



## Open Archive TOULOUSE Archive Ouverte (OATAO)

OATAO is an open access repository that collects the work of Toulouse researchers and makes it freely available over the web where possible.

This is an author-deposited version published in : <http://oatao.univ-toulouse.fr/>  
Eprints ID : 15560

**To link to this article** : DOI: 10.1016/S2095-3119(14)60884-4  
URL: [http://dx.doi.org/10.1016/S2095-3119\(14\)60884-4](http://dx.doi.org/10.1016/S2095-3119(14)60884-4)

**To cite this version** : Verbeke, Wim and Sans, Pierre and Van Loo, Ellen J *Challenges and prospects for consumer acceptance of cultured meat*. (2015) *Journal of Integrative Agriculture*, vol. 14 (n° 2). pp. 285-294. ISSN 2095-3119

Any correspondance concerning this service should be sent to the repository administrator: [staff-oatao@listes-diff.inp-toulouse.fr](mailto:staff-oatao@listes-diff.inp-toulouse.fr)

# Challenges and prospects for consumer acceptance of cultured meat

Wim Verbeke<sup>1</sup>, Pierre Sans<sup>2,3</sup>, Ellen J Van Loo<sup>1</sup>

<sup>1</sup> Department of Agricultural Economics, Ghent University, Ghent B-9000, Belgium

<sup>2</sup> INP-ENV Toulouse, Toulouse 31076, France

<sup>3</sup> UR1303 ALISS, INRA, Ivry-sur-Seine 94205, France

## Abstract

Consumer acceptance of cultured meat is expected to depend on a wide diversity of determinants ranging from technology-related perceptions to product-specific expectations, and including wider contextual factors like media coverage, public involvement, and trust in science, policy and society. This paper discusses the case of cultured meat against this multitude of possible determinants shaping future consumer acceptance or rejection. The paper also presents insights from a primary exploratory study performed in April 2013 with consumers from Flanders (Belgium) ( $n=180$ ). The concept of cultured meat was only known (unaided) by 13% of the study participants. After receiving basic information about what cultured meat is, participants expressed favorable expectations about the concept. Only 9% rejected the idea of trying cultured meat, while two thirds hesitated and about quarter indicated to be willing to try it. The provision of additional information about the environmental benefits of cultured meat compared to traditional meat resulted in 43% of the participants indicating to be willing to try this novel food, while another 51% indicated to be 'maybe' willing to do so. Price and sensory expectations emerged as major obstacles. Consumers eating mostly vegetarian meals were less convinced that cultured meat might be healthy, suggesting that vegetarians may not be the ideal primary target group for this novel meat substitute. Although exploratory rather than conclusive, the findings generally underscore doubts among consumers about trying this product when it would become available, and therefore also the challenge for cultured meat to mimic traditional meat in terms of sensory quality at an affordable price in order to become acceptable for future consumers.

**Keywords:** acceptance, artificial, attitude, consumer, cultured, *in vitro*, meat, synthetic

doi: 10.1016/S2095-3119(14)60884-4

## 1. Introduction

Until recently, new product development in the meat sector has typically focused on secondary processing activities

during the post-slaughtering phase that aimed at differentiation from the rest of the products in the commodity meat market. Consumer insight has always been crucial to ensure that the new developments were in line with consumer preferences and to enhance the likelihood of commercial success (Grunert *et al.* 2011). The idea of growing meat from animal cells (Post 2012) presents itself as a radically new way of obtaining meat through substituting livestock production at the very beginning of the meat production chain. This evolution has been referred to as "the third stage in meat production", after hunting and herding (Welin 2013). The technology may

provide a possible solution to several problems facing current livestock production such as reducing the environmental impact of livestock farming, eliminating issues about animal welfare and slaughter, and improving meat safety and healthiness, although some of this potential is debated as well at least in the short term (reviewed by Hocquette *et al.* 2013). Commonly used names for the resulting product are cultured, *in vitro*, synthetic, artificial, and laboratory-grown or factory-grown meat. The term 'cultured meat' will be used in the present paper.

Cultured meat represents indeed a totally new development with possible benefits but also some issues of debate. Several published studies thus far are situated in the natural sciences domain and have focused on technological aspects, advancements and challenges facing the culturing of meat, most of which are believed to be solvable at some point in time (Datar and Betti 2010; Post 2012, 2014). Meanwhile, a growing number of social sciences studies have focused on sociological, philosophical, moral and ethics arguments around the issue (Pluhar 2010; Chiles 2013; van der Weele and Driessen 2013; Welin 2013; Marcu *et al.* 2015). Up to the present day, it remains largely unknown though how consumers will react to this new technology and, whether and under which conditions they would be willing to accept and adopt this novel food.

While consumers may be likely to place less importance on the issue as long as the product is not available and the time of availability is uncertain (Goodwin and Shoulders 2013), consumer insight will be indispensable for future marketplace acceptance. Several recent examples, such as biotechnology and nanotechnology illustrate that consumers may not embrace novel agro-food technologies as enthusiastically as hoped for at the times when the technologies were developed and adopted (Verbeke 2011). de Barcellos *et al.* (2010), for example, indicated that while consumers may support the development of non-invasive (processing) technologies that improve the healthiness and eating quality of meat, they are very reluctant to manipulations and interventions that are perceived as excessive, invasive and non-natural in meat production chains.

