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Advances in Sensory Science: From Perceptions to Consumer Acceptance

Consumers' perception of cultured meat relative to other meat alternatives and meat itself: A segmentation study

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Abstract: Cultured meat is still under development but could possibly serve as a meat alternative. As a result, the acceptance and perception of cultured meat have received considerable attention in consumer research. However, only few comparisons to meat or meat alternatives have been made, which makes it unclear how cultured meat compares to these products. This is the first study to directly compare cultured meat to plant-based meat alternatives (PBMA), fish, insects, and conventional meat. Dutch consumers ($n = 288$) evaluated their perception and willingness to consume (WTC) patties made from the five sources listed above. Consumer segmentation based on the WTC ratings was performed, and the resulting clusters were compared in terms of their preferences, perception of cultured meat, and demographic and psychographic variables. To see if naming affected consumers' cultured meat perception, respondents were assigned to one of five naming conditions for cultured meat.

The clusters analysis yielded three clusters, two of which showed moderate WTC cultured meat. The first cluster could be characterized as "meat lovers." Their WTC was strongest for conventional meat, followed by cultured meat, and tastiness was their main driver of WTC. The second cluster's preference was fish, followed by PBMA, with naturalness, safety, and tastiness being their drivers of WTC. The third cluster's highest WTC was for PBMA, followed by cultured meat. Among their drivers of WTC were healthiness, sustainability, and animal friendliness. Psychographic variables were highly valuable in explaining the clusters. Finally, no effects of naming for cultured meat were observed.

KEYWORDS
clustering, consumer acceptance, cultured meat, meat alternatives, naming

Practical Application: The results contribute to the design of guidelines to promote different meat alternatives considering specific target populations.

1 | INTRODUCTION

1.1 | Background on cultured meat

For many consumers all over the world, meat (used interchangeably with conventional meat) forms a central part of their diet, provided that they have the financial resources to buy it; a welfare increase in developing countries is generally followed by an increase in meat consumption (OECD/FAO, 2020). In 2011, the FAO predicted a 70% increase in global meat demand by 2050, with the largest increases found in developing countries (McLeod, 2011). There are however major drawbacks to further scaling of meat consumption. Animals, especially ruminants (e.g., cattle), produce protein inherently less efficiently than plants (Wirsenius et al., 2010). Consequently, 75% of agricultural land is used for livestock farming and the growth of feed crops, even though meat is just a small element of our diets (Steinfeld et al., 2006). Moreover, livestock production is water-intensive and contributes to global warming by the emission of greenhouse gasses (Aiking, 2011; González et al., 2011; Leip et al., 2015; Mekonnen & Hoekstra, 2012). The emission of greenhouse gasses is even intensified by deforestation for feed crop farming (Cederberg et al., 2011; McMichael et al., 2007). Apart from the environmental impact, there are the ever-present ethical debates surrounding animal welfare. Consumers themselves also experience a moral conflict, the so-called "meat paradox," because they enjoy eating meat, but do not want to hurt animals (Loughnan et al., 2010). As a response to these problems, the development of meat alternatives gained momentum in recent years. An innovative and interesting meat alternative is cultured meat.

Cultured meat is produced by using the combined techniques of stem cell isolation, cell culturing, and tissue engineering (Post, 2012). These techniques enable the growth of single muscle fibers outside the animal. Together, these fibers form a piece of meat. In August 2013, the first cultured meat beef burger was presented. At that point, the development of cultured meat was incomplete (Post, 2014), but large developments have been made since then. The production of cultured meat now includes fish and chicken among others (Khazan, 2019) and fetal bovine serum has been substituted by a plant-based growth medium (Mosa Meat, 2020; Terlingen, 2020). Moreover, prices dropped significantly (Corbyn, 2020; JUST, n.d.; Lucas, 2019), and cultured meat recently received regulatory approval to enter the market in Singapore (Trager, 2020). These developments took and take place under large financial impulses (Choudhury et al., 2020). For the near future, cultured meat relies on interest from investors, Silicon Valley, animal welfare organizations, and the meat industry (van der Weele et al., 2019). This broad support is much needed given some of the major technological and regulatory hurdles that need to be cleared in the further development of cultured meat (Post et al., 2020).

Meanwhile, the first studies on the sustainability of cultured meat have been conducted. From several life cycle assessments, it has become clear that cultured meat can reduce land use, but has a fairly high energy use (Mattick et al., 2015; Smetana et al., 2015; Tuomisto & Teixeira de Mattos, 2011). It is unclear if and to what extent energy use will increase and the consequences of high(er) energy use are difficult to predict. Lynch and Pierrehumbert (2019) conducted a thorough modelling study in which different scenarios of beef cattle and cultured meat production were considered. Based on that study, it is not a given that cultured meat will have a lower global warming potential. However, the undisputed improvements in animal welfare and reduced land use make cultured meat an interesting meat alternative nonetheless.

1.2 | Consumer perception of cultured meat

Next to research on the regulatory, technological, and environmental aspects of cultured meat, there is also a growing body of consumer research. The emerging insight is that there is a moderate interest in cultured meat, with a considerable proportion of consumers expressing concerns about price, sensory quality, and safety (e.g., Verbeke, Sans et al., 2015; Wilks & Phillips, 2017). However, it is difficult to say how cultured meat compares to other meat alternatives, as most research focused on cultured meat only (e.g. Laestadius and Caldwell, 2015; Mancini & Antonioli, 2019; Verbeke, Marcu et al., 2015). Some studies compared cultured meat to a single alternative, either conventional meat (Verbeke, Sans et al., 2015; Wilks & Phillips, 2017) or plant-based meat alternatives (PBMA) (Bryant et al., 2019). Only Slade (2018) compared cultured meat to both conventional meat and PBMA. In a choice experiment, results showed that, equal prices assumed, 11% of consumers would choose cultured meat burgers, whereas 21% and 65% would choose PBMA and conventional meat, respectively. Including multiple other meat alternatives can yield more of such valuable insights for understanding perception and acceptance. Therefore, this study will compare cultured meat to conventional meat, fish, insects, and PBMA. This approach is not only relevant for cultured meat, but also answers to the general call for more direct comparisons between meat alternatives (Onwezen et al., 2021).

The following subsections are a brief justification of the inclusion of each of the four products in this work, but especially of fish, which is often overlooked as a potential meat alternative.

