



Sustainable diets and meat consumption: consumers' preferences towards cultured meat

Matteo Carzedda, Stefania Troiano

aprile 2021

n. 1/2021

Politica Economica e Economia Applicata

Sustainable diets and meat consumption: consumers' preferences towards cultured meat

M. Carzedda¹, S. Troiano²

¹ Department of Economics, Business, Mathematics and Statistics (DEAMS), University of Trieste, P.le Europa, 1, 34127, Trieste (TS), Italy.

² Department of Economics and Statistics (DIES), University of Udine, via Tomadini 30/a, 33100, Udine (UD), Italy.

Abstract

The aim of this study was to investigate young consumers' preferences towards cultured meat. Due to the negative environmental impacts associated to the production and consumption of meat, several stakeholders are discussing about the need to adopt a more sustainable behavior towards food consumption, also as far as meat is concerned. A survey was carried out to collect data about consumers' habits and preferences when buying and consuming food. Part of the questions of the interview were devoted to understand consumers' willingness to consume cultured meat, and a choice experiment (CE) was used to point out consumers' preferences among different hamburgers (i.e. conventional meat, vegetarian meat, cultured meat).

According to the results, in general, some specific features of the hamburger, such as in vitro production of meat, foreign origin, or larger carbon footprint, contributed in reducing the utility of consumers.

To evaluate the heterogeneity of preferences characterizing the demand of different respondents, a latent class model was estimated. Our results suggest that actions focused on improving the level of transparency on cultured meat technology and enhancing consumers' information about the potential benefits deriving from its implementation, may be helpful tools in overcoming major challenges in developing new niche markets.

Keywords: cultured meat, consumer preference, environmental concern, food sustainability.

Introduction

According to Costantini et al. (2021), animal production and livestock industry' has been recognized as one of the major drivers of global warming and climate change, being responsible for the generation of roughly 20% of greenhouse gases (GHGs) emitted worldwide and to some 35% of GHGs emissions created within the agricultural sector only. In addition, Barouki et al. (2021) highlighted that the emergence and spread of SARS-CoV-2 appears to be related to a number of human activities including intensive livestock farming.

Livestock production plays a major role in enhancing methane and nitrous oxide concentration in the Earth's atmosphere, mainly arising from the mismanagement of animal manure and from their process of digestion. In exacerbating this trend, the projected long-lasting increase in global population density

and higher per capita income are expected to further fuel the rise in the demand for animal-based proteins in the forthcoming years (Aleksandrowicz et al., 2016). In light of the manifold adverse implications arising from the production and consumption of animal-based products, a heavy restriction in the intake of meat on a global scale may constitute the only possible solution allowing to mitigate human-induced negative pressure on the natural environment, and to prevent potential imminent and irreversible harms on the ecosystems' stability in the upcoming future (Weinrich, 2019). During the past decades, several research studies and Life Cycle Assessments have focused their attention on the investigation of the negative environmental and health implications arising from the adoption of dietary regimes rich in animal-based products (Bhatt and Abbassi, 2021; Costantini et al., 2021), ultimately agreeing that the potential restriction in the intake of meat and dairies, in favour of a higher consumption of plant-based foods – such as cereals and legumes, could bring about very positive results in terms of climate change mitigation, land-use change, water and air pollution, and natural resources preservation (Sun et al., 2015; The EAT Lancet Commission, 2019). Nevertheless, past experience reveals that reversals of individuals' preferences and consumption behaviours are very hard to be undertaken, and in general, are likely to take some time to become final (Faccio et al., 2019; Kadim et al., 2015). This condition holds especially when talking about food consumption, and consumers' inflexibility seems to be quite pronounced when facing the idea of reducing, or substituting, their habitual intake of meat (Van der Weele and Driessen, 2013). Alongside the various plant-based vegetarian alternatives to conventional meat available on the market, the past two decades have unveiled a rising global interest for the idea of creating meat products within a laboratory, that is producing cultured meat (Alexander, 2011; Alexander et al., 2017; Jairath et al, 2021). More specifically, cultured meat represents an animal-based alternative to conventional meat, being it produced in vitro, by growing a sample of cells extracted from the body of a living animal, using advanced engineering techniques. The idea behind this innovative technology is to promote the creation of a product which could substitute meat, while keeping the same aspect, taste, and composition of conventional meat, but whose production process could allow for a lower impact to be generated on the environment, compared to the conventional forms of livestock production (Siegrist and Hartmann, 2020). A number of researchers have tried to point out some of the major environmental advantages associated with the potential application of cultured meat techniques to the production of animal-based proteins for direct human consumption (Treich, 2021; Zhang et al., 2020). Indeed, available results are actually positive and quite optimistic, and this innovative technology has been acknowledged as a very promising solution allowing to keep producing and consuming meat, while alleviating most of the adverse environmental and health burdens arising from conventional livestock practices.

We decided to investigate consumers' preferences towards cultured meat, identifying in detail young consumers' willingness to consume this product. A number of studies analyzed preferences towards cultured meat (e.g. Bryant and Barnett, 2018, 2020; Bryant and Sanctorem, 2021; Slade, 2018; Zhang and Bai, 2020; Weinrich et al., 2020), but only a limited number of them so far have studied Italian consumers (e.g. Mancini and Antonioli, 2019, 2020; Palmieri et al., 2020). Consequently, we have decided to carry out a survey to better understand Italian consumers' attitude and behaviour when purchasing this product. Then a quantitative analysis has been performed, aimed at investigating consumer's reactions when facing the idea of substituting their habitual conventional meat intake, with meat products grown in vitro. Data were collected through the establishment of an on-line questionnaire mainly addressed to students from the University of Udine because of potential consumption of young citizens (Chriki and Hocquette, 2020). The survey presents three major parts: the first one is devoted to the investigation of the demographic characteristics of the respondents; the second part analyses the eating lifestyle of participants, with a specific regard to the importance they attach to the intake of meat

within their habitual diets; finally, the third part focuses on the evaluation of the general level of knowledge on cultured meat, and of the propensity to purchase and consume this type of product. Also, the final part of the survey aims at analyzing participants' consumption preferences, and critical factors driving their decisions while purchasing meat products. This last step was realized by performing a Choice Experiment, in which respondents were called to indicate their preferred option among a set of three alternative hamburgers, differentiated among them on the basis of a set of specified attributes. The method gave the possibility to evaluate the degree of importance they associated to each of the attributes characterizing the commodities, thereby allowing to understand their consumption preferences when purchasing meat products

Method

The main objective of the exploratory study was to investigate the consumption attitude and behaviors of individuals towards meat consumption, primarily focusing on their willingness to accept for a substitution in their habitual meat intake, and on their perception of clean meat products. The enquiry was researched with the aid of an online survey sent to all students, professors and all the administrative staff of the University of Udine.