The aim of the present paper is to provide a brief review of first, the criteria or determinants that can be expected to shape consumer acceptance of cultured meat and its production technology and second, the possible reactions, concerns and questions that consumers might raise when facing this new technology and novel food product. Furthermore, this paper presents exploratory findings from a primary quantitative study with consumers in Flanders (Belgium) probing about their initial reactions when facing the idea of cultured meat as a future substitute for traditionally produced meat.

## 2. Criteria shaping consumer acceptance

Apart from the potential of cultured meat to meet and cope with some of the challenges associated with current livestock production, the question about its acceptability by the general public and consumers must be addressed. Numerous criteria shaping consumer acceptance of novel agro-food technologies and their resulting end-products have been discussed in previous studies. It is an interesting exercise to review and check the case of cultured meat production technology against each of these criteria, and to critically reflect on the complex picture of possible advantages and disadvantages from the perspective of future end users.

Two recent reviews identified about 15 different issues impacting on consumer acceptance of novel agro-food technologies in general (Frewer *et al.* 2011; Rollin *et al.* 2011), while Hopkins and Dacey (2008) proposed about a dozen possible objections that might be provoked if a product like cultured meat would be put on the market. A first set of determinants of acceptance or rejection included the perceived personal and societal benefits and risks of the technology, as well as perceived differences in who eventually benefits and who bears the risks associated with the technology and its end products. Hence, a major challenge lies in identifying the real and perceived benefits and risks of cultured meat (and its production technology), as well as in providing transparency about who (e.g., primary producers, industry, individual consumers or, society as a whole) is bearing them.

A second set of determinants of consumer acceptance or rejection is related to the technology itself. Technology-related perceptions pertain to perceived scientific knowledge or uncertainty (which is still substantial in the case of cultured meat, e.g., scalability of the production process or the replacement of serum-based culture media), perceived controllability of the technological processes (e.g., quality control and safety monitoring of cell and tissue cultures), and perceived naturalness of the technology and product. The perceived naturalness of food and food production technologies, for example has been shown to strongly influence the acceptance of innovative food technologies (Siegrist 2008).

Furthermore, the perceived efficacy of the regulatory framework and general trust in science and regulation in the food domain were identified as trust-related issues that determine public and consumer acceptance of novel agro-food technologies. Other issues pertain to the level of public or consumer involvement in the technology development process, as well as public awareness or familiarity with the technology, each of which is almost non-existent at the present time for the case of cultured meat. Also possible cognitive associations or attitude activation play a role,

such as associations linked to other technologies owing to the name of the technology or the type of manipulations involved. It can be expected for example that the term '*in vitro*' will activate attitudes, ideas or emotions linked with *in vitro* fertilization or with *in vitro* laboratory practices like the more contested biotechnology or growth processes in bioreactors. Alternatively, the use of other names like 'artificial' or 'synthetic' may evoke thoughts or strengthen perceptions of unnaturalness. Finally, ethical concerns (which may play in favor of cultured meat as far as animal welfare is concerned, and as far as the technology is not too much perceived as 'tampering with nature' or 'playing God') and socio-cultural differences were identified as factors shaping consumer reactions to novel agro-food technologies.

Frewer *et al.* (2011) also concluded that especially technologies characterised as having a 'bioactive' component raise particular concerns among people. This is mainly because of feared possible unpredictable effects, the risk of uncontrolled use and ethical concern, more so than because of perceptions of unnaturalness or unfamiliarity. Rollin *et al.* (2011) pointed in addition to effects from information and media coverage, as well as the objective (factual) and subjective (perceived) knowledge of consumers, and the possible role of product labelling. They explicitly referred to the role of media, the content of media reporting and the quantity of media coverage as determinants of consumer acceptance or rejection. An interesting remark is the fact that even positive intended information can fuel consumer resistance because it can increase awareness of previously unknown risks (Verbeke *et al.* 2007). Driessen and Korthals (2012) mentioned the fact that the development of cultured meat had already given rise to heightened media attention in the Netherlands, for example, and this prior to the highly publicized tasting of the first cultured meat burger in August 2013 in London (Hopkins 2015). Goodwin and Shoulders (2013) analysed the media coverage about cultured meat in the United States (U.S.) and the European Union (prior to the August 2013 cultured burger tasting) and concluded that print media were primarily supporting the idea of cultured meat production. Problems associated with conventional or traditional meat production as well as the advantages of cultured meat were mostly discussed in the print media, and information sources included mainly proponents of cultured meat, which may have positively influenced initial consumer reactions. However, details on the technology described by the print media were felt to be too technical and possibly confusing for the wider public. A more recent analysis of Western media coverage after the August 2013 cultured burger tasting (Hopkins 2015) concluded that mass media provided a quite distorted picture of the obstacles in the path of cultured meat acceptance, notably through portraying mainly vegetarian consumers' reactions and referring mainly

to cultured meat's future potential as a meat substitute for vegetarian or vegan consumers who still constitute only a niche market in most countries.