1.2.1 | Meat

The perception of cultured meat is most informative when it can be compared to meat, which will be the reference to most consumers. In Western countries, the annual per capita meat supply is between 60 and 120 kilograms (Ritchie & Roser, 2017). In other regions, the meat supply is often not as high. In many countries, however, meat supplies are on the rise, mainly as a function of growing GDP (Ritchie & Roser, 2017).

Even under a large increase of meat alternative consumption, meat will most likely keep a place in our diets, albeit a less prominent one. Van Zanten et al. (2018) pointed out that meat consumption is needed for an efficient food chain. They propose a system in which livestock is raised under a circular economy. In this system the yield of animal source protein is estimated at 9–23 g per capita per day, which is a significant proportion of the required 50–60 g of protein per day. Van Hal et al. (2019) conducted a more detailed study, which showed that the circular system could provide 26 g of animal source protein per capita per day. This would, among other animal source products, come down to two 100-g portions of beef per week.

1.2.2 | Plant-based meat alternatives

Plant-based meat alternatives (PBMA) are an established meat alternative. The production of PBMA is in an advanced stage (He et al., 2020), and PBMA already have a modest market share that has been growing over the last decade (van der Weele et al., 2019). The environmental benefits of PBMA are undisputed. The production of plant-based foods is inherently more efficient than the production of meat because meat requires an intermediate conversion step. As a result, plant-based diets have lower global warming potential, land use, and water use (Hallström et al., 2015; Willett et al., 2019). When looking at specific PBMAs, it is known that soy, often the main ingredient in PBMA, has a lower environmental impact than meat on many different variables, for example, global warming potential and land use (Parodi et al., 2018; Reijnders & Soret, 2003; Smetana et al., 2015). Importantly, PBMA are nutritionally adequate in terms of amino acid composition (van Mierlo et al., 2017).

1.2.3 | Fish

For several reasons, fish has the potential to subset a significant share of meat consumption. First, from a nutritional perspective, fish is a well-suited meat alternative. Fish is rich in protein, and it contains the poly-unsaturated fatty acids EPA and DHA, and essential micronutrients. Second, for most consumers, fish already forms a part of their diet. Global per capita fish consumption was 20.3 kg live weight equivalent in 2017 (FAO, 2020). This amounts to approximately 30% of total meat and fish supply (Béné et al., 2015). In the Netherlands in particular, the per capita consumption (actual consumption, not for example live weight or carcass weight equivalent) of fish and meat are 16 and 98 g per day, respectively (van Rossum et al., 2020). Consumers' familiarity with fish could ease the adoption as a meat alternative.

Thirdly, the actual potential of fish as a meat alternative lies in new production systems. Capture fisheries have long been the predominant source of fish production. However, since seas and lakes are exhaustible, fish production from capture fisheries has been stable at approximately 90 million tonnes per year ever since the late 1980s (FAO, 2020). To meet the growing demand, aquaculture, the seafood equivalent of livestock production, has meanwhile grown over five-fold to a production of 82 million tonnes per year in 2018 (FAO, 2020).

In terms of land use and greenhouse gas emissions per unit of protein or carcass weight, aquaculture scores similar to or slightly better than poultry, the most sustainable type of meat (Macleod et al., 2020; Nijdam et al., 2012: Parodi et al., 2018). However, production increases from current forms of aquaculture will put a greater strain on freshwater availability, lead to more water pollution and eutrophication, and increase greenhouse gas emissions (Ahmed et al., 2019). Moreover, aquaculture is susceptible to the consequences of climate change such as droughts, floods, and ocean acidification. Environmental pressure and climate change thus call for more sustainable aquaculture techniques to further increase in production.

One such technique could be the recirculating aquaculture system (RAS). RAS is a land-based technique in which water is filtered and reused (Ahmed et al., 2019; Dalsgaard et al., 2013). The main advantage of RAS is that it is a closed system, making it highly efficient and controllable. Water is constantly being filtered for reuse in the system, which reduces the demand for water by somewhere between 90% and nearly 100% (Bregnballe, 2015; Ebeling & Timmons, 2012). Moreover, numerous parameters that affect growth can be optimized for efficiency (Bregnballe, 2015). Like culturing meat, the energy use of RAS is relatively high

(Badiola et al., 2018; Tilman & Clark, 2014), which causes significant emission of greenhouse gases when fossil fuels provide this energy. There is however potential to reduce the use of fossil fuels as well as energy use in general (Badiola et al., 2018; Dalsgaard et al., 2013). Around 2014, the estimated number of RAS installations in the United States and Europe was 360, and it has increased since then (Badiola et al., 2018). These farms provide a fraction of the total fish production, but the fact that several hundreds of farms are up and running means RAS is a viable technique despite its high initial costs to set up the system. To summarize this third point, fish currently is a relatively sustainable meat alternative and could become even more so if RAS gets adopted at a larger scale.

1.2.4 | Insects

The prospect for insects as a meat alternative is somewhat mixed. From a nutritional perspective, insects may replace meat. In general, insects are high in protein, fiber, and fat, in particular unsaturated fatty acids (van Huis et al., 2013). Moreover, they are significant sources of iron, zinc, vitamins B1 and B2, and some species also provide B12.

Van Huis et al. (2013) pointed out that insects possess several characteristics that are interesting from an environmental perspective. Insects can be reared on side streams and compared to livestock animals; a far larger share of the insect is edible. Moreover, their body temperature depends on external warmth, which increases energy requirements, but allows for efficient feed conversion (van Huis & Oonincx, 2017). When looking at the actual environmental impact, it seems that compared to pork and poultry, the production of insects requires less land and water, and, despite its considerable energy use, has a lower global warming potential (see: Halloran et al., 2018; Parodi et al., 2018; van Huis and Oonincx, 2017; van Huis et al., 2013).

A major hurdle to overcome is low consumer acceptance. To investigate the readiness to adopt insects as food, Mancini et al. (2019) conducted a systematic review with 41 studies, all conducted in Europe. Most of the studies that investigated some form of acceptance (attitude, willingness to buy, etc.) found only a small group of consumers that responded positively.

1.3 | Consumer differences in their perception of cultured meat

Consumer research so far has observed demographic differences between consumers who do and do not show interest in cultured meat. For example, men show greater interest in cultured meat than women (Mancini et al., 2019; Slade, 2018; Wilks & Phillips, 2017); this effect of gender being mainly found in Western countries. Interestingly, Bryant et al. (2019) observed the reverse pattern in China. Such findings suggest that differences in cultured meat perception exist within and between cultures. The comparison between cultured meat and meat (alternatives) gains power when consumers can be differentiated according to their preferences. To this end, different consumer segments were investigated in this via a cluster analysis.