Given the limited availability of alternative resources, the just mentioned research tool has been applied. The study focused on collecting four types of information on the participants: firstly, the demographic data; secondly, the food preferences and habitual dietary pattern; thirdly, the consumption attitude and degree of attachment to conventional meat-based products; and fourthly, the willingness to purchase and consume cultured meat products, together with their opinion on different topics related to cultured meat. Given the objective of the inquiry, the survey was divided into three major parts. The first part was devoted to the investigation of participants socio-demographics, including for instance gender, age, and level of education. The next part of the survey was addressed to the analysis of respondents' habitual dietary regime, attitude towards different types of food, and of the importance they attributed to the consumption of meat products within their diets. This part of the survey was also devoted to test the importance attributed to sustainability at the moment of food consumption. The last part of the survey focused on the topic of cultured meat, investigating participants' knowledge and propensity to taste this product and analyzing their perceptions on the level of naturalness, safety, good taste, and environmental sustainability of meat grown in vitro. The last part also required participants to answer to six groups of multiple choice questions, for which they had to select one type of hamburger among a set of three different alternatives. The specific hamburger chosen by respondents allowed to raise information on the criteria driving each respondent's choices when purchasing and consuming meat products. The survey was accessible in Italian, for one month between May 2nd and June 3rd 2019.

The study used a convenience sampling method, that is only the replies of the individuals that voluntarily decided to participate to the survey were considered within the analysis. One of the advantages of this method is given by the fact that the sample consists on a group of people which is relatively easy to contact and to reach. The methodology chosen to conduct the analysis simply consisted on the direct distribution of questionnaires to participants. This was recognized as the best way to collect information from respondents, given the research objective. Indeed, it allowed for an adequate amount of contributions to be gathered, in a relatively short period of time. Questionnaires had a quantitative nature, which means it was almost exclusively based on closed questions, based on single and multiple choice answers. The survey was structured based on the principles of simplicity and essentiality, that is questions

were designed to be highly comprehensible and straightforward, in order to encourage participants to answer. Nevertheless, the clarity of the questions was preventively tested by sending the survey to a sample of relatives and friends, in order to check whether eventual corrections were required, before definitely launching the questionnaire. Participants could access and complete the questionnaire in an online platform. In particular, the website link of the questionnaire was advertised by email address to all students, as well as all teachers, and the administrative staff, of the University of Udine. This allowed to guarantee higher simplicity to respondents in directly accessing the questionnaire. Besides, the questionnaire remained accessible to the external public online, so that everyone which showed an interest for the topic analyzed, could have the possibility to complete it. This allowed to slightly increase the number of contributions collected. Ultimately, the tool allowed to collect a sufficient amount of replies, thereby preventing further reminders to be sent. The online platform chosen to perform the analysis and collect the data from the survey, was the “EUSurvey” tool, representing the official survey management tool established by the European Commission.

The first part of the survey aimed at identifying the average socio-demographic features of the respondents. The second section were devoted to the analysis of respondent’s food consumption habits, and to the investigation of the major factors driving their usual food purchase and consumption activities. The section was divided into three major parts: i) the first one to investigate the general food consumption habits of the respondents, and the role of sustainability during their food purchasing activities; ii) the second one to evaluate the importance attributed to meat as a regular meal, and the individual willingness to accept for a reduction in the daily intake of meat; iii) the third part will discuss the level of knowledge and the perception of respondents on the topic of clean meat.

Results and discussion

Respondents’ characteristics

1069 replies were ultimately collected. The greatest part of the respondents is female, specifically the 63%, while only 37% of the sample is constituted by males. This may suggest that women are more inclined to care about the healthiness of their dietary regimes, and show higher interest for the argument of sustainable diets. Investigating the age distribution of the sample, it is possible to argue that the vast majority of respondents are within the university student age range boundaries (658 people, 62%), hence between 18 to 25 years old. This is not surprising, given that the questionnaire was primarily targeted to a population of students. The mean age of the sample amounts to 29.66 years. The median value was also calculated, in order to have a more realistic picture of respondents’ age, and avoid extreme values of the distribution from affecting the final results. The median age of the sample is 24 years. When considered individually, ages of 20 and 21 are the single age-years including the majority of respondents (127 people each).

Data about the geographical distribution of respondents were collected by asking them their region of origin. The vast majority of participants declared to come from Friuli Venezia Giulia Region (74%), followed by Veneto (16%) and Trentino Alto Adige (6%). Other regions play just a marginal role in the distribution. The final results were actually quite predictable, being the majority of respondents students attending university in Udine (Friuli Venezia Giulia).

As far as the level of education is concerned, the majority of the sample, 57.25% of the respondents specifically, indicated the option “High school degree” as education level. This is in line with the previous findings about age. About 33% of participants declared to hold a bachelor or master university degree,

while 89 people stated to have attended a PhD course. Only a small minority declared to have attended just a few years of education (16 people, 1.50%). This suggests that the average level of education characterizing the sample is quite high.

As expected from the abovementioned findings about age and education, the greatest part of the sample declared to be a student. This option has been chosen by 709 people, namely the 66% of the sample. The share of participants reporting “Subordinate worker” as a profession is also considerable, and amounts to 28%. The remaining part of the sample includes 40 autonomous workers, 9 unemployed people, 7 housewives, and 6 retired individual.

With the objective of investigating the academic field of study characterizing students participating to the survey, a “filter” question was included, that is a question which is visible to respondents only if a specific condition is present. In this case, the condition required the participant to be a student. A large proportion of students is engaged in scientific (40%) and humanities (28%) disciplines. Respondents attending a university course included in one of these two academic fields combined, amount to an overall 481 individuals, on the total of 709 respondents declaring to be a student. This may suggest a particular attraction for the survey topics among students interested in scientific and humanistic subjects. With respect to the other options, 127 students declared to be engaged in the economics and law field, while 101 are involved in some medical discipline studies.

Approximately 64% of the respondents belongs to a family composed of 3 to 4 persons (including the interviewee), while 18% of them declared their families to count more than 4 members. 40 people stated not to have any additional family member, outside of herself\himself. This could be explained by the fact that many respondents – students at the first place – may live on their own in the city of studies or work.

Respondents' eating behaviour

To obtain a first comprehensive picture of the habitual eating lifestyles and general food preferences of the respondents, the first question required them to identify their own habitual dietary regime among a set of six different alternatives, namely 1) omnivorous, 2) vegetarian, 3) vegan, 4) pescatarian, 5) flexitarian, and 6) others. In order to avoid for misunderstandings while answering the question, a specific definition of “Flexitarian” was explicitly provided to respondents, as an “individual regularly eating foods of animal origin, but on a limited amount”.

The vast majority of respondents habitually follows an omnivorous diet. This option has been chosen by 939 individuals. This may initially indicate that the average individual is likely to consume animal-based products on an ordinary basis, and that maybe is not thinking about restricting their habitual intake. As a matter of fact, just roughly 8% of the sample declared to pay attention to the amount of meat consumed (chooses the “Flexitarian” option), while less than 3% (25 people) of respondents described themselves as “Vegetarian”. Vegan and pescatarian individuals constituted only marginal shares of the sample.

The importance participants attributed to good nutrition habits was tested using a Likert-type scale from 1 (absolutely not important) to 10 (absolutely important). Answers to this question revealed mean values of 8.9, indicating that the average respondent actually considerably cares about conducting a healthy lifestyle through nutrition. More specifically, 980 individuals chose value “10” as the answer to this question (“How much do you think your diet is important for your health?). Consequently, participant’s eating habits were identified by asking them to indicate the frequency in the consumption of various foods during the past week. Some of the foods included in the option pool were meat, dairies, vegetarian meat alternatives (i.e. soy-burgers, tofu, seitan) and plant-based substitutes for dairies. The answering categories adopted were: “Never”, “1-2 times per week”, “3-4 times per week”, and “5 or more times per week”.