When evaluating the aforementioned criteria more specifically against the case of cultured meat, three major issues seem to predominate. The first issue pertains to the perceived (un)naturalness of 'factory-growing meat'. The perceived unnaturalness of the manufacturing process could lead to strong reticence among the general public and consumers, considering that the process represents yet another manipulation of nature to the advantage of man. In other words, although cultured meat may contribute to solving major ethical concerns with respect to livestock farming and animal slaughter for human consumption, and may contribute to the alleviation of hunger problems in the world, the technology for producing meat might as well be perceived as intervening and messing too much with nature. Although the perceived (un)naturalness can be expected to be one of the most problematic issues for cultured meat (Hopkins and Dacey 2008), it has been argued also that a product may be natural even if produced in an unnatural way, and that the natural or unnatural status of a product does not necessarily mean the product is good or bad (Welin 2013). In addition, the artificial character of cultured meat may be seen by others as an advantage since production in a fully controlled environment prevents eventual harmful consequences of natural meat production (e.g., zoonotic risks) where animals are also increasingly perceived to be reared under rather unnatural conditions (Hopkins and Dacey 2008). Besides, *in vitro* cell culture involves the use of natural biological mechanisms and a similar technology is widely accepted in other areas, such as medical applications or *in vitro* fertilization (Welin and van der Weele 2012). With respect to the manufacturing process and its operational scale, Post (2014) argues that the acceptance of cultured meat might further depend on the concrete implementation of the technology in future food production. He gives the example of homemade beef in an incubator with a similar appearance as any other commonly used kitchen appliance. Cultured meat produced in one's own kitchen (i.e., kind of 'self-made') is according to Post (2014) likely to be perceived quite differently (and perhaps as less unnatural) than cultured meat produced on large industry scale in a factory by a multinational food company. Hence, homemade or 'home-cultured' meat may perhaps be more acceptable to consumers.

A second major issue pertains to possible repulsion or the so-called 'yuck factor' as the typical initial reaction that consumers might feel at the idea of eating cultured meat (Pluhar 2010). As with many other new foods or technologies applied in the food chain, the very idea of commercializing a novel product generates fear. In the case of cultured meat,

potential neophobia may be exacerbated first, because food is not like any other product and second, because both simple aversion to new foods (food neophobia, Pliner and Hobden (1992)) and fear for unknown or unfamiliar technologies (food technology neophobia, Cox and Evans (2008)) may reinforce each other for this specific product. The cultural and identity dimensions of food, together with the fact that the product's constituents will enter the body as a result of biological transformations occurring after its ingestion, may accentuate this potential fear and therefore the likelihood of reticence to purchase cultured meat. Furthermore, it has been shown that disgust reactions are particularly strong towards unfamiliar foods from animal origin, mostly owing to their expected aversive textural properties and reminders of livingness or animalness (Martins and Pliner 2005).

By contrast, the promoters of cultured meat argue that once the manufacturing process has been fine-tuned and explained to the public, consumer repulsion may decrease. Furthermore, this type of reticence is in no way specific to the case of cultured meat (Hopkins and Dacey 2008; Bhat and Bhat 2011). For example, the launching of products such as surimi or tofu sparked considerable debate; their novel nature generated much concern in Western societies before these products became established, even though they consisted of a raw material which was familiar to the general public. In addition, if consumers were fully aware of the conditions and technologies currently associated with livestock production, animal slaughter, or meat processing, many of them might feel disgust as well and turn away from eating meat.

The third major issue relates to the perceived healthiness or consequences for personal health from eating cultured meat. The possible risks associated with the manufacturing and distribution of a new 'technological' product that has not been validated or assessed for its effects on human health, may induce concern among consumers. As seen with genetically modified organisms (GMOs), the launching of cultured meat is bound to be controversial and its large-scale acceptance may depend on the progressive unveiling of the advantages and/or disadvantages of the product together with guarantees from trustworthy public authorities and market participants. Issues such as how safety controls are performed and guaranteed, how credible and transparent the information is, and how regulatory structures and procedures are set up are major challenges in this respect (Driessen and Korthals 2012).

### 3. Preliminary insights from consumer studies

Vanhonacker *et al.* (2013) investigated consumer interest in available substitutes for meat in the context of a more

sustainable food choice in Flanders (Belgium). Although many consumers may already have changed their meat consumption habits in Western Europe during the last decade because of consecutive meat safety crises since the mid-nineties (Verbeke *et al.* 1999, 2005), the readiness to further reduce meat consumption seemed quite prominent. Consumers' claimed willingness to reduce meat consumption was very high with 72% of the sample reporting to be willing to decrease their meat consumption in the coming years. In the same study, 73% of the participants reported a willingness to shift to more ecologically friendly meat substitutes, 45% to hybrid meat types (presented as mixtures of animal-based and plant-based protein) and 35% to plant-based protein instead of meat. By contrast, only 5% reported to be willing to shift to insect-based protein. Multiple reasons can be found for intentions to reduce meat consumption, ranging from the often-mentioned meat safety, healthiness and animal welfare concerns to the more recent awareness about the ecological impact, sustainability issues and frauds facing traditional livestock and meat production and commercialization. While cultured meat may provide an answer or partly solution to these issues, it remains to be investigated whether consumers will also perceive cultured meat and its way of production as a solution that is realistic, feasible and effective.

Mattick and Allenby (2012) highlighted the possible positive and negative economic, social and environmental implications of a shift to what they call "factory-grown meat". They pointed to a considerable amount of uncertainty with respect to regulatory issues, technology adoption and production processes. Their overview flagged important social, political, cultural and ethical challenges and finally, they pointed to public perception and the likelihood of consumer acceptance which were explicitly referred to as largely unknown and un-investigated thus far.