1.4 | Naming of cultured meat

Considering the complexity of growing cultured meat, it can be classified as a novel food technology. Experimental research as well as real-world examples have shown that the perception of novel food technologies, for example, genetic modification, is prone to framing (Heiman & Zilberman, 2011; Siegrist & Hartmann, 2020). These findings suggest that the perception of cultured meat may also be prone to framing. So far, several studies have shown the effect of framing on cultured meat perception (e.g., Bekker et al., 2017; Bryant & Barnett, 2019, Bryant & Dillard, 2019; Greig, 2017; Siegrist et al., 2018; Szejda, 2018). The effect of naming itself on perception has also been demonstrated (Bryant & Barnett, 2019; Greig, 2017; Szejda, 2018; Szejda et al., 2019; The Good Food Institute, n.d.). It takes little effort to use a different name, but it apparently results in profound effects on perception. Also, Bryant and Barnett (2019) pointed out that the use of different names for cultured meat could lead to variation in the results of consumer research.

The search for the best term for cultured meat started when Friedrich (2016) from the Good Food Institute (GFI), an advocacy group that focuses on plant-based and cultured meat, coined the term clean meat. Studies by GFI (n.d.) and Greig (2017) from the Animal Charity Evaluators, an advocacy group for animal welfare, showed that consumers indeed prefer clean meat over cultured meat. However, a year later, cell-based meat was adopted as a neutral and descriptive name that would be better suited to involve the conventional meat industry in the transition to cultured meat (Watson, 2018). On behalf of GFI, Szejda (2018) conducted a study on naming and found slaughter-free meat to perform well. This term was however discarded for its lack of neutrality. Szejda et al. (2019) conducted additional research in which clean meat and slaughter-free meat were not considered anymore. Based on this report, Friedrich (2019) proposed cultivated meat for its combined optimum of appeal and descriptiveness.

In parallel to GFI, Bryant and Barnett (2019) also studied naming in an online study among English-speaking populations. They studied four names, of which clean meat performed best. Animal-free meat and cultured meat came close to clean meat. Only lab-grown meat clearly performed worse. Based on these findings, clean meat was proposed as the best term for cultured meat. The authors decided to discard the term animal-free meat based on signs of confusion from the respondents, as this term was the only one particularly associated with terms like vegan/vegetarian and, to a lesser extent, soy and tofu. However, the confusion may have been caused by the lack of context provided, as the terms were given without explanation. Then at first sight, animal-free meat may seem a *contradictio in terminis*, but it is well possible that with only a short description, this confusion would have been avoided.

1.5 | Aims

The first aim of this study was to explore Dutch consumers' perception and drivers of willingness to consume (WTC) cultured meat relative to other relevant products in the product category of meat and meat alternatives. Thereto, the scope was broadened by including conventional meat, PBMA, fish, and insects. To allow for more detailed and meaningful insights, consumers were clustered based on their WTC the five products and characterized based on their perceptions, preferences, and background (i.e., demographic and psychographic) variables.

Since different potential names for cultured meat could lead to different perceptions, also relative to other meat alternatives and meat, a second aim of this study was to further investigate the effect of naming of cultured meat. For this purpose and to avoid placing too much emphasis on the naming, respondents only assessed one of five names for cultured meat (between-subjects design for this factor). Studying different names places the focus of the study on the concept and not on the specific name used.

2 | MATERIALS AND METHODS

2.1 | Study design and procedure

An online survey was built in Qualtrics Survey Software. The survey started with a short introduction after which respondents had to give their informed consent. No specific inclusion criteria were considered since the interest was on the general population. Respondents were randomly assigned to one of the five naming conditions (see section 2.2). Then, each respondent encountered five question blocks in a randomized order. Each question block focused on the five products (conventional meat, cultured meat, fish, insects, PBMA). A question block contained a picture of a burger (Figure 1) and a description as short and neutral as possible (Table 1). Burgers were chosen because they can be produced for each of the products. Each of the ingredients (beef, salmon, soy and larvae of the buffalo bug) had to be among the most common ones in their respective category (e.g., soy is frequently used in PBMA burgers). A lengthy description for conventional meat is unnecessary, but insects and especially cultured meat require more context. No (dis)advantages regarding the environment, health, animal welfare, or other characteristics were mentioned. Since consumers have different considerations when choosing meat and/or meat alternatives, focusing on only one characteristic, for example, animal welfare, could have biased the results, whereas addressing all characteristics requires too lengthy and nuanced descriptions. In the five blocks, respondents had to score their perception for 10 attributes: natural, disgusting, safe, nutritious, healthy, tasty, sustainable, ethical, interesting, animal friendly, and the WTC. All were assessed on 9-point intensity scales completing the sentence "To me this product is or seems …". A slider scale, where 1 was on the extreme left and 9 on the extreme right, followed each attribute.

An extensive section with background characteristics and demographics followed. This section started with two four-item factors of the Meat Attachment Questionnaire (5-point Likert scale) (Graça et al., 2015). These factors were hedonism and affinity, the latter of which was measured as the inverse of repulsion. The questionnaire continued with the 10-item Food Neophobia Scale (5-point Likert scale) (Pliner & Hobden, 1992), questions on meat, fish and PBMA consumption, demographics (gender, age, and education), financial satisfaction, prior familiarity with cultured meat, and prior familiarity/consumption of insects. At the end, respondents could leave notes or questions. The study was conducted according to the guidelines established in the Declaration of Helsinki and complied with the code of conduct of Wageningen University & Research. The survey was held in December 2020.