As expected, findings highlighted that the vast majority of the respondents constituted meat-eaters individuals. Indeed, approximately 62% of the sample declared to have consumed meat 3 or more times during the past week. Some 33% said to have consumed moderate amounts of meat, restricting consumption events to 1 or 2 times a week. Few people did not consume meat at all, 54 individuals precisely. In contrast, almost the majority of them never ate vegetarian alternatives to meat. Only a small proportion of respondents (7 people) indicated to have consumed vegetarian meals more than 5 times during the week, while 14 individuals declared to have eaten them at least 1-2 times on a weekly basis. This is quite in line with previous findings, in that non-meat eaters only constituted a very small proportion of the sample.

Focusing on the other categories of foods, in general, respondents have revealed to conduct a healthy eating lifestyle, with the majority of them having consumed fruits, vegetables, and cereals at least 5 times during the past week. Fish was only rarely consumed by the most (70% of the respondents consumed fish only 1-2 times per week), but this could be easily explained considering that the vast majority of respondents are students, and presumably could not afford a more frequent intake. As much as plant milk and other vegetable-based dairy alternatives are concerned, final results were quite similar to those obtained in the case of vegetarian meat products, with the majority of respondents (75%) never having consumed these products during the week. However, results revealed that, compared to plant-based meat substitutes, plant-based dairy alternatives were on average slightly preferred by respondents: as a matter of fact, 102 people declared to have consumed them at least 3 times during the week, compared to only 21 people having eaten vegetarian meat on an equal frequency.

Subsequently, participants were also asked to indicate the extent in which they deem actual environmental issues to be important in their life, using a Likert-type scale from 1 (absolutely not important) to 10 (absolutely important). Recipients were provided with some examples of environmental problems in brackets, just in order to be sure the question was fully comprehensible for them, i.e. global warming, climate change, air and water pollution. Answers to this question resulted on an average value of 9.05, indicating a general high level of involvement of respondents in current global environmental issues. The major part of respondents, specifically 54%, declared to consider current environmental problems as absolutely important (chose the answer “10”), while only 10 people indicated a value lower or equal to “4”.

Respondents' opinions about food impacts

The following question was focused on asking respondents to state whether they thought their habitual eating habits could have negative implications for the environment. The answering options in this case were only two, namely “Yes” or “No”. Participants are more or less equally divided between believing their food choices could have, or not, some implications on the environment. However, a slightly higher number of individuals seems to be convinced that by changing the way they eat, they could potentially contribute in ameliorating the environmental conditions: these people amount to 569, compared to some 500 who were not convinced about it.

Subsequently, the respondents were asked to indicate the food commodity they perceived as the most burdening for the environment. A single choice question was applied, and the set of available alternatives included: 1) “Red meat (beef, lamb,..)”, 2) “White meat (chicken, turkey,..)”, 3) “Dairies (milk, cheese, yogurt,..)”, 4) “Fish”, 5) “Fruits and vegetables”, 6) “Cereals (pasta, rice, bread,..)”, and 7) “Meat substitutes (e.g. soy-based)”. Some 70% (735 people) of respondents was aware of the unsustainability of red meats, and indicated them as the perceived most burdening food category. Interestingly, 101 respondents reported the option “Meat substitutes” as answer, indicating that vegetarian alternatives may

be perceived as a very injurious commodity towards the environment, even more than poultry and dairy products, which instead were selected by 43 and 24 individuals respectively. This result, however, could possibly be biased by the existence of a sort of prejudice against those individuals following a vegetarian or vegan diet, which could maybe be attributed to a general lack of dietary information.

Some information was collected on the level of awareness and involvement of participants towards environmental issues, and their relationship with the food system. Participants were asked to report their willingness to accept a substitution of their habitual meat intake with alternative plant-based vegetarian products (e.g. pulses, seitan, tofu). This passage was tested using a Likert-type scale from 1 (strongly disagree) to 10 (strongly agree). The average response highlighted that the sample had, in general, a neutral intention of changing behaviour about meat consumption, showing an overall sense of indifference in shifting towards plant-based alternatives. As a matter of fact, the average value amounted to 4.7. More specifically, 423 respondents declared to prefer animal-based meals, selecting a value on the Likert-scale ranging from 4 below. 196 people stated not to be willing to give up meat at all (indicated the option “1”), compared to 70 people which expressed the maximum promptness in substituting their habitual intake (indicated the option “10”).

The level of meat attachment and food neo-phobia of participants were tested by requiring individuals to indicate the extent in which they agreed or disagreed with a set of five sequential statements (e.g. “I fear trying new foods” or “Meat is not replaceable in my diet”). Four answering options were available, namely “Strongly disagree”, “More than not”, “More than yes”, “Totally agree”.

The expression food neo-phobia indicates the tendency of individuals to be reluctant towards, and ultimately reject, eating foods they have never tried before. As a matter of fact, people affected by food neo-phobia tend to approach novel foods with extreme caution, and possibly, to eschew them in favour of habitual commodities. Drivers of food neo-phobia could be manifolds, including the fear of incurring in negative consequences in terms of health, perceived disgust for how the food is produced, and dislike for the food’s features and appearance (Pliner and Salvy, 2006).

We analyzed the reactions of participants by asking to indicate how they thought the statement “I fear trying new foods” could represent their own situation. A large proportion of respondents does not agree at all, or moderately disagrees, with the statement. These two options combined were chosen by 901 respondents. This may indicate that, in general, the sample is ready to accept new foods, and could be willing to purchase and try them at least once. However, there still exists a minority of people showing a certain degree of hesitation: 148 people stated they are more inclined not to consume novel foods: this may indicate that specific features of the food commodity under discussion, could play a role in determining the ultimate decision of respondents to consume or avoid a specific item.

The reactions to the statement “I always try new foods when I can” were also analyzed. As predictable from the findings beforehand revealed, approximately 70% of participants declared to be opened to experience novel meals, whenever possible. This may indicate a general sense of curiosity in trying new foods, characterizing the sample.

The next two statements have been introduced with the aim of evaluating the level of affective connection of respondents towards conventional meat products, and the degree of importance they attributed to meat for their individual wellbeing. More or less 24% of the sample considers meat as an indispensable meal to be consumed on a regular basis, while an additional 36% moderately agrees with this statement. These findings suggest that meat products play a focal role within the habitual diets of the majority of respondents, and could hardly be replaced with alternative sources of proteins. Alongside with this, approximately one quarter of the sample declared to “More than not” agree with the statement, while

even a smaller minority (14%) totally rejected it. This may indicate a potential opportunity for new innovative meat alternatives to be approved by these clusters of respondents.

As much as the relationship between meat and health status is concerned, evidence proved that the 71% of the sample (761 people) perceives eating meat as part of a healthy lifestyle. This highlights a general vision of meat as an essential and irreplaceable source of force and vitality. Conversely, 7% of respondents reported a negative option to this question, indicating that a residual share may perceive meat consumption as being totally decoupled from the conduct of a healthy lifestyle, and that by limiting their meat intake could ultimately favor their health status.

Despite the special status assigned to meat in enhancing good health and its central position in shaping the ideal regular meal, the majority of participants (63% of the sample) was convinced that a reduction in their habitual meat intake could benefit the environment. This may indicate some sort of paradox of meat consumption, that is to say, the greatest part of the sample regularly consumes meat-based products, and actually shows no intentions of substituting them, while at the same time there is a general recognition of meat consumption as highly harmful for the environment.