Sustainable consumer acceptance of cultured meat will depend on the product-related expectations and experienced performance upon product usage. Besides perceptions about how the product has been produced, the product will be evaluated in terms of attributes that provide consumers with relevant benefits that ultimately yield satisfaction and possible repeat purchase. As with any food product and if adequately informed, consumers will not be willing to compromise on food safety. Expectations in terms of taste, healthiness, affordability and sustainability will also have to be met. Even if consumers are willing to try this novel product, such willingness does not reveal much about the likelihood of repeat purchase or a sustainable change of eating habits. Saeed *et al.* (2013) showed how the trial of meat products can change quality perceptions and influence the formation of future purchase intentions, in particular in those cases where positive expectations were



not confirmed during trial. By lack of product experience thus far, consumers can be expected to form expectations based on the information received (e.g., mass media coverage) and based on image transfer from more familiar technologies and products. The positioning of cultured meat as a substitute or as a complement for conventional meat will be very important because consumers are likely to refer to products with a similar positioning in the market when forming product-related expectations.

While numerous studies exist on consumer acceptance of novel agro-food technologies such as genetic modification, food radiation, nanotechnology and cloning, studies about consumer reactions to the concept of cultured meat are still very scarce at this moment. Based on an exploratory poll flagged as 'unscientific' by the author herself because of its exploratory nature, Pluhar (2010) reported that the initial U.S. consumer reaction to cultured meat was mainly one of repulsion owing to associations with horror and the possible use of objectionable additives in a laboratory setting. In a recent study exploring public sense-making around cultured meat and involving participants from different European countries, Marcu *et al.* (2015) and Verbeke *et al.* (2015) found that consumers raised many questions about diverse issues such as product safety, nutritional content, price, as well as about technological procedures, scientific uncertainties, and social, economic, and cultural implications relative to current livestock production and agribusinesses. These questions encapsulated both concerns and curiosity. Their study also revealed that much of people's reasoning around cultured meat mirrored reasoning seen or heard previously around other biotechnologies such as GMOs or animal cloning. The authors concluded that cultured meat production is likely to inherit considerably from previous technological controversies, and therefore participation of, and interaction with the broader public will be crucial in the future development and marketing of cultured meat.

Nevertheless, a quantitative study in the Netherlands performed in February 2013 (thus, prior to the August 2013 cultured burger tasting) with about 1 300 participants indicated that most people (79%) had never heard of cultured meat. Only few had heard of it and claimed to know what it is about (14%) (Flycatcher 2013). After explaining the technique and the possible advantages and disadvantages associated with cultured meat production, nearly two-thirds (63%) supported the idea of producing cultured meat. More than half of the participants (52%) in that study claimed to be willing to try cultured meat while almost one quarter was doubting (23%) and another quarter reported they would never want to try it. In a similar vein, in an internet poll organized by The Guardian in the United Kingdom (U.K.) in 2012, 68% of the participants indicated they would be willing to eat "lab-grown meat" (The Guardian 2012).

## 4. Primary exploratory consumer study about cultured meat

### 4.1. Materials and methods

We performed an exploratory study on consumers perceptions of cultured meat through a web-based survey in Flanders (the northern Dutch-speaking part of Belgium) during April 2013. The study used a convenience sampling procedure and targeted mainly a student population. Hence, the exploratory insights obtained from this study mainly apply within the characteristics of the sample, whereas generalization to the overall population remains speculative. The sample ( $n=180$ ) contained an almost equal share of men (45%) and women (55%), but it was biased towards younger age (73% younger than 30 years) and higher education (60% with higher education). First, participants were asked about their meat consumption habits and possible reasons to eat less meat. Details about items and measurement scale are presented with Table 1. The next section of the survey focused on cultured meat. The primary term used in the study was '*in vitro* meat', but it was explicitly mentioned that 'cultured meat' is an alternative and often used term with the same meaning. After probing the unaided awareness about cultured meat, basic background information about cultured meat was presented. Expectations about cultured meat were measured for five attributes using seven-point semantic differential scales (Table 2). Three statements were also included comparing expectations about cultured meat directly with traditionally produced meat in terms of expected price, taste and sustainability. Next, participants evaluated the production of cultured meat as a substitute for conventional production of meat in terms of 'good', 'feasible', 'acceptable', 'effective', 'long term solution (to the problems facing livestock production)'. Finally, claimed willingness to try, purchase and eventually also pay a price premium for cultured meat were measured, first, after the provision of basic information about cultured meat and, a second time after additional information was presented (see footnote Table 3). The additional information stressed the problems facing conventional meat production and explicitly referred to the potential of cultured meat production as a possible solution. Note that this type of additional information reflects the viewpoints of proponents of cultured meat, which is consistent with the dominant media coverage seen thus far (Goodwin and Shoulders 2013). The last part of the questionnaire registered socio-demographics including gender, age and education level.

### 4.2. Results

Most participants were meat eaters who almost never ate

vegetarian meals (61.1%). While some claimed to eat both meat and vegetarian meals on regular basis (22.8%), 16.1% of the participants claimed to eat mostly vegetarian meals. Mean scores around the midpoint (4) of the scale were reported for possible reasons to reduce meat intake, except for intending to eat less meat because it is too expensive. This suggests that the price of meat is not a major argument for most participants to reducing meat intake. When comparing the three segments based on meat consumption, more extreme values were observed. Consumers who ate vegetarian meals more frequently, agreed more strongly that being against the practices in traditional meat production, wanting to consume more in an ecologically friendly way, and being more convinced that eating less meat is healthier were stronger motivations for them intending to reduce or stop meat consumption (Table 1).