2.2 | Selection of names for cultured meat

To study names for cultured meat in the Dutch market, *kweekvlees*, *diervrij vlees*, *slachtvrij vlees*, *puur vlees*, and clean meat were used. *Kweekvlees*, the direct translation of cultured meat and cultivated meat, is included because it is the predominant, if not the only Dutch name used for cultured meat. In the study of Bryant and Barnett (2019), "animal-free" meat (*diervrij vlees*) scored well, especially on attitude. Szejda (2018) found that "slaughter-free meat" (*slachtvrij vlees*) is an appealing and descriptive name,

FIGURE 1 From left to right and from top to bottom: Soy, salmon, beef, cultured meat (as presented in 2013 on television), insect (larvae of the buffalo bug (Bugfoundation GmbH))

TABLE 1 The descriptions that were used together with the pictures

Product	Description
Cultured meat	A ***cultured meat***[1] burger. Cultured meat is grown from several stem cells that are obtained from a living animal (bovine in the above picture). The animal is not slaughtered. With plant-based nutrients, these cells grow into cultured meat.
Meat	A beef burger
Fish	A salmon-based burger
Insects	A burger based on ground buffalo worms (larvae of the buffalo bug)
PBMA	A soy burger

Abbreviation: PBMA = plant-based meat alternatives.
[1]One of the five names was used instead, depending on the naming condition respondents were in.

but it was decided not to use it for its lack of neutrality. The need to study "clean meat" or a closely related term is evident when examining earlier research. It is not uncommon that English words become a part of Dutch vocabulary, and it is here assumed that both "clean" and "meat" are words most Dutch consumers know. For this reason, the term "clean meat" itself will be used. A Dutch alternative that fits the concept of clean meat, but is not a direct translation, is *puur vlees* (pure meat). Henceforth, in the context of naming, the following English translations will be used: cultured meat (*kweekvlees*), animal-free meat (*diervrij vlees*), slaughter-free meat (*slachtvrij vlees*), pure meat (*puur vlees*), and clean meat (translation not used).

It was expected that animal-free meat and slaughter-free meat, and pure meat and clean meat may be conceptually alike. To ensure no concept was dominant, which would occur when two names are being perceived conceptually identical, a small sorting task with a discussion was conducted. Respondents ($n = 17$, balanced gender, age range: 18–65) had to group five cards, with one of the five names per card, in whichever way they wanted. They were asked to think out loud and explain their decisions. Only 3 out of 17 respondents grouped both pairs of names, which shows sufficient conceptual difference between the 5 names.

2.3 | Participants

Dutch respondents were recruited via convenience sampling: partially from a Wageningen University & Research consumer panel and partially via social networks. There were no in- or exclusion criteria, except for a minimum age of 18. The sampling was targeted at consumers of different age, sex, and educational background, but had not to be representative of any population. No compensation was awarded for participation. A total of 323 respondents completed the survey. After a check for non-sensical answers such as flatliners and paradoxical scores (e.g., high disgust

TABLE 2 Demographics details for the entire sample ($N = 288$)

Variable	Level	n (%)
Gender	Female	181 (63%)
	Male	105 (36%)
	Other	2 (1%)
Education	High School	10 (3%)
	Vocational Education	49 (17%)
	Higher education	120 (42%)
	University	109 (38%)
Age	18-29	99 (34%)
	30–39	32 (11%)
	40–49	28 (10%)
	50–59	67 (23%)
	60–69	55 (19%)
	70+	18 (6%)

and high WTC at the same time), the data of 288 respondents were found eligible for analysis. Table 2 displays the demographic details of the sample.

2.4 | Data analysis

As a first step, it was ensured that respondents in the different naming conditions had similar background characteristics. Of the demographic and psychographic variables, only the distribution of age differed significantly between conditions ($\chi^2(8, N = 288) = 33.79, p = 0.028$). The animal-free meat condition contained more young participants (55% ≤ 39 years old versus 36% to 50% in other conditions).

The Cronbach's Alphas of the factors hedonism and affinity from the Meat Attachment Questionnaire were 0.94 and 0.84, respectively. Cronbach's Alpha for the Food Neophobia Scale was 0.83. These scores indicate reliability of the scales used to further characterize the clusters.

With respect to the first aim, first an ANOVA was performed on the WTC and the nine attributes. Then a cluster analysis was performed on the standardized WTC scores of each individual across the five products. ANOVAs were performed to compare the clusters in terms of (1) mean-centered WTC scores for the five products, (2) the scores of cultured meat on the nine attributes, and (3) several background characteristics. Chi-square tests were performed on categorically assessed background variables. Additionally, principal component analysis was performed for each cluster on the attributes (and WTC as supplementary variable) to obtain an overall picture of their perceptual space.

With respect to the second aim, ANOVAs were performed on the 10 attributes to assess the effect of naming on consumers perception. If any of the F-tests in this study provided evidence for a treatment effect, Tukey's HSD test was used as a post-hoc with $\alpha = 0.05$ as significance level. R 3.6.3. was used for data analysis.

3 | RESULTS AND DISCUSSION

Regarding the first aim, for which attribute perceptions of the five products were compared by means of ANOVAs, strong differences were observed at the aggregate level (Table 3). The WTC cultured meat was comparable with the other products, except for insects, which scored significantly lower. Compared to the other products, cultured meat was perceived as less safe, healthy (though comparable to meat), and natural. For tastiness it was relatively on the lower end, but considerably higher than insects and comparable to PBMA. Cultured meat scored high in terms of sustainability, ethicality, animal friendliness, and interestingness. A more detailed view will be provided in the next paragraphs, which describe the results per cluster.

3.1 | Cluster analysis

3.1.1 | Cultured meat perception and product preferences

To investigate more deeply whether segments of consumers who shared similar patterns of preference existed, the cluster analysis was performed on the WTC data. This analysis resulted in three clusters of 114, 70, and 104 respondents. There was a homogeneous distribution of the naming conditions over the clusters (χ^2 (8, $N = 288$) = 5.21, $p = 0.735$), which means that differences in cultured meat perception between clusters cannot be attributed to naming effects. From Table 4 it can be observed that, relative to cluster 2, clusters 1 and 3 had a high WTC cultured meat. Besides, cluster 1 had a strong preference for meat and a negative preference for insects and, to a lesser extent, PBMA. Cluster 2 had a preference for fish and a negative preference for insects and cultured meat. Finally, cluster 3 preferred PBMA and had a negative preference for meat and fish.

To assess differences in cultured meat perception between clusters, attribute scores were compared. Table 5 shows that there were significant differences between the clusters for all attributes. Compared to cluster 2, clusters 1 and 3 perceived cultured meat to be safer, tastier, more ethical and interesting, and less disgusting. Cluster 1 also perceived cultured meat to be more natural, healthy, and sustainable than cluster 2, and more animal friendly than both clusters 2 and 3.