Respondents' knowledge about clean meat

The first question of the second part of the questionnaire was directed at understanding whether respondents were familiar with the concept of clean meat. The largest part of the sample (67%, 720 people) claimed to have never heard about cultured meat before. 349 participants stated to know what cultured meat is about. These results indicate that the technology was hardly known among the population sample, at least at the time the survey was conducted.

Afterwards, participants were provided with a short definition of clean meat, namely “Clean meat (or “cultured meat”, “synthetic meat”, “in-vitro meat”) is an animal-based product created in laboratory: the technique consists on painfully extracting a sample of stem cells from living animals, and grow them in vitro, with the objective of creating meat cuts exactly comparable to the conventional ones. The principle is that of producing meat, while avoiding directly using the animal” (Bhat et al., 2015; Emery, 2020). Subsequently, respondents were asked to report the extent to which they agreed to purchase and consume this kind of product on a 10- point Likert-type scale ranging from 1 (strongly disagree) to 10 (fully agree). Despite being informed about the general features of the product, on average, the sample revealed scarce intentions in acquiring and trying meat products grown in vitro. As a matter of fact, the mean answer for this questions amounted at 4.25. Notably, whilst 300 participants declared not to be willing to try cultured meat at all, 578 revealed a moderate to low intention to consume it, indicating an answer equal or lower than 4 on the Likert-scale. On the other hand, 65 people argued they would surely want to consume this type of product if available on the market (choosing value “10” as answer), while 212 respondents claimed they would possibly try it, indicating an answer ranging from 7 to 9.

The following question of the survey required respondents to indicate the extent to which they personally expected clean meat to be 1) “natural”, 2) “safe”, 3) “tasty”, and 4) “environmental friendly”, using a 4-point scale ranging from “Not at all” to “For sure”. Cultured meat was perceived as a non-natural commodity by approximately 68% of the sample. Only 71 respondents were fully convinced of the naturalness of meat cultured in vitro. Approximately one half of the sample took more or less a neutral position. This may indicate that the fact of cultured meat being produced in vitro, within a laboratory, may constitute a potential factor hampering consumers' acceptability and likelihood to consume such products in future.

In general, clean meat was positively evaluated in terms of safety, with 27% (291 people) of the sample being absolutely convinced of its reliability for human health, and roughly 40% describing it as

“Reasonably” safe. The consumption of cultured meat was considered as totally unsafe by just a residual 12% the sample.

Findings about respondents’ perceptions on taste were also moderately positive. 45% of the sample (477 people) imagined cultured meat as reasonably tasty, and an additional 15% (157 people) claimed to be totally convinced about its good taste. According to a consumer’s perspective, results may suggest that perceptions of flavor are likely to not constitute a major factor hindering the consumption of this product in the future.

Perceptions about the sustainability of cultured meat scored best among all four analyzed attributes. Negative answering categories to this question were indicated by just approximately 20% of respondents, while the largest proportion described it as moderately (29%) and certainly (51%) sustainable. The findings allowed to realize that the sustainable attribute of cultured meat may be placed among the primary factors stimulating consumers’ purchasing activities, primarily with regard to those categories of consumers showing higher concerns for environmental problems.

Finally, using a 10-point Likert-type scale ranging from 1 (strongly disagree) to 10 (fully agree), participants expressed the extent to which they recognized clean meat production as a potential solution for the environmental problems related to the conventional livestock sector. Findings to this last question revealed that, on average, the sample had neutral expectations in terms of future possibility to mitigate the damage on the natural environment using clean meat technologies. The average answer for this question was 5.22. Specifically, only 10 individuals indicated the maximum value of the Likert-scale.

Respondent’ willingness to purchase and consume clean meat

The propensity among respondents to purchase and consume cultured meat products was measured with the aid of a 10-point Likert-type scale ranging from 1 (strongly disagree) to 10 (fully agree). With the objective of better understanding whether some specific socio-demographic features and characteristics of respondents could effectively influence their willingness to consume this product, the gender of respondents was taken into consideration. Male respondents are the ones showing the largest propensity to try this type of product. As a matter of fact, slightly less than 40% of all males expressed the willingness to try cultured meat, compared to some 30% of all females. Nevertheless, data are evident in highlighting that the majority of respondents of both genders is against the idea of consuming cultured meat. Individuals having a neutral position represent instead just a minority.

The propensity to try meat grown in vitro has also been analyzed on the basis of the age groups of participants, in order to evaluate whether younger or older individuals showed higher or lower willingness to consume this product. In this case, respondents belonging to the younger age classes seem to be the ones expressing the higher level of propensity to consume clean meat. In particular, individuals aging 26 to 40 years old have shown the highest interest in trying this commodity (37.2%), followed by those belonging to the youngest age class ranging from 18 to 25 years of age (34.4%). These results are opposite to the ones previously obtained when analyzing the level of knowledge of cultured meat techniques per age class, and thus indicate that even if younger respondents are not extensively familiar with the concept of cultured meat, they actually show higher levels of curiosity in trying such product if available on the market, compared to older age groups. Also in this case, the highest proportion of respondents, regardless of age, showed negative reactions to the idea of consuming this type of meat.

As far as the education level is concerned, evidence shows that the willingness to consume this type of product proportionally increases with the degree of instruction of the participant. People having attended higher education are also those who show the highest propensity to try the commodity, as opposed to respondents who attained fewer years of schooling. More specifically, 36% of all participants having

obtained a master degree, or equally, 36% of those having a PhD, expressed a positive interest in purchasing cultured meat, compared to 33% of respondents with a High school diploma, and 19% of people who only completed Middle school. This finding suggests that by increasing the level of information on current major environmental problems, and by improving peoples' awareness on the potential advantages cultured meat technology entails, it might be possible to enlarge consumers' acceptability of this commodity in the future.

The following part of the analysis will be devoted to investigate the propensity to purchase and consume cultured meat, focusing the attention to merely the category of respondents who declared to be students. Coherently with the findings obtained in the previous sections, more than one half of the students did not express much interest in trying cultured meat products. This proportion amounts to 51% of all the students who took part in the survey. Only some 37% of them declared a positive intention to consume this product, while a minoritarian share (12%) maintained a neutral position.

Among all academic fields considered, evidence revealed that the category of students engaged in medical subjects were the ones characterized by the largest propensity in consuming cultured meat products. As a matter of fact, 41% of them declared they would surely try it. Interestingly, students enrolled in economic and law courses show the second highest willingness to consume clean meat, with some 39% of them stating they would eat it if available on the market. On the other hand, the humanistic field constitutes the area of studies showing the largest proportion of students not willing to consume this product (53%). Again, this proves that low knowledge on the topic of cultured meat does not necessarily imply the absence of curiosity in trying this product. As a matter of fact, previous findings revealed that young respondents attending economic and juridical subjects were the ones having the lowest information about the topic.