Similarly as in the Netherlands where 14% of the study participants had heard of cultured meat and claimed to know what it is about (Flycatcher 2013), 13% of the participants in our study stated to have heard of cultured meat and to know what it is about (Table 2). Half of the participants (51%) had never heard of cultured meat while 36% reported to have heard about it but not to know what it is about. These findings show that cultured meat was hardly known among Flemish consumers, at least before the August 2013 cultured burger tasting and consecutive media coverage. There were no significant differences in the claimed awareness of cultured meat between the three meat consumer groups ( $P=0.809$ ).

After basic information about cultured meat was provided, participants expressed their beliefs and expectations about it. In general, participants believed cultured meat would be safe, nutritious, ecological and ethical (Table 2), while they scored neutral in terms of expected healthiness. Compared to traditional meat production, cultured meat production was expected to be more sustainable, but yielding slightly less tasty and more expensive meat. Cultured meat was generally positively evaluated as a possible substitute for traditional meat in terms of perceived goodness, feasibility,

acceptability and effectiveness (Table 2). The expectations about cultured meat and cultured meat production as an alternative for traditional meat production did not differ significantly between the three meat consumer groups ( $F$ -tests, all  $P>0.05$ ), except for expected healthiness ( $P=0.004$ ). Cultured meat was perceived (or expected to be) as healthier by consumers who ate both meat and vegetarian meals compared to those who mostly ate vegetarian meals. A possible explanation may be that consumers eating mostly vegetarian meals are more strongly convinced that meat is simply less healthy than the plant-based or other types of meat substitutes they have gradually adopted, while they may perceive cultured meat still as 'meat', and thus as being less healthy for them. This finding suggests first, that vegetarian consumers may perceive meat as unhealthy no matter whether it has been traditionally produced or cultured, and second, that vegetarian consumers are generally satisfied with the alternatives they have adopted and thus see little or no reason for returning to consuming (cultured) meat.

Two out of three participants (67%) indicated that they would maybe be willing to try cultured meat if it was available on the market. One quarter (24%) indicated surely wanting to try it (Table 3). Additional information stressing the environmental problems associated with conventional livestock and meat production, resulted in 43% of the participants claiming to surely, and 51% claiming to maybe wanting to try cultured meat. About half of the participants who initially claimed not to be willing to try cultured meat, changed their opinion after receiving the additional information into 'maybe willing' to try it, but none of them switched to 'surely wanting to'. In a similar vein, 29% of those initially 'maybe wanting' to try cultured meat switched from 'maybe' to 'surely' wanting to try cultured meat. In addition, those who claimed initially to be willing to try cultured meat (i.e., before receiving the additional information) did not change their mind afterwards. As a result, providing additional information on the benefits of producing cultured meat (relative to the problems facing traditional livestock production) positively impacted the claimed willingness to try it, resulting in a higher proportion

**Table 1** Possible reasons to reduce or stop eating meat, and mean scores (SD) on 7-point interval scales (1=Totally disagree, 7=Totally agree) for the total sample ( $n=180$ ) and meat consumer groups

"I may plan to reduce or stop eating meat because ..."	Total sample ( $n=180$ )	Meat consumers (61.1%)	Meat and plant- based meat substitute consumers (22.8%)	Mostly plant-based meat substitute consumers (16.1%)
I am against the practices in traditional meat production	3.99 (1.75)	3.41 e	4.32 f	5.72 g
I want to behave more ecologically friendly and therefore eat less meat	3.94 (1.99)	3.12 e	4.51 f	6.24 g
I am convinced that eating less or no meat is healthier	3.52 (2.05)	2.86 a	4.02 b	5.28 c
I believe meat is too expensive	2.45 (1.62)	2.08 a	2.85 ab	3.28 b

a, b, c indicate significantly different means using Scheffe Post Hoc comparison tests ( $P<0.05$ ); e, f, g indicate significantly different means using Dunnett T3 Post Hoc comparison tests ( $P<0.05$ ).

**Table 2** Awareness (%) and expectations about cultured meat (7-point semantic differential scale) and evaluation of *in vitro* meat as an alternative for traditionally produced meat (1=Totally disagree, 7=Totally agree) (n=180)

Awareness about cultured meat: "Have you heard about <i>in vitro</i> meat?"	%	
Yes, and I know what it means	13.0	
Yes, but I do not know what it means	36.0	
No, I have never heard of <i>in vitro</i> meat	51.0	
Expectations about cultured meat	Mean	SD
Not healthy (1)–very healthy (7)	3.98	0.92
Not safe (1)–very safe (7)	4.64	1.24
Not nutritious (1)–very nutritious (7)	4.59	1.13
Not ecological (1)–very ecological (7)	4.91	1.26
Not ethical (1)–very ethical (7)	4.73	1.62
Much more expensive (1)–much cheaper than traditional meat (7)	3.31	1.52
Much less tasty (1)–much tastier than traditional meat (7)	3.38	0.90
Much less sustainable (1)–much more sustainable than traditional meat (7)	5.12	1.28
"I believe <i>in vitro</i> meat as a substitute for traditional meat is ..."	Mean	SD
Good	4.61	1.41
Feasible	4.35	1.43
Acceptable	4.58	1.44
Effective	4.53	1.41
A long term solution	4.84	1.63