TABLE 3 Mean scores (9-point intensity scale) and standard deviations per product for the entire sample ($N = 288$)

Attribute	Cultured meat	Meat	Fish	Insects	PBMA[1]	$F_{(4, 1148)}$
WTC[2]	5.41 ± 2.55[a]	5.77 ± 2.51[a]	5.31 ± 2.54[a]	4.04 ± 2.43[b]	5.65 ± 2.19[a]	29.22***
Natural	3.98 ± 2.30[c]	5.91 ± 2.27[a]	5.47 ± 2.20[b]	5.66 ± 2.35[ab]	5.98 ± 2.20[a]	59.33***
Safe	5.56 ± 2.19[c]	6.08 ± 2.00[b]	6.13 ± 1.90[b]	5.79 ± 2.17[bc]	6.73 ± 1.95[a]	22.94***
Disgusting	2.86 ± 2.00[b]	2.48 ± 2.01[b]	2.72 ± 2.09[b]	4.40 ± 2.56[a]	2.71 ± 2.02[b]	46.29***
Healthy	4.84 ± 2.09[b]	4.76 ± 2.00[b]	5.78 ± 1.89[a]	5.95 ± 2.05[a]	6.04 ± 1.78[a]	43.19***
Animal Friendly	7.05 ± 2.11[b]	2.91 ± 1.98[e]	3.53 ± 2.08[d]	4.78 ± 2.44[c]	7.73 ± 1.90[a]	360.69***
Tasty	5.20 ± 2.19[c]	6.71 ± 2.18[a]	5.89 ± 2.37[b]	3.86 ± 2.17[d]	5.34 ± 2.09[c]	82.16***
Sustainable	6.46 ± 2.10[a]	2.94 ± 1.78[d]	3.93 ± 2.08[c]	5.89 ± 2.27[b]	5.91 ± 2.17[b]	182.16***
Ethical	5.86 ± 2.36[b]	3.60 ± 2.13[e]	4.13 ± 2.24[d]	5.39 ± 2.34[c]	6.37 ± 2.22[a]	104.74***
Interesting	6.29 ± 2.57[a]	4.13 ± 2.54[d]	4.65 ± 2.40[c]	5.19 ± 2.64[b]	5.25 ± 2.37[b]	37.12***

[1]PBMA = plant-based meat alternative.
[2]WTC = willingness to consume.
Significant differences among products are indicated at the .05, .01, and .001 levels with *, ** and *** respectively.
Different letters within rows refer to significant differences among the products according to Tukey's test.

TABLE 4 Mean-centered willingness to consume scores, standard deviations, and original scores (9-point intensity scale) for each product per cluster

	Cluster 1	Cluster 2	Cluster 3	
Product	***n* = 114**	***n* = 70**	***n* = 104**	$F_{(2, 285)}$
Cultured Meat	0.74 ± 1.32[a] (6.15)	−1.49 ± 1.40[b] (3.70)	0.67 ± 1.51[a] (5.74)	63.96***
Meat	2.18 ± 1.50[a] (7.59)	0.74 ± 1.62[b] (5.93	−1.39 ± 1.31[c] (3.68)	162.12***
Fish	0.03 ± 1.62[b] (5.43)	1.79 ± 1.23[a] (6.97)	−1.03 ± 1.61[c] (4.04)	71.08***
Insects	−1.91 ± 1.65[b] (3.50)	−1.93 ± 1.78[b] (3.26)	0.09 ± 1.53[a] (5.61)	49.80***
PBMA[1]	−1.03 ± 1.52[c] (4.39)	0.89 ± 1.61[b] (6.07)	1.67 ± 1.99[a] (6.74)	70.00***

[1]PBMA = plant-based meat alternative.
Significant differences among clusters are indicated at the .05, .01, and .001 levels with *, ** and *** respectively.
Different letters within rows refer to significant differences among the products according to Tukey's test.

TABLE 5 Mean scores (9-point intensity scale) and standard deviations for cultured meat per cluster

	Cluster 1	Cluster 2	Cluster 3	
Attributes	**n = 114**	**n = 70**	**n = 104**	$F_{(2, 285)}$
Natural	4.56 ± 2.33[a]	3.14 ± 2.11[b]	3.90 ± 2.22[ab]	8.78***
Safe	5.86 ± 1.92[a]	4.63 ± 2.31[b]	5.86 ± 2.22[a]	8.82***
Disgusting	2.63 ± 1.66[b]	3.51 ± 2.33[a]	2.68 ± 2.03[b]	5.01**
Healthy	5.26 ± 1.91[a]	4.31 ± 2.16[b]	4.73 ± 2.16[ab]	4.81**
Animal Friendly	7.61 ± 1.61[a]	6.34 ± 2.50[b]	6.90 ± 2.16[b]	8.69***
Tasty	5.89 ± 1.92[a]	3.80 ± 1.95[b]	5.38 ± 2.22[a]	23.55***
Sustainable	7.00 ± 1.63[a]	5.69 ± 2.51[b]	6.38 ± 2.10[ab]	9.22***
Ethical	6.41 ± 2.03[a]	4.61 ± 2.45[b]	6.10 ± 2.34[a]	14.69***
Interesting	6.45 ± 2.48[a]	4.91 ± 2.66[b]	7.04 ± 2.24[a]	16.23***

Significant differences between clusters are indicated at the .05, .01, and .001 levels with *, ** and *** respectively.
Different letters within rows refer to significant differences among the products according to Tukey's test.

3.1.2 | Characterization of the clusters

To better understand the underlying reasons for the clusters' perceptions of cultured meat and its preferences relative to other products, each cluster was then characterized by demographic and psychographic variables. Tables 6 and 7 show that these three clusters differed in all their background characteristics except for financial satisfaction.