Respondents following a vegetarian dietary pattern presented less favorable intention to purchase and consume meat grown in vitro. As a matter of fact, 72% of them stated they would absolutely not buy it. This finding is actually not surprising, and can be easily explained by considering that cultured meat still constitutes an animal-based commodity, and therefore, this particular feature is likely to promote the outbreak of vegetarians' disapproval, primarily based on ethical considerations and concerns. This suggest that vegetarian people may not be the right consumer segment to address cultured livestock products to in the future. Flexitarians and pescatarians, instead, seem to be moderately interested in purchasing this type of product, in particular with 39% and 36% of them, respectively, indicating positive intentions in this sense. Accordingly, it could be likely that these categories of individuals– which by definition, are the ones attributing higher attention to their everyday nutrition in the aim of benefiting not only their personal health, but also the environment – will express a higher degree of acceptability of cultured meat in the future, and thereby, could represent the optimal clusters of consumers to address this product, once launched on the market.

Interesting results were obtained in the analysis of the level of acceptability and willingness to consume cultured meat, while accounting for the specific opinions of respondents with regard to the relationship between food consumption and the condition of the natural environment. In particular, these information were collected from respondents during the second part of the questionnaire.

Considering the opinion on diets' environmental impact first, it is possible to notice that the majority of individuals convinced that diets are not likely to cause negative implication on the environment, are also the ones showing the lowest interest in consuming cultured meat. This proportion, in particular, represents 64% of the whole group. Interestingly, the willingness to consume seems to be quite equally distributed among the other category of respondents, with 41% expressing the desire of eating clean meat, and another 45% maintaining a negative position about it.

38%, of all the individuals who identified “Red meat” as the most environmentally burdening food category, also declared to be ready to purchase cultured meat. Similar results characterize the categories of participants, respectively counting about 32.5% and 33% of them, considering “Dairies” and “Poultry” as highly environmentally hazardous; these same participants expressed positive intention in consuming meat alternatives grown in vitro. Even more interesting findings emerge from the responses interviewees who deemed the vegetarian option “Meat substitutes” the most burdening food commodity. Among these, only 13% declared to be willing to consume cultured meat.

The desire to consume cultured meat was measured according to the willingness of respondents to accept a replacement in their habitual intake of meat with some alternative plant-based products. Results revealed that the propensity to consume cultured meat is coherently proportional to the willingness of respondents to accept a substitution in their habitual meat intake. In other words, those same consumers willing to substitute meat with vegetarian alternatives, showed the highest propensity to purchase and consume cultured meat – specifically, 45% of all them, with this intention gradually declining among neutral respondents (37%), and, ultimately, those who are absolutely not interested (23%) in changing their habitual food consumption habits.

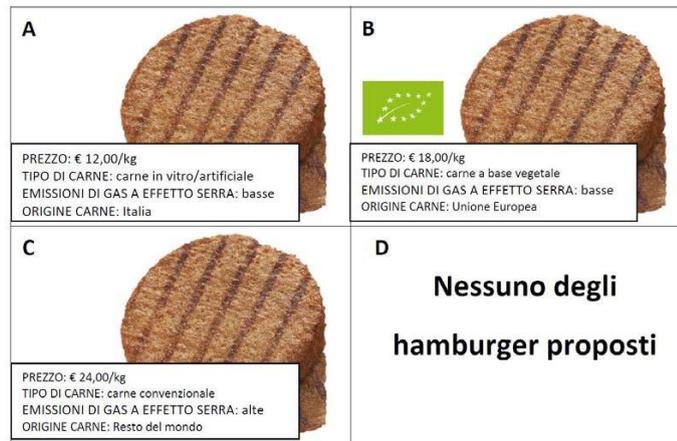
Respondents’ preferences: the choice experiment

The final scope of the survey was to investigate which attributes of meat influenced consumers’ decisions at the moment of purchasing. In order to reach this objective, the final part of the questionnaire was devoted to the performance of a choice experiment (CE). More specifically, participants were required to choose one type of hamburger among a set of three alternatives. A fourth option was also available, offering respondents the possibility not to choose any of the available hamburgers: this allowed to take into account income differences among respondents, and eventual lack of interest for the topic analyzed. The hamburgers available for selection differed in terms of a set of attributes: 1) Price: €12, €18, €24; Country of origin: Italy, European Union, Rest of the world; GHG emissions: High, Low; Type of meat: Conventional, Plant-based, Cultured; Organic meat: Yes, No.

The choice of using a hamburger for the CE can be explained by the fact that this type of meat could be accessible for the population targeted, that is a primarily a group of students. Moreover, the hamburger represents a food commodity that is reasonably familiar among individuals. The selection of product attributes was mainly inspired by the main features appearing on traditional meat labels actually available in every supermarket. To favor the aims of the survey, some specific attributes – such as the type of meat, and the level of GHG emissions – were strategically introduced within the experiment. The first critical factor was the determination of reasonable and realistic meat price levels. According to the Standard Economic theory, price represents a major determinant in influencing consumers’ decisions at the moment of purchasing. This is also valid in the case of food commodities, that is the higher the price, the lower the willingness to pay to enjoy them. Moreover, as previously discussed in this dissertation, income per capita plays a significant role in defining the type of goods included within each individual’s dietary regime, and primarily in establishing the type and amount of meat included in their regular meals (Dernini et al., 2012; Garnett et al., 2014; Green et al., 2018). What is more, according to the available literature, the opportunity for cultured meat to be accepted in the future on the market, highly depends on the possibility to compete in cost with conventional meat products (Bhat et al., 2011; Bhat et al., 2015). Bearing in mind the intention to test such conditions on the population sample under analysis, and thereby evaluate the elasticity of demand of the respondents for various types of meat, three different levels of price were introduced to characterize the alternative hamburger options. Three levels were selected to describe this attribute, namely 12, 18, and 24, expressed in euros per kilogram of meat. Prices were

introduced to cover the most likely income classes of respondents, with the aim to render these commodities generally assessable for all of them. A second distinctive feature that was considered to be worth of attention is reflected on the method of production of the meat. Evidence shows that different forms of livestock farming and production processes are currently available on a global scale (Serè et al., 1996), with each of them playing a role either in determining the specific intensity of the resulting anthropogenic impact on the environment (Steinfeld et al., 2006), and in defining the wellbeing and health conditions of cattle. As a way to evaluate the level of importance consumers attached to how the livestock commodities were produced, the hamburgers were designed to differ in terms of conventional and organic farming. In particular, organic hamburgers presented the well-known European organic logo – outlined by the shape of a green leaf, that certifies that meat comes from livestock raised basing on the principles of organic farming. Furthermore, in line with the general topic of this dissertation, the Carbon Footprint of the various hamburgers was tested as a potential additional factor which could be considered by consumers during their meat purchasing activities. This attribute entails a measure for the amount of GHG emissions generated during the whole process of production of the hamburgers. In order to avoid for misunderstandings among respondents not extensively informed on the topic, impacts were simply measured as “high” or “low”. This attribute can be read as a parameter allowing to evaluate the role of sustainability characterizing respondents meat purchasing activities. As much as the origin of the product is concerned, it was thought that the place of production could constitute an essential factor influencing respondents’ final decisions to purchase a specific type of meat. Accordingly, the hamburgers could be nationally produced, or imported from abroad. Specifically, when imported, their origin locations could be either the European Union, or the rest of the world. This implies that three major levels for the attribute “Country of origin” were ultimately used to distinguish the hamburger options, that are: Italy, European Union, and the rest of the world. In particular, this attribute was recognized as a parameter of quality, which could either positively or negatively affect the final decisions of consumers. Ultimately, given that the primary objective of the survey was to investigate the factors driving consumers’ decisions to purchase one type of meat product or its alternatives, the final attribute of the hamburger was the type of meat. In particular, three different kinds of meat were introduced, namely a conventional beef patty, a plant-based vegetarian substitute, and a cultured meat hamburger. This attribute allowed to understand the willingness to consume clean meat products among the respondents. Six choice sets were sequentially proposed to the respondents. One example of the choice sets is represented in Figure 1. As a way to understand, a brief description of the choice set will be provided. Alternative A represents a hamburger costing 12 euros/kg, nationally produced in Italy, using a cultured meat technique, and whose production process has generated a low level of GHG emissions. The second option is a plant-based hamburger costing 18 euros/kg, that is produced under organic agriculture outside Italy, specifically in the European Union, and whose carbon emissions are low. Option C represents a conventional hamburger costing 24 euros/kg, produced outside the European Union, and presenting a high Carbon Footprint. The last alternative offers the respondent the option not to choose any of the previous cases.

