diets by introducing cultured meat in the EU market differs among countries. These results should be considered in the cultured beef development and market launching processes that should be customized to the specific market segments that are willing to pay a premium price for this new product in each country. These findings are also relevant for designing EU policies that contributes to foster diet shifts by introducing in the EU market cultured meat products as well as other alternative protein products (e.g. plant-based, insect-based, algae-based, etc.). The Food 2030 Pathway for Action focusing on "Alternative Proteins and Diet Shift" (European Commission, 2021) research and innovation policy should incorporate recommendations that highlight the importance of new product development processes and market launches being guided by the consumer segments (i.e. innovators, younger and less neophobic) that are willing to pay a premium price for new alternative protein products in each country. This study also shows that market segments are minorities relatively large in each country. In this context, market research with both hypothetical and real products become a key activity in the new product development processes to achieve the desired dietary shift. Second, the relatively large group of respondents across the three European countries investigated who are willing to pay a premium price for cultured meat, suggests that cultured meat can have a significant potential market in Europe and thus could offer relevant business opportunities for cultured meat producers. Given the challenges of traditional livestock producers being able to meet the sustainability needs, EU policy makers can support producers who wish to move from traditional livestock to cultured meat production through financial incentives to purchase new equipment, training, access to market data, etc. needed to produce and market cultured meat. Third, EU policy makers should increase funding resources to conduct more consumer and marketing research to gather more refined information about consumer preferences for cultured meat which can be used to increase the acceptance (e.g. how to nudge consumers, which specific labeling information consumer prefer, which beef cuts should be marketed, etc.). Fourth, we found that on average Spanish and French respondents tend to value cultured meat significantly differently than conventional meat which suggests a need for labeling regulations in those countries to help consumers make more informed purchase decisions by allowing them to identify cultured meat. Indeed, consumers are likely to demand transparency and the right to know what they are purchasing, especially for the consumer segments who are willing (i.e. innovators) or unwilling (i.e. traditionalists) to pay a premium price for cultured meat. Thus, it is of crucial importance that policy makers support the establishment of a regulatory framework controlled by authorities to ensure effective and standardized cultured meat labeling that consumers can trust and use to make more informed choices (Ong, Choudhury, and Naing, 2020). Fifth, we found that consumers are willing to pay a premium price for beef produced with lower carbon footprint and without using antibiotics. Thus, governments should increase their investments and support the reduction of carbon footprint and use of antibiotics in meat production. Similar to what may happen for conventional meat, consumer preferences for beef produced with lower carbon footprint may lead to a risk of opportunistic behaviour from cultured meat producers in the market, e.g., by using unverified claims. Thus, we argue that in the initial period of the introduction of cultured meat, public authorities should remain the main actor and provide standards, information, and control procedures for cultured meat labelling to reduce the potential of negative issues arising from information asymmetry between practitioners (i.e. producers and retailers) and consumers. Subsequently, markets driven by consumers may slowly stimulate the food business to adopt labelling more strongly. Sixth, our findings suggest that older people and those who have higher levels food technology neophobia are more reluctant to purchase cultured meat. Thus, governments should promote consumer education campaigns aimed at informing consumers about the benefits of cultured meat by focusing more on intrinsic attributes of the meat that are similar to conventional meat rather than focus on the technology of production which differs between conventional and cultured meat.

Overall, this manuscript advances the understanding of the future potential market for cultured meat in two main ways. First, in the investigated European countries there is a potential large group consumers (i.e. between 30 and 50 %) who are willing to pay a premium price for cultured beef. Second, this positive consumer preference differs in consumer group size, magnitude of the premium price, and preference for food labeling regarding environmental impact and antibiotics use. This also highlights the importance of conducting cross-country studies.

In conclusion, our findings show that consumers' WTP for cultured beef depends on their country of residence, age, and their degree of neophobia towards new food technologies. Our results provide insights into consumers' acceptance that can be useful for designing effective ways to communicate the potential benefits of cultured meat to the public to maximize the chances of making these products commercially viable.

8. Transparent Reporting

Pre-registration of the study is available in https://aspredicted.org/blind.php?x=hz9pk4.

CRediT authorship contribution statement

Daniele Asioli: Conceptualization, Methodology, Formal analysis, Software, Supervision, Validation, Writing – review & editing. **Joaquìn Fuentes-Pila:** Project administration, Supervision, Funding acquisition, Writing – review & editing. **Silverio Alarcón:** Formal analysis, Validation, Software, Writing – review & editing. **Jia Han:** . **Jingjing Liu:** Formal analysis, Software. **Jean-Francois Hocquette:** Conceptualization, Writing – review & editing. **Rodolfo M. Nayga:** Conceptualization, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodpol.2022.102376.

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