It can be observed from Tables 6 and 7 that cluster 1 was composed by more male consumers. They enjoyed meat, had a high affinity toward it, and consumed it often,

TABLE 6 Distribution of categorically assessed characteristics across the clusters

Variable	Level	Cluster 1 $n = 114$	Cluster 2 $n = 70$	Cluster 3 $n = 104$	Chi-square
Gender	Female ($n = 181$)	50 (44%)	51 (73%)	80 (77%)	31.35***
	Male ($n = 105$)	64 (56%)	19 (27%)	22 (21%)	
	Other[1]	0	0	2 (2%)	
Education	High School[1]	5 (4%)	2 (3%)	3 (3%)	20.02***
	Vocational Education	20 (18%)	21 (30%)	8 (8%)	
	Higher Education	49 (43%)	30 (43%)	41 (39%)	
	University	40 (35%)	17 (24%)	52 (50%)	
Age	18-29	39 (34%)	8 (11%)	52 (50%)	34.10***
	30—39	12 (11%)	9 (13%)	11 (11%)	
	40—49	15 (13%)	7 (10%)	6 (6%)	
	50—59	25 (22%)	25 (36%)	17 (16%)	
	60—69	14 (12%)	17 (24%)	13 (13%)	
	70+	9 (8%)	4 (6%)	5 (5%)	
Familiarity with cultured meat	No	32 (28%)	28 (40%)	12 (12%)	19.52***
	Yes, no understanding	25 (22%)	15 (21%)	27 (26%)	
	Yes, understanding	57 (50%)	27 (39%)	65 (63%)	
Familiarity with insects as food	No[1]	7 (6%)	3 (4%)	1 (1%)	13.02*
	Yes, no prior consumption	70 (61%)	48 (69%)	52 (50%)	
	Yes, prior consumption	37 (32%)	19 (27%)	51 (49%)	
Fish consumption	>2 times per week[2]	18 (16%)	20 (29%)	24 (23%)	41.10***
	Several times per month	73 (64%)	47 (67%)	45 (43%)	
	Several times per year	21 (18%)	3 (4%)	17 (16%)	
	Never	2 (2%)	0	18 (17%)	
PBMA consumption	>4 times per week[2]	2 (2%)	2 (3%)	26 (25%)	109.34***
	2-3 times per week	17 (15%)	15 (21%)	43 (41%)	
	Several times per month	20 (18%)	29 (41%)	27 (26%)	
	Several times per year	39 (34%)	9 (13%)	4 (4%)	
	Never	36 (32%)	15 (21%)	4 (4%)	
Meat consumption	Daily	24 (21%)	6 (9%)	2 (2%)	127.16***
	4-6 times per week	57 (50%)	30 (43%)	11 (11%)	
	2–3 times per week	25 (22%)	26 (37%)	23 (22%)	
	Several times per month	6 (5%)	5 (7%)	28 (27%)	
	Several times per year	2 (2%)	0	13 (13%)	
	Never	0	3 (4%)	27 (26%)	

Significant differences between clusters are indicated at the .05, .01, and .001 levels with *, ** and *** respectively.

[1]These levels were not included in the chi-square test because of low expected values (< 5).

[2]In the case of fish, the consumption frequencies "2–3″ times per week," "4–6 times per week," and "daily" were merged because of low expected counts in the latter two categories. In the case of plant-based meat alternatives (PBMA) the same was done with "4–6 times per week" and "daily."

whereas they barely consumed PBMA. This was in line with their stated WTC meat and PBMA. In terms of most of the other demographic and psychographic variables, cluster 1 was largely in between the other two clusters. Cluster 2 was composed by more female, and fewer young and high-educated consumers. In terms of consumption pattern, it was notable that although fish was not consumed particularly often, almost everyone consumed fish on at least a monthly basis. Consumption frequencies of meat and PBMA consumption were average. This consumption pattern fitted the stated high WTC meat, fish, and PBMA. Familiarity with cultured meat was low and, compared to cluster 3, food neophobia was high. Finally, cluster 3 was composed by more female, young, and high-educated consumers. They enjoyed meat the least and had the lowest affinity, that is, strongest repulsion, toward it.

TABLE 7 Mean scores (1–5) and standard deviations of consumer characteristics assessed on a Likert scale (totally disagree = 1, totally agree = 5), except for financial satisfaction (totally unsatisfied = 1, totally satisfied = 5)

Scale	Cluster 1 *n* = 114	Cluster 2 *n* = 70	Cluster 3 *n* = 104	$F_{(2, 285)}$
MAQ[1]—Hedonism	3.66 ± 0.82[a]	2.98 ± 0.98[b]	2.11 ± 1.00[c]	76.46***
MAQ—Affinity	4.11 ± 0.60[a]	3.83 ± 0.72[b]	3.06 ± 0.94[c]	53.38***
Food neophobia	2.27 ± 0.61[ab]	2.35 ± 0.57[a]	2.09 ± 0.51[b]	4.90**
Financial Satisfaction	1.93 ± 0.69[a]	1.77 ± 0.68[a]	1.99 ± 0.82[a]	1.89

[1]MAQ = Meat Attachment Questionnaire.
Significant differences between clusters are indicated at the .05, .01, and .001 levels with *, ** and *** respectively.
Different superscripts within each row indicate significant differences at the 0.05 level according to Tukey's HSD test.

Correspondingly, meat consumption as well as fish consumption was low, whereas PBMA consumption was high. Again, this was in line with WTC each of these products. These consumers were familiar with cultured meat and insects as food, and had low food neophobia, which could have explained their relatively high WTC cultured meat.

How these findings compare to earlier research depends on the approach one takes. It is here assumed that cultured meat is being developed to provide an animal and (as far as possible) environmentally friendly alternative for conventional meat. From that perspective, cultured meat is no more than a means to an end. Consequently, it is important to narrow down the scope of consumer research to the consumers that would make the greatest impact when switching to cultured meat. Even if cultured meat can be produced at an industrial scale, it will not be the only meat alternative on the market. Based on this study, PBMA and possibly also fish could be other "contributors" in solving the problems caused by widescale meat consumption. At first sight, clusters 1 and 3 seem to bear equal potential for the adoption of cultured meat, since their mean-centered WTC ratings are alike and positive. However, many consumers in cluster 3 have already adopted a sustainable and animal-friendly meat alternative, namely PBMA. That leaves cluster 1 as the cluster that could make the largest impact by adopting cultured meat.

Two of the most notable characteristics of cluster 1 were the relatively high share of male consumers and frequent meat consumption. Both these findings align with earlier research. When looking at gender and meat consumption, respectively, men and frequent meat consumers are more accepting toward cultured meat. Onwezen et al. (2021) drew the same conclusion with respect to meat consumption. There are also differences with earlier research though. Bryant and Barnett (2020) observed that young and high-educated people show greater interest in cultured meat. Overall, this study would conclude the same, but mainly because of the consumers in cluster 3, who are of less interest because they have to a large extent adopted PBMA as a meat alternative. The discrepancy with earlier consumer research on cultured meat highlights the power of this study. If segmentation would not have been done, it would not have been possible to narrow down further consumer research to where it can be most impactful.