Figure 1: Example of the choice set in Italian language



As previously anticipated, the questionnaire was available online from May until June 2019, primarily to a population of students attending the University of Udine. During this period, 1069 replies were ultimately collected.

With the aid of the program NLOGIT6®, a multinomial logit model (MNL) was estimated. The utility function considered for the analysis is reported below:

$$U(x_i) = \beta_1 * Prezzo_i + \beta_2 * Vitro_i + \beta_3 * Conv_i + \beta_4 * Emalte_i + \beta_5 * Biosi_i + \beta_6 * RMondo_i + \beta_7 * IT_i$$

where:

- *Prezzo* represents the variable for the hamburgers' price, measured in euros per kilogram;
- *Vitro* is the dummy variable for cultured meat;
- *Conv* is the dummy variable for conventional meat;
- *Emalte* is the dummy variable indicating the production of the hamburger had generated high level of GHG emissions;
- *Biosi* is the dummy variable for the presence of an Organic certification;
- *RMondo* is the dummy variable indicating the hamburger was produced in the rest of the world;
- *IT* is the dummy variable indicating the hamburger was produced in Italy.

The validity of a model can be evaluated by looking at the level of significance of the coefficient estimates. Analyzing the P-value, it is visible that all variables are significant at the 95% confidence level. This means that all predictors are likely to offer a meaningful contribution to the analysis. In particular, the β coefficients cannot be interpreted based on their magnitude. They provide a representation of the weight assumed by each attribute level within the individual utility function of the respondents, and therefore they inform us about how the features of one hamburger can influence the consumers' final decision to purchase it. They include information about the expected sign. While examining the column of the estimated coefficients, the first aspect coming into attention is that the fact that meat was produced in vitro negatively influences the probability of respondents to purchase the hamburger. As a matter of fact, the estimated coefficient for *Vitro* is negative. At the opposite side, the coefficient for conventional meat is positive, indicating that this commodity is more attractable to the population sample. In light of the data collected from the other questions of the survey, this result

was not surprising. As far as sustainable attributes are concerned, the negative sign of high GHG emissions' coefficient, reveals that the environmental impact arising from the hamburger production is not irrelevant to respondents. High levels of Carbon Footprint are negatively influencing the probability to purchase the meat-based product. Also, the presence of an organic certification seems to positively influence the probability of purchasing. Ultimately, the negative sign for the price coefficient confirms what the economic theory states, that is the higher the price, the lower the quantity of meat purchased and consumed. However, being the aim of this study to analyze the heterogeneity of preferences characterizing different consumers' demands, the basic MNL models have a strong limitation, in that they only assume homogeneous preferences among individuals. As a matter of fact, the above discussed basic model relies on the assumption that all parameters' coefficients were constant and valid for the whole population sample, not accounting for eventual differences among respondents. One of the main methods allowing for the incorporation of preference heterogeneity within the analysis is the latent class method. This framework assumes the presence of a "hidden" latent variable, that is a variable not directly measurable or observable, that nevertheless allows to observe all the other related variables. By analyzing these variables, it is possible to understand how the latent variable varies within the population sample. The observable variables are able to both influence the final consumption decisions of an individual, and determine his/her kinship to a homogeneous, specific group. The latent class methods can be considered as an extension of the latent variable methods. This method ultimately allows to define the likelihood for respondents to be included within a number of homogeneous consumers' segments. Respondents characterized by similar behaviors, preferences and characteristics, will belong to the same cluster. Furthermore, the heterogeneity of preferences could derive from a vast range of factors characterizing the consumers, and primarily their socio-demographic features, their attitudes, their perceptions, and their past experience.

Table 1 shows the final results of the latent class analysis. The definition of the number of classes has been based on the application of the conventional Akaike (AIC) and Bayesian (BIC) information criteria. The optimal number of segments is obtained when the AIC and BIC, measured for the model, are at their lowest value. The analysis of these indicators suggested that the model with four classes constituted the best option.

The analysis of the model was performed through the NLOGIT6® program.

Table 1: Estimation of the latent class model

Variable	Coefficient	Standard Error	b/St.Er.	P[Z >z]
-----+Utility parameters in latent class --> 1				
ASC 1	2.56871772	.61081453	4.205	.0000
PREZZO 1	-.04740141	.01677961	-2.825	.0047
VITRO 1	-.07770459	.30510645	-.255	.7990
CONV 1	2.09202398	.25099680	8.335	.0000
EMALTE 1	-2.73208821	.40428552	-6.758	.0000
BIOSI 1	.63299398	.25594736	2.473	.0134
RMONDO 1	-1.47022971	.47853313	-3.072	.0021
IT 1	1.15834326	.29818334	3.885	.0001
-----+Utility parameters in latent class --> 2				
ASC 2	-.30473890	.34811673	-.875	.3814
PREZZO 2	-.11480661	.01457778	-7.875	.0000
VITRO 2	-.81118238	.20562058	-3.945	.0001
CONV 2	3.36674036	.18014417	18.689	.0000
Cont.				
Tab.1				
EMALTE 2	.56416193	.23482471	2.402	.0163
BIOSI 2	.90405384	.32374014	2.793	.0052
RMONDO 2	-1.44226949	.15788359	-9.135	.0000
IT 2	.87089569	.25124976	3.466	.0005
-----+Utility parameters in latent class --> 3				
ASC 3	-2.58678680	.31136768	-8.308	.0000
PREZZO 3	-.18550151	.01043294	-17.780	.0000
VITRO 3	1.76251212	.15318888	11.505	.0000
CONV 3	2.63689334	.22654300	11.640	.0000
EMALTE 3	-.86186302	.20329565	-4.239	.0000
BIOSI 3	.11661342	.25696235	.454	.6500
RMONDO 3	.09877114	.15072204	.655	.5123
IT 3	.45676698	.27031788	1.690	.0911
-----+Utility parameters in latent class --> 4				
ASC 4	-.71755697	.19468232	-3.686	.0002
PREZZO 4	-.03884590	.00479225	-8.106	.0000
VITRO 4	-.42611986	.04506539	-9.456	.0000
CONV 4	.11083203	.07554261	1.467	.1423
EMALTE 4	-.71825846	.08173355	-8.788	.0000
BIOSI 4	1.24739204	.11408615	10.934	.0000
RMONDO 4	-.42234113	.08457395	-4.994	.0000
IT 4	1.34022923	.12093451	11.082	.0000
-----+Estimated latent class probabilities				
PrbCls_1	.27761029	.01854933	14.966	.0000
PrbCls_2	.20774916	.01906045	10.899	.0000
PrbCls_3	.16124883	.02039773	7.905	.0000
PrbCls_4	.35339172	.01684161	20.983	.0000

The primary objective of the analysis was to investigate what, and how, different attributes of meat could influence respondents' decisions to purchase, in particular while devoting particular attention to their willingness to purchase and consume cultured meat products.