**Table 3** Frequency (%; n=180) of participants claiming to be 'not', 'maybe' and 'surely' willing to try, purchase and pay a price premium for cultured meat

	Basic information about technology <sup>1)</sup>			Additional information about benefits <sup>2)</sup>		
	Not	Maybe	Surely	Not	Maybe	Surely
Willing to try	9.4	66.7	23.9	6.1	51.4	42.5
Willing to purchase	11.7	68.9	19.4	5.6	58.1	36.3
Willing to pay more	42.2	43.9	13.9	36.3	27.9	35.8

<sup>1)</sup> Basic information: "*In vitro* meat, which is also called 'cultured meat', is meat produced in a laboratory using stem cells from an animal and a suitable growth medium. This way, it may be possible to cultivate basically one million ton of meat muscle tissue by using stem cells from one animal. This could be an alternative to traditional meat as we know it nowadays. The product should not be confused with meat substitutes like tofu or quorn because it is real meat, only it has not been obtained as part of a living animal." This basic information was combined with the visual flowchart "How it works" based on Daily Mail (2012).

<sup>2)</sup> Additional information: "Currently about one-third of Earth's land area is agricultural land. About two-thirds of this agricultural land is used for cultivating livestock, which is responsible for about 18% of the greenhouse gas (GHG) emissions. This is more than the transportation sector. The environmental problems associated with livestock production could partially be reduced by no longer producing meat in the traditional way but instead produce meat *in vitro*. This could lead to a 96% reduction of GHG emissions compared to traditional meat. By culturing meat in a lab, one could also prevent diseases such as mad cow disease and microbiological infections, such as *Salmonella*. Also the fat composition of the meat can be improved, for example by enriching the meat with omega-3 fatty acids." Note that this information message explicitly points at the environmental burden of traditional livestock production, while it is univocally positive about culturing meat and stressing possible benefits only.

who indicated "surely" to be wanting to try it (43% after receiving additional information, vs. 24% initially). Findings for 'willingness to purchase' largely follow the same pattern. These findings are generally consistent with the findings from quantitative studies in the Netherlands and the U.K. where also a majority of consumers indicated they would (maybe or surely) be willing to try this novel food product.

The findings of our study finally suggest that price will be an important factor for consumers. Four out of ten participants (42%) were not willing to pay a price premium for cultured meat compared to traditional meat, and this percentages only decreased slightly after receiving additional information about the environmental benefits of cultured meat relative to traditional meat production (Table 3). Of those willing to pay more for cultured meat, 79% did not want

to pay more than 50% extra compared to traditional meat.

## 5. Discussion

The list of possible criteria shaping future consumer acceptance of cultured meat is extended and ranges from perceived risks and benefits related to the technology and the product, over trust in science, society and regulation, to public involvement in the product development and media coverage about the issue. Generally speaking, there are two major types of acceptability criteria for cultured meat. The first is of moral order: is the technology acceptable and does it not transgress the laws of nature? This dilemma in itself is not new, as demonstrated by the discussions provoked by the adoption of other new food technologies like



biotechnology in industrialized countries. One important dimension of such a debate relates to the society's perceived need for the technology in question (or lack thereof), this being assessed from a cost/benefit balance of introducing and implementing the technology. In the case of cultured meat, the major expected benefits, as opposed to possible moral objections against the application of the technology, would be reduced animal suffering, reduced production of greenhouse gasses and the creation of a new source of proteins with the potential of feeding the growing world population (Post 2012). Future studies and debates should clarify whether these benefits are worth the costs, and whether these are indeed also perceived as such by the public and consumers.

The second type of acceptability criteria concerns the acceptability of the physical product that is released on to the market, with all its attributes ranging from its intrinsic sensory quality, healthiness, safety, sustainability, up to its price, market positioning and branding. The topic of investigation in the present paper is still purely hypothetical. The likely reception of cultured meat by consumers can hardly be predicted at present because (apart from the prototype tested in August 2013) no finished product has yet been introduced on the market. There is, in fact, a considerable gap between culturing a relatively small quantity of cells *in vitro* and developing a marketable product. It seems risky to rely on a few tests carried out by the project financiers (such as People for the Ethical Treatment of Animals (PETA), i.e., stakeholders with a vested interest) using 'artificial chicken' products which indicated their good reception by consumers (Driessen and Korthals 2012). Major challenges ahead pertain to further improving the product and its production process in order to make it mimic traditional meat (based on the insights of the present study, notably in terms of sensory characteristics and price), up-scaling the process and making it more resource- and cost-efficient, and dealing with regulatory and intellectual property issues (Post 2014). The expectation is that a cultured burger could become marketable by 2020 at an expected price of 65 US\$ kg<sup>-1</sup> (Post, personal communication).

Most of the published consumer studies date from before the August 2013 cultured burger tasting. As a consequence, and despite the fact that scientific evidence was already available about the technological feasibility of culturing meat, these studies were dealing with a hypothetical issue for the 'Far Future' in consumers' perceptions. The limited number of studies—most of which are qualitative and exploratory until this stage—suggest that consumers are quite skeptical towards the idea of culturing meat and eating it, which seems to be largely due to anchoring cultured, *in vitro* or synthetic meat to biotechnologies. On one hand, preliminary quantitative data—including the primary data reported in this

paper—indicate that only a minority of consumers definitely reject the idea of trying cultured meat. On the other hand, consumers' claimed willingness to try cultured meat does not say much about the likelihood of repeat purchase or sustainable behavioral change.