3.1.3 | Drivers of willingness to consume (WTC)

To identify the drivers of WTC, a principal component analysis was conducted per cluster on the mean ratings of the attributes for the five products as active variables and WTC as supplementary, to have a visual representation. Figure 2 shows the correlation circle per cluster. For cluster 1 (Figure 2A), it is clear that tastiness was the single-most important driver of WTC in cluster 1. Safe and natural correlated negatively with animal friendly, ethical, and sustainable. This does not mean that consumers in this cluster intrinsically perceived these attributes as opposites. It can only be said that within this limited set of products, no product combined negatively and positively loaded attributes on dimension 1 as perceived by consumers in this cluster. On a similar note, healthiness may not have been an "inhibitor" of WTC. Of course, consumers can be indifferent to the healthiness of a product, but it seems likely that consumers in this cluster preferred the products perceived as tastier and disliked those perceived as healthier, which received opposite scores. It should thus be kept in mind that relations between attributes only apply within this specific set of products used. For dimension 3 (not shown, variance accounted for is 9.4%), interesting, safe, and animal friendly were the main contributors to dimension 3. Interesting loaded negatively on this dimension, and safe and animal friendly loaded positively. For cluster 2 (Figure 2B), safety, naturalness, and tastiness were important. The roles of safety and naturalness could explain why the consumers in this clusters had low WTC insects and cultured meat. The novelty of these products may evoke concerns about safety and naturalness. Cluster

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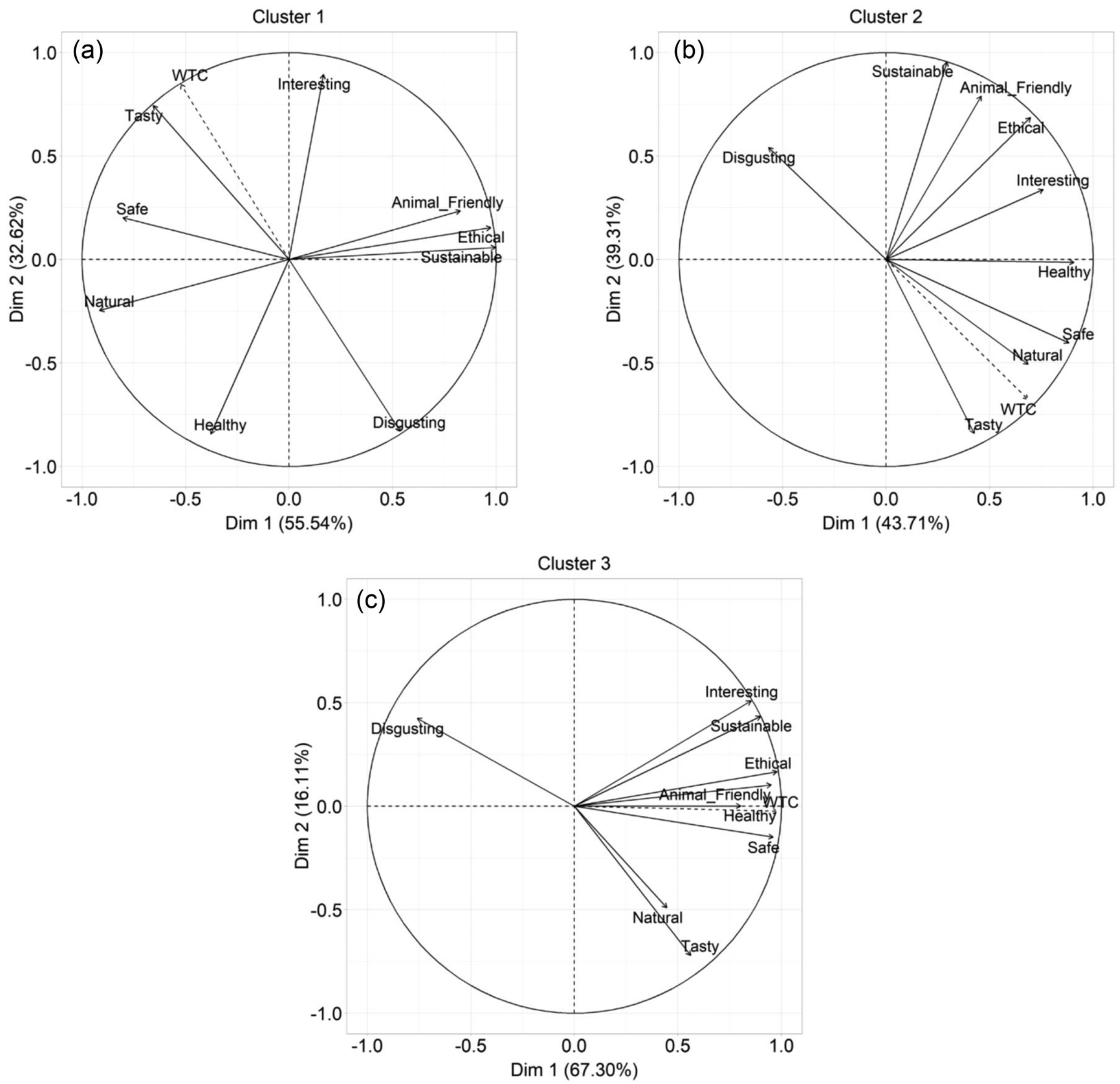

FIGURE 2 The correlation circle of the principal component analysis per cluster for the first two principal components. (A) Cluster 1; (B) Cluster 2; and (C) Cluster 3. Willingness to consume (WTC) was added as supplementary variable

3 was notably different from the other clusters (Figure 2C). Nearly all attributes correlated strongly with WTC, except for natural, tasty, and obviously disgusting. This suggests that these consumers were demanding when it comes to the societal aspects of meat and its alternatives, and that tastiness is subordinate to these aspects. This would also align with the stated high WTC and frequent consumption of PBMA.