Given the differences in sign and magnitude characterizing the coefficients of the hamburgers'

attributes, the results highlight the presence of heterogeneity of preferences among the various classes of respondents. The likelihood for one individual to be included in each class - i.e. the membership probability, are represented in the four bottom rows of Table 1. The membership probability for the first class is 28%. The analysis of the results for this cluster firstly highlights that the variable *Vitro* is not significant, while all the other variables are significant at the 95%. In particular, members of this class paid considerable attention to the level of GHG emissions generated during the production of the hamburger. This attribute is characterized by a negative sign and a considerable magnitude, indicating that the final decisions of respondents have been highly and adversely influenced by the Carbon Footprint of the product. Moreover, the fact that the meat originated from abroad, rather than from Italy, together with a higher price per kilogram, negatively affected the probability of buying the hamburger. As far as the type of meat is concerned, data show that members of this group are more attracted by conventional meat products and the presence of some form of organic certification. Because of this, it is possible to define this group as sustainability seekers. Coming to the second class, its membership probability is 21%. In this case, all the parameters seem to be significant at the 95% confidence level. Looking at the results, it is noticeable that consumers belonging to this cluster are negatively affected by price, and by the fact that the meat, composing the hamburger, was cultured in vitro. The very high coefficient associated to the parameter for conventional meat, clarifies that the traditional hamburgers were strongly preferred by these consumers. This segment of respondents is also highly negatively influenced by the country of origin of the product. More specifically, hamburgers being imported from the rest of the world have proved to be less attractive to them. Conversely, the coefficient for Italian production has a positive sign, indicating that this attribute positively affected the final decisions to purchase the hamburger. This group can be denoted as quality and tradition seekers. The third class presents a membership probability equal to 16%. Looking at the significance levels of the various attributes, it is possible to notice that the coefficients for organic meat and for extra- European Union production are both non-significant at the 95% confidence level. This cluster of respondents seems to be positively influenced by the fact that the hamburger was produced using a clean meat technique. However, they are also highly attracted by conventional hamburgers. In particular, the magnitude of the coefficient for conventional meat is higher, compared to the one featuring cultured meat. As a matter of fact, it is possible to state that, despite still preferring conventional meat, this group seems to express a sense of curiosity in purchasing and consume cultured meat products. In light of this, they can be denoted as cultured meat supporters. For this segment, the price and the high level of GHG emissions negatively influenced the probability for this class to purchase the hamburger. The membership probability for the last segment is equal to 35%. They can be denoted as the Italian organic supporters. As a matter of fact, the fact that the hamburger was produced under organic agriculture, and within the national Italian context, positively influenced consumers' preferences. Indeed, the magnitude of the coefficients characterizing these attributes were dominant, compared to the others. Moreover, the sign of the coefficient for the high emission intensity attribute is negative, highlighting that respondents' decisions were negatively influenced by this factor. In this case, only the coefficient for conventional meat was not significant.

Conclusions

In the objective of practically evaluating the central factors driving consumers' behaviors and choices at the moment of meat consumption, a questionnaire has been designed and directed to a population of students attending the University of Udine. The central focus of the survey was the investigation of the

knowledge and perceptions of respondents about the topic of cultured meat, as well as the evaluation of their willingness to purchase and consume this product, if it was available on the market. In particular, the survey was divided into four major parts: the first part is devoted to the exploration of the socio-demographics characteristics of the respondents. Findings revealed that the majority of the respondents was female (63%), student (66%), with a median age of 24 years old, with a high school diploma (57%), engaged in scientific studies (40%) and coming from Friuli Venezia Giulia (74%). This is the description of the profile of the average participant to this survey. The second part was devoted to the analysis of the general eating habits of the respondents, as well as to the evaluation of their perceptions and involvement towards current environmental problems. From the answers, it emerged that the largest majority of respondents stuck to omnivorous diet (88%), which include meat intake at least 3-4 times during the week (62%), and generally attributed high importance to good nutrition as a way to preserve their health status. Respondents also revealed to be quite involved in current environmental issues, and were generally aware of the fact that their daily food choices could influence the status of the environment. Moreover, the vast majority of them (69%) recognized red meat as the most environmentally burdening food category among all, and 63% of them declared to be convinced that a reduction in her/his ordinary intake of meat could contribute in mitigating negative pressures on the environment. However, when facing the idea of substituting their habitual meat intake with alternative vegetarian meals, respondents' reaction was not so positive, but rather neutral, indicating a scarce interest to effectively change their consumption habits. The third part of the research focused on the evaluation of the level of knowledge and perceptions of respondents on the topic of cultured meat, and on the analysis of their propensity to purchase and consume such a product, in substitution to conventional meat. The results highlighted that the largest majority of the sample (67%) was not aware about the existence of this technology, and on average showed no intention to eventually consume it, if available on the market. Moreover, cultured meat was generally perceived as unnatural (68%), safe (67%), tasty (60%), and environmentally sustainable (80%). A bivariate analysis was also conducted, in the aim of evaluating eventual relationships between socio-demographics features of the respondents, and their knowledge and propensity to consume cultured meat. The last part of the chapter is devoted to the analysis of the criteria driving respondents' behavior at the moment of meat consumption. A Choice Experiment was conducted, in which participants were required to choose among a set of alternative hamburgers. This allowed us to estimate and analyze the utility function of the individual, where the total utility was represented by the sum of the relative utilities the participant derived from various attributes characterizing the chosen hamburger. More specifically, the attributes were price, the country of production of meat, the Carbon Footprint of meat, the presence of an organic certification, and ultimately the type of meat, which could be either conventional, plant-based, or cultured. Firstly, a basic Multinomial Logistic model was estimated. The results revealed that hamburger produced in vitro, made with foreign meat, or characterized by large Carbon Footprint, generally contributed in reducing the utility of consumers. On the other hand, the presence of an organic label, and the fact that conventional meat was used to make the hamburger, both determined positive effects on respondents' utility. As far as price is concerned, the negative coefficient allowed to confirm the arguments of the traditional economic theory. In order to evaluate the heterogeneity of preference characterizing the demands of different respondents, the following step was to analyze a latent class model, which allowed to subdivide the population sample into different segments of consumers, on the basis of their similarities in taste and preferences. The final results made it possible to identify four major classes of consumers, namely the sustainability seekers, the quality and tradition seekers, the cultured meat supporters, and the Italian organic supporters. What is possible to conclude

looking at the results of this case study is that the existence of cultured meat technology is still little known among consumers, especially between younger age classes. On average, consumers show low interest in consuming this kind of product, but rather reveal higher interest in maintaining their habitual eating habits. This may suggest that omnivorous individuals may not be the right target to address cultured meat in the future; the flexitarian cluster, i.e. those consumers who pay higher attention to the quantity of meat consumed primarily for sustainability reasons, may viceversa be a more ideal cluster to firstly advance it. However, the vast majority of the sample is informed about current environmental problems and is aware of the adverse pressure red meat production and consumption poses on the environment. This could be considered as a positive aspect, and respondents' perception of cultured meat as highly environmentally sustainable could represent a promising first step allowing the acceptability of product in the future. At the same time, the high proportion of respondents considering cultured meat as a non-natural commodity, highlights the fact that the way the commodity is produced might represent a major barrier, hampering the possibility to commercialize this innovative food on a large scale. Nevertheless, this suggests that potential actions focused on improving the level of transparency on cultured meat technology, and, according to Rolland et al. (2020), in enhancing consumers' information about the potential benefits deriving from its implementation, may be helpful in overcoming this major challenge.