Our exploratory study further suggests that the likelihood of acceptance increases with the provision of additional information that stresses the benefits of cultured meat relative to traditional meat, notably in terms of its environmental benefits. It should be noted that the information provided to our study participants was univocally positive about cultured meat, i.e., stressing only possible benefits without mentioning possible risks or uncertainties, and that the specific wording of questions may have caused bias to some of the results. Although consumers may be willing to try cultured meat sometime in the future, data about consumer beliefs and expectations support the idea that it will be very important to mimic conventional meat as good as possible with respect to taste, mouth feel or texture, nutritional value, and appearance (Post 2014). Providing cultured meat that mimics the characteristics of traditional meat without creating an extremely expensive product will be a major challenge. Based on our study, if cultured meat mimics conventional meat at an affordable price, it may have the potential to be widely accepted among consumers.

Apart from the conditions governing the acceptability of cultured meat by consumers and the general public, the objectives of the various stakeholders in the future production and marketing chain of cultured meat are also worth analyzing. The motivations of different research teams and their financing agencies may not always be convergent: some may consider this product as a substitute to traditional meat, addressing consumers who are sensitive to emerging societal questions facing traditional livestock production such as animal well-being and the environmental impact of livestock production, while planning to continue eating meat. Others may see it as a substitute for plant-based protein products, which are typically positioned towards the vegetarian market but often qualified as ersatz and unappetizing by traditional meat consumers. Finally, still others may consider that cultured meat may help to win back the vegetarians to eat meat by offering additional diversity to the food available. The finding of our study that vegetarians have a less favorable perception of cultured meat's healthiness supports the idea that taking the reactions of vegetarians as a benchmark might be a risky strategy towards the future positioning and adopting of cultured meat (Hopkins 2015).

Goodwin and Shoulders (2013) finally pointed out that the meat industry might need to closely monitor how traditional meat is covered in the media and communicate in a more proactive way. It can indeed be expected that attitudes towards food in general and towards traditional meat in

particular will play an important role in future consumer acceptance of cultured meat. Worsening beliefs that traditional meat is healthy, nutritious, safe or sustainable, and stronger intentions to reduce traditional meat consumption (i.e., evolutions that are clearly seen in industrialized countries nowadays) may help paving the path for alternatives such as cultured meat. By contrast, cultured meat will not be the sole alternative to traditional meat in the future. Plant-based meat substitutes, algae, and insects, for example, may benefit from a so-called 'first mover' advantage if these meat substitutes manage to meet consumer expectations and satisfy them. A gaining market presence of these substitutes, which is in line with the dietary shift away from muscle meat consumption as already seen in many Western countries, may reduce the perceived necessity for more far-reaching innovations and technological developments such as cultured meat.

## 6. Conclusion

The present paper reviewed the diversity of criteria shaping future consumer acceptance of cultured meat. Acceptability criteria are of moral order related to the technology and its application, and related to the physical product, its expected quality attributes and the possible benefits and risks these imply. Conclusive consumer insight about cultured meat is still very scarce. Primary exploratory findings reported in this paper suggest that most of the consumers hesitate when asked the question whether they would be willing to try cultured meat in the future. Only a small minority definitely reject this idea. The findings also suggest that benefits in terms of sustainability of cultured meat relative to traditional meat are recognized by consumers, and that the provision of information that stresses these benefits increases consumers' claimed willingness to try, purchase and (to a lesser extent) pay for cultured meat sometime in the future. Further studies into personal and environmental determinants—notably personal motivations and information effects—that may shape consumer perceptions, expectations, and the likelihood of acceptance or rejection of cultured meat are recommended.