Taken together, animal welfare and sustainability do not seem to be drivers of WTC for the "meat-loving" consumers from cluster 1, which aligns with earlier research. Tucker (2014) conducted a qualitative study on meat-reducing strategies (nose-tail-eating, entomophagy, cultured meat consumption, and meat reduction) with a sample consisting largely of regular meat consumers. It was observed that the main hurdle to adopt meat alternatives was low sensory appeal. Apostolidis and McLeay (2019) used a discrete choice experiment to study the effect of seven attributes on utility in meat eaters, meat reducers, and vegetarians. The attributes used were: fat content, carbon footprint, type of mince, brand, production method, origin, and price. Latent class analysis was used to identify segments within the meat eaters, meat reducers, and vegetarians. Within the meat eaters, three segments were found, the largest of which (61%) was heavily influenced by price. Apparently, the very benefits that give cultured meat its potential as a meat alternative will not be the strongest incentives for "meat lovers" to adopt cultured meat. Instead, producing cultured meat at competitive costs and optimizing the sensory characteristics will probably form stronger incentives for the adoption of cultured meat.

TABLE 8 Mean scores (9-point intensity scale) and standard deviations for cultured meat per naming condition

Attributes	Pure meat $n = 55$	Cultured meat $n = 55$	Clean meat $n = 59$	Slaughter-free meat $n = 59$	Animal-free meat $n = 60$	$F_{(4, 283)}$
Natural	3.96 ± 2.26	3.64 ± 2.14	3.53 ± 2.12	4.37 ± 2.32	4.37 ± 2.56	1.75
Safe	5.40 ± 2.22	5.85 ± 1.66	5.24 ± 2.18	5.66 ± 2.35	5.65 ± 2.43	0.70
Disgusting	3.24 ± 2.40	2.82 ± 1.78	2.95 ± 1.94	2.81 ± 2.15	2.53 ± 1.70	0.92
Healthy	4.78 ± 2.13	4.73 ± 1.91	4.86 ± 2.16	4.81 ± 2.10	5.00 ± 2.19	0.14
Animal friendly	6.80 ± 2.35	7.04 ± 2.13	7.14 ± 1.85	7.17 ± 2.02	7.08 ± 2.23	0.27
Tasty	5.16 ± 2.13	5.00 ± 2.05	5.04 ± 2.33	5.47 ± 2.19	5.32 ± 2.27	0.47
Sustainable	6.55 ± 2.09	6.56 ± 2.09	6.39 ± 2.20	6.51 ± 2.01	6.32 ± 2.17	0.15
Ethical	5.91 ± 2.38	5.95 ± 1.97	5.66 ± 2.64	5.83 ± 2.40	5.97 ± 2.39	0.16
Interesting	6.34 ± 2.53	6.24 ± 2.27	5.75 ± 2.76	6.61 ± 2.51	6.52 ± 2.72	1.01
WTC[1]	5.36 ± 2.49	5.18 ± 2.46	5.05 ± 2.65	5.80 ± 2.44	5.62 ± 2.69	0.84

[1]WTC = willingness to consume.

3.2 | Naming

The second aim was to investigate whether different names for cultured meat led to differences in perception, when measured relative to other products. There were no differences among the five names used for cultured meat on any of the attributes measured (Table 8). Some tendencies were present, such as a more natural perception when slaughter-free meat or animal-free meat was used. During the analysis, it was decided to also assess the effect of naming on WTC, within each cluster. Again, no effect of naming was observed (cluster 1: F(4, 109) = 0.18, $p = 0.947$; cluster 2: F(4,65) = 0.35, $p = 0.843$; cluster 3: F(4,99) = 0.82, $p = 0.518$).

Contrary to earlier research (GFI, n.d.; Bryant & Barnett, 2019; Greig, 2017; Szejda, 2018), no significant effect of naming on perception was found. Interestingly though, shortly after this study was conducted, Janat and Bryant (2020) published a study on German naming, which did not find any significant effects either. What sets this study and the one by Janat and Bryant (2020) apart from prior research was the use of a between-subjects rather than a within-subjects design. Consequently, a major share of the consumers must have been unaware of the focus of the experiment, which could possibly explain the differences with earlier within-subjects studies. In addition, participants in this study evaluated their perception also against four other products, which further reduced the focus on the name itself.

It must be noted that even if an effect was found, adopting an alternative name would not necessarily be the best option. This is because *kweekvlees* has already gained foothold in the Dutch language, making a switch possibly rather confusing. Next to that, most alternatives have other applications or connotations (e.g., pure meat is sometimes used in the context of artisanal meat).

4 | CONCLUSIONS

The first aim of this study was to investigate the WTC cultured meat relative to other products (conventional meat, fish, insects, and PBMA), and to identify and characterize consumer segments sharing similar preferences (WTC). To the best of our knowledge, this is the first study to have compared cultured meat to this many other products.

It has been observed that two groups of consumers express moderate interest in cultured meat. One of these groups has already largely adopted PBMA. From an environmental perspective, there would be no need for this group to adopt cultured meat, since PBMA are both animal friendly and sustainable. The other group of consumers can be characterized as meat lovers whose WTC products is mainly driven by tastiness. This group still consumes meat very frequently, so from a societal perspective, it would be most useful to further study this group of consumers and, where possible, take their preferences and wishes into account during further developments of cultured meat.

When doing so, a study design with more products would be desired. Per product category, only one "type" or ingredient was used. For example, this study used a beef burger for conventional meat, but chicken and pork are also frequently consumed types of meat. Consumer perception of beef may not have been reflective of the product category as a whole. Similarly, only one form of meat (alternatives) was used, namely burgers. For some product categories, especially conventional meat and fish, unprocessed forms take up a large share of the market. Future consumer research on "meat lovers" could include more types and forms of cultured and conventional meat. Consumer studies with physical samples would also be a desirable step, to confirm the stated preferences based on their current experience.

The second aim was to assess the effect of naming on cultured meat. Not for the sample as a whole, nor within individual clusters, did this study show outcomes that support the adoption of an alternative name for cultured or cultivated meat (*kweekvlees* in Dutch).

In conclusion, cultured meat, regardless of the naming used, seems to have potential within the Dutch population, since the WTC was similar to other well-established products, and higher than the average score (of the five products) for two of the clusters, comprising 75% of the sample. Cultured meat was considered relatively interesting, sustainable, and animal friendly, even for those consumers who have already adopted PBMA. Its image of naturalness seems to be the main challenge it would have to overcome for a general acceptance, though guaranteeing other attributes (e.g., tastiness) might suffice for it to be well accepted by a smaller target group.

AUTHOR CONTRIBUTIONS

Kees Cornelissen: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Writing – original draft; Writing – review & editing. **Betina Piqueras-Fiszman**: Conceptualization; Investigation; Methodology; Supervision; Writing – review & editing.

CONFLICT OF INTEREST

No conflicts of interest to declare.

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