Acknowledgments

We thank Elisabetta Bettega for her valuable contribution in collecting data.

References

- Alexander, R. (2011). In vitro meat: a vehicle for the ethical rescaling of the factory farming industry and in vivo testing or an intractable enterprise?. *Intersect: The Stanford Journal of Science, Technology, and Society*, 4, 42-47.
- Alexander, P., Brown, C., Arneith, A., Dias, C., Finnigan, J., Moran, D., & Rounsevell, M. D. (2017). Could consumption of insects, cultured meat or imitation meat reduce global agricultural land use? *Global Food Security*, 15, 22-32.
- Aleksandrowicz, L., Green, R., Joy, E. J., Smith, P., & Haines, A. (2016). The impacts of dietary change on greenhouse gas emissions, land use, water use, and health: a systematic review. *PloS one*, 11(11), e0165797.
- Bhat, Z. F., & Fayaz, H. (2011). Prospectus of cultured meat—advancing meat alternatives. *Journal of Food Science and Technology*, 48(2), 125-140.
- Bhat, Z. F., Kumar, S., & Fayaz, H. (2015). In vitro meat production: Challenges and benefits over conventional meat production. *Journal of Integrative Agriculture*, 14(2), 241-248.
- Bhatt, A., & Abbassi, B. (2021). Review of environmental performance of sheep farming using life cycle assessment. *Journal of Cleaner Production*, 126192.
- Barouki, R., Kogevinas, M., Audouze, K., Belesova, K., Bergman, A., Birnbaum, L., ... & HERA-COVID-19 working group. (2021). The COVID-19 pandemic and global environmental change: Emerging research needs. *Environment international*, 146, 106272.
- Bryant, C., & Barnett, J. (2018). Consumer acceptance of cultured meat: A systematic review. *Meat science*, 143, 8-17.

- Bryant, C., & Barnett, J. (2020). Consumer acceptance of cultured meat: an updated review (2018–2020). *Applied Sciences*, 10(15), 5201.
- Bryant, C., & Sanctorem, H. (2021). Alternative proteins, evolving attitudes: Comparing consumer attitudes to plant-based and cultured meat in Belgium in two consecutive years. *Appetite*, 161, 105161.
- Chriki, S., & Hocquette, J. F. (2020). The myth of cultured meat: a review. *Frontiers in nutrition*, 7, 7.
- Costantini, M., Vázquez-Rowe, I., Manzardo, A., & Bacenetti, J. (2021). Environmental impact assessment of beef cattle production in semi-intensive systems in Paraguay. *Sustainable Production and Consumption*, 27, 269-281.
- Dernini, S., Berry, E. M., Bach-Faig, A., Belahsen, R., Donini, L. M., Lairon, D., & CIHEAM. (2012). A dietary model constructed by scientists. *MediTERRA, The Mediterranean diet for sustainable regional development*.
- Emery, I. (2020). Growing meat sustainably: The clean meat revolution. The Good Food Institute, https://gfi.org/wp-content/uploads/2021/01/sustainability_cultivated_meat.pdf
- Faccio, E., & Guiotto Nai Fovino, L. (2019). Food Neophobia or Distrust of Novelties? Exploring consumers' attitudes toward GMOs, insects and cultured meat. *Applied Sciences*, 9(20), 4440.
- Garnett, T., Appleby, M., & Balmford, A. (2014). What is a sustainable healthy diet. Food Climate Research Network, Oxford.
- Green, H., Broun, P., Cook, D., Cooper, K., Drewnowski, A., Pollard, D., ... & Roulin, A. (2018). Healthy and sustainable diets for future generations. *Journal of the Science of Food and Agriculture*, 98(9), 3219-3224.
- Jairath, G., Mal, G., Gopinath, D., & Singh, B. (2021). An holistic approach to access the viability of cultured meat: A review. *Trends in Food Science & Technology*.
- Kadim, I. T., Mahgoub, O., Baqir, S., Faye, B., & Purchas, R. (2015). Cultured meat from muscle stem cells: A review of challenges and prospects. *Journal of Integrative Agriculture*, 14(2), 222-233.
- Mancini, M. C., & Antonioli, F. (2019). Exploring consumers' attitude towards cultured meat in Italy. *Meat science*, 150, 101-110.
- Mancini, M. C., & Antonioli, F. (2020). To What Extent Are Consumers' Perception and Acceptance of Alternative Meat Production Systems Affected by Information? The Case of Cultured Meat. *Animals*, 10(4), 656.
- Palmieri, N., Perito, M. A., & Lupi, C. (2020). Consumer acceptance of cultured meat: Some hints from Italy. *British Food Journal*.
- Pliner, P., & Salvy, S. J. (2006). Food neophobia in humans, In Septhert R. and Raats M. (Eds). *The psychology of food choice*, (pp.75-92). Guildford, UK. http://ssu.ac.ir/cms/fileadmin/user_upload/Mtahghighat/taghzie_imani/book/The-Psychology-of-Food-Choice.pdf
- Rolland, N. C., Markus, C. R., & Post, M. J. (2020). The effect of information content on acceptance of cultured meat in a tasting context. *PLoS One*, 15(4), e0231176.
- Siegrist, M., & Hartmann, C. (2020). Perceived naturalness, disgust, trust and food neophobia as predictors of cultured meat acceptance in ten countries. *Appetite*, 155, 104814.
- Slade, P. (2018). If you build it, will they eat it? Consumer preferences for plant-based and cultured meat burgers. *Appetite*, 125, 428-437.
- Sun, Z. C., Yu, Q. L., & Lin, H. A. N. (2015). The environmental prospects of cultured meat in China. *Journal of Integrative Agriculture*, 14(2), 234-240.
- The EAT-Lancet Commission (2019), *Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems*.

Treich, N. (2021). Cultured meat: Promises and challenges. *Environmental and Resource Economics*, 1-29.

Van der Weele, C., & Driessen, C. (2013). Emerging profiles for cultured meat; ethics through and as design. *Animals*, 3(3), 647-662.

Zhang, M., Li, L., & Bai, J. (2020). Consumer acceptance of cultured meat in urban areas of three cities in China. *Food Control*, 118, 107390.

Zhang, G., Zhao, X., Li, X., Du, G., Zhou, J., & Chen, J. (2020). Challenges and possibilities for bio-manufacturing cultured meat. *Trends in Food Science & Technology*, 97, 443-450.

Weinrich, R. (2019). Opportunities for the adoption of health-based sustainable dietary patterns: A review on consumer research of meat substitutes. *Sustainability*, 11(15), 4028.

Weinrich, R., Strack, M., & Neugebauer, F. (2020). Consumer acceptance of cultured meat in Germany. *Meat science*, 162, 107924.