## References

- de Barcellos M D, Kügler J O, Grunert K G, Van Wezemael L, Pérez-Cueto F J A, Ueland Ø, Verbeke W. 2010. European consumers' acceptance of beef processing technologies: A focus group study. *Innovative Food Science and Emerging Technologies*, **11**, 721–732.
- Bhat Z F, Bhat H. 2011. Tissue engineered meat—Future meat. *Journal of Stored Products and Postharvest Research*, **2**, 1–10.
- Chiles R M. 2013. If they come, we will build it: *In vitro* meat and the discursive struggle over future agrofood expectations. *Agriculture and Human Values*, **30**, 511–523.
- Cox D N, Evans G. 2008. Construction and validation of a psychometric scale to measure consumers' fears of novel food technologies: The food technology neophobia scale. *Food Quality and Preference*, **19**, 704–710.
- Daily Mail. 2012. Artificial meat grown in a lab could become a reality this year. [2012-01-17]. <http://www.dailymail.co.uk/sciencetech/article-2087837/Test-tube-meat-reality-year-scientists-work-make-profitable.html>
- Datar I, Betti M. 2010. Possibilities for an *in vitro* meat production system. *Innovative Food Science and Emerging Technologies*, **11**, 13–22.
- Driessen C, Korhals M. 2012. Pig towers and *in vitro* meat: Disclosing moral worlds by design. *Social Studies of Science*, **42**, 797–820.
- Flycatcher. 2013. Kweekvlees [cultured meat]. [2013-12-18]. [http://www.flycatcherpanel.nl/news/item/nwsA1697/media/images/Resultaten\\_onderzoek\\_kweekvlees.pdf](http://www.flycatcherpanel.nl/news/item/nwsA1697/media/images/Resultaten_onderzoek_kweekvlees.pdf) (in Dutch)
- Frewer L J, Bergmann K, Brennan M, Lion R, Meertens R, Rowe G, Siegrist M, Vereijken C. 2011. Consumer response to novel agri-food technologies: Implications for predicting consumer acceptance of emerging food technologies. *Trends in Food Science and Technology*, **22**, 422–456.
- Goodwin J N, Shoulders C W. 2013. The future of meat: A qualitative analysis of cultured meat media coverage. *Meat Science*, **95**, 445–450.
- Grunert K G, Verbeke W, Kügler J O, Saeed F, Scholderer J. 2011. Use of consumer insight in the new product development process in the meat sector. *Meat Science*, **89**, 251–258.
- Hocquette J-F, Mainsant P, Daudin J D, Cassar-Malek I, Rémond D, Doreau M, Sans P, Bauchart D, Agabriel J, Verbeke W, Picard B. 2013. Will meat be produced *in vitro* in the future? *INRA Productions Animales*, **26**, 363–374. (in French)
- Hopkins P D, Dacey A. 2008. Vegetarian meat: could technology save animals and satisfy meat eaters? *Journal of Agricultural and Environmental Ethics*, **21**, 579–596.
- Hopkins P D. 2015. Cultured meat in western media: The disproportionate coverage of vegetarian reactions, demographic realities, and implications for cultured meat marketing. *Journal of Integrative Agriculture*, **14**, 264–272.
- Marcu A, Gaspar R, Rutsaert P, Seibt B, Fletcher D, Verbeke W, Barnett J. 2015. Analogies, metaphors, and wondering about the future: Lay sense-making around synthetic meat. *Public Understanding of Science*, doi: 10.1177/0963662514521106
- Martins Y, Pliner P. 2005. Human food choices: An examination of the factors underlying acceptance/rejection of novel and familiar animal and nonanimal foods. *Appetite*, **45**, 214–224.
- Mattick C S, Allenby B R. 2012. Cultured meat: The systemic implications of an emerging technology. In: *Proceedings of the IEEE International Symposium on Sustainable Systems and Technology ISSST*. May 16–18, 2012. IEEE, Boston.

- Pliner P, Hobden K. 1992. Development of a scale to measure the trait of food neophobia in humans. *Appetite*, **19**, 105–120.
- Pluhar E B. 2010. Meat and morality: Alternatives to factory farming. *Journal of Agricultural and Environmental Ethics*, **23**, 455–468.
- Post M J. 2012. Culture meat from stem cells: Challenges and prospects. *Meat Science*, **92**, 297–301.
- Post M J. 2014. Cultured beef: Medical technology to produce food. *Journal of the Science of Food and Agriculture*, doi: 10.1002/jsfa.6474
- Rollin F, Kennedy J, Wills J. 2011. Consumer response to new food technologies. *Trends in Food Science and Technology*, **22**, 99–111.
- Saeed F, Grunert K G, Therkildsen M. 2013. How product trial changes quality perception of four new processed beef products. *Meat Science*, **93**, 119–127.
- Siegrist M. 2008. Factors influencing public acceptance of innovative food technologies and products. *Trends in Food Science and Technology*, **19**, 603–608.
- The Guardian. 2012. Would you eat lab-grown meat? [2012-02-20]. <http://www.guardian.co.uk/commentisfree/poll/2012/feb/20/lab-grown-meat-test-tube-burger?INTCMP=SRCH>
- Vanhonacker F, Van Loo E J, Gellynck X, Verbeke W. 2013. Flemish consumer attitudes towards more sustainable food choices. *Appetite*, **62**, 7–16.
- Verbeke W. 2005. Agriculture and the food industry in the information age. *European Review of Agricultural Economics*, **32**, 347–368.
- Verbeke W. 2011. Consumer attitudes and communication challenges for agro-food technologies. *Agro-Food Industry Hi-Tech*, **22**, 34–36.
- Verbeke W, Frewer L J, Scholderer J, De Brabander H F. 2007. Why consumers behave as they do with respect to food safety and risk information. *Analytica Chimica Acta*, **586**, 2–7.
- Verbeke W, Marcu A, Rutsaert P, Gaspar R, Seibt B, Fletcher D, Barnett J. 2015. 'Would you eat cultured meat?': Consumers' reactions and attitude formation in Belgium, Portugal and the United Kingdom. *Meat Science*, **102**, 49–58.
- Verbeke W, Viaene J, Guiot O. 1999. Health communication and consumer behaviour on meat in Belgium: From BSE until dioxin. *Journal of Health Communication*, **4**, 345–357.
- van der Weele C, Driessen C. 2013. Emerging profiles for cultured meat: Ethics through and as design. *Animals*, **3**, 647–662.
- Welin S. 2013. Introducing the new meat. Problems and prospects. *Etikk i praksis: Nordic Journal of Applied Ethics*, **7**, 24–37.
- Welin S, van der Weele C. 2012. Cultured meat: Will it separate us from nature? In: Potthast T, Meisch S, eds., *Climate Change and Sustainable Development: Ethical Perspectives on Land Use and Food Production*. Wageningen Academic Publishers, Wageningen. pp. 348–351.