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Cultured meat for a disruptive sustainable future – A preliminary literature review with bibliometric analysis to design a research agenda

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1. Introduction

In order to feed nearly 10 billion people by 2050, whilst also ensuring food production systems stay within the planetary boundaries, it is essential that transformational approaches are adopted in food production and provisioning (Willett et al., 2019). Meat production and consumption has always been a contentious topic from a sustainability perspective. Indeed, the growth of veganism and animal rights activism has only strengthened advocacy for meatless diets (Pohjolainen and Jokinen, 2020). In response to the global need to reduce meat consumption, alternative protein sources have gained significant interest in recent years (Sexton, 2018). Of these, including plant-based meat, edible insects, algae, legumes, etc., ‘cultured meat’ is considered a sustainable and responsible solution to the growing demand for meat in the next decade (Shahbandeh, 2022). Also known as lab-based meat or in-vitro meat, cultured meat offers a unique solution to the competing demands of environmental sustainability, animal ethics, and the need to increase the supply of animal proteins for an ever-growing global population (Ching et al., 2022). Hence, as a future food, this developmental paper argues that cultured meat represents a *disruptive sustainability* alternative to the traditional meat production and supply.

The production of cultured meat requires stem cells from a donor animal to be cultured into edible muscle tissues (Faustman et al., 2020). In the absence of animal rearing and slaughter, cultured meat offers a safer, more efficient, and humane alternative to traditional meat (ibid). Whilst the potential of cultured meat has been a topic of interest in academia, practitioners and industry stakeholders are yet to see this as a commercially viable alternative to traditional meat (Swann and Kelly, 2023). Indeed, recent studies show that out of all alternative proteins, cultured meat garners the least willingness to eat amongst consumers (Hamlin et al., 2022). Hence, a vast majority of the cultured meat literature concerns understanding and enhancing consumers’ acceptance of cultured meat as an alternative protein.

In order to meet the growing demand for animal proteins, cultured meat presents a win-win solution for both meat eaters and people who oppose meat eating due to several reasons including animal welfare, environmental vegetarianism and veganism, antimicrobial resistance, health considerations, religion, taste preferences, etc. (Sanchez-Sabate and Sabaté, 2019). In that respect, cultured meat represents *disruptive sustainability* where we see new business opportunities and challenges emerge. The objective of this developmental paper is to carry out a bibliometric review of the extant literature on cultured meat to find knowledge gaps, which would then inform our future research agenda.

2. Overview of the cultured meat literature

The vast majority of the cultured meat literature has been studied from an agricultural or food science perspective, rather than from a marketing and management perspective. From a food science perspective, the literature largely focusses on the process of culturing meat through in-vitro and/or 3-D printing technologies; discusses the challenges of scaling up this technology for mass production, and raises questions about consumer acceptance of cultured meat (Kadim et al., 2015, Ching et al., 2022, van der Weele and Tramper, 2014). However, the last five years has seen a marked growth in academic research on understanding consumer acceptance of cultured meat (Siddiqui et al., 2022). Research shows that variances in consumers willingness to buy/eat cultured meat stem from personal and environmental factors (Verbeke et al., 2015). Hence, how consumers perceive cultured meat influences their willingness to accept and potentially replace traditional meat with this novel food.

Acceptance of cultured meat is influenced by various socio-cultural and psychological factors (Klöckner et al., 2022). It is known that younger consumers (Gen Z and Millennials) show higher openness to try cultured meat (Szejda et al., 2021, Ruzgys and Pickering, 2020). In terms of gender, men seem to be more willing to consume cultured meat than women (Chriki

and Hocquette, 2020). However, there are limited studies done to understand how culture affects consumer perceptions of cultured meat (Siddiqui et al., 2022). Specifically, research on how cultured meat acceptance is influenced by religiosity is lacking. In terms of psychological factors, consumers holding strong environmental and ethical values are more likely to accept cultured meat (Weinrich et al., 2020). Contrarily, food neophobia, mistrust in science or food technology, negative beliefs, and poor taste and quality expectation lead to rejection of cultured meat (Siddiqui et al., 2022, Tomiyama et al., 2020).

Individual attitudes and perceptions towards, and willingness to eat cultured meat can be influenced by social norms. In other words, media discourse has influenced consumers acceptance of cultured meat (Ryynänen and Toivanen, 2022, Chriki and Hocquette, 2020, Dilworth and McGregor, 2015). The overarching literature suggests that consumer perceptions depends on the nature of information provided about cultured meat (Chriki and Hocquette, 2020, Hopkins, 2015). For example, message framing in public discourse about cultured meat impacts consumer perceptions towards cultured meat (Bryant and Dillard, 2019). Notably, the association of high technology with cultured meat leads to increased negative perceptions and lower consumer acceptance (ibid). This implies, that high-tech associations need to be avoided, whilst societal and environmental benefits of cultured meat should be enhanced. Indeed, a notable factor enabling the rejection of cultured meat is its perceived ‘unnaturalness’, which leads to poor taste and nutrition perceptions (Lupton and Turner, 2018) and evokes a strong sense of disgust, and thus rejection (Verbeke et al., 2015, Siegrist et al., 2018). In fact, Bryant and Barnett (2019) demonstrate that consumers show positive attitudes towards cultured meat when it is labelled as ‘clean meat’ and ‘animal free meat’ than when it is labelled as ‘lab grown meat’. Thus, Siegrist et al. (2018) suggest using non-technical terminology that describes the final product, and not the production process, to increase the acceptance of cultured meat.

However, as data forecasts predict that by 2040, the consumption of cultured meat will reach 35% of the total meat production (Kearney, 2021), which makes it important for us to understand the nature of the cultured meat literature to identify knowledge gaps for future research. Thus, in the next section, the results from a bibliometric review will be reported to understand the nature and direction of the cultured meat literature to date.

3. Bibliometric Analysis

This section applies bibliometric analysis using the VOSviewer application (Amankwaa et al., 2022) to present a bibliometric review of 410 research articles on cultured meat obtained from the Web of Science Core Collection Database published between 2005 to March 2023 (See Table 1).

Publication Years	Record Count
2022	155
2021	100
2020	44
2019	35
2018	20
2017	14
2023	13
2015	11
2013	5
2014	4
2016	3
2005	1

2008	1
2009	1
2010	1
2011	1
2012	1

Table 1: Studies on cultural meat by publication year

The search string used for this review is: [("cultured meat" OR "clean meat" OR "lab-grown meat" OR "animal-based meat")] AND [(accept* OR percept* OR attitud*)]. The results obtained were limited to peer-reviewed journals in English.

Geographical coverage

Building on Table 2, the bibliometric review of literature based on place/country of research suggests that most of the cultured meat literature is based in the United States of America (25.85%), England (13.66%), and Peoples Republic of China (11.22%), as is also demonstrated by the size of the circles in the network map (see Figure 1). Hence, we see that the geographical focus of most published research in cultured meat has been the global west.

Countries	Record Count
USA	106
England	56
Peoples Republic of China	46
Netherlands	35
Germany	26
South korea	22
Australia	21
France	21
Brazil	20
Canada	17

Table 2: Top 10 Countries for studies on cultured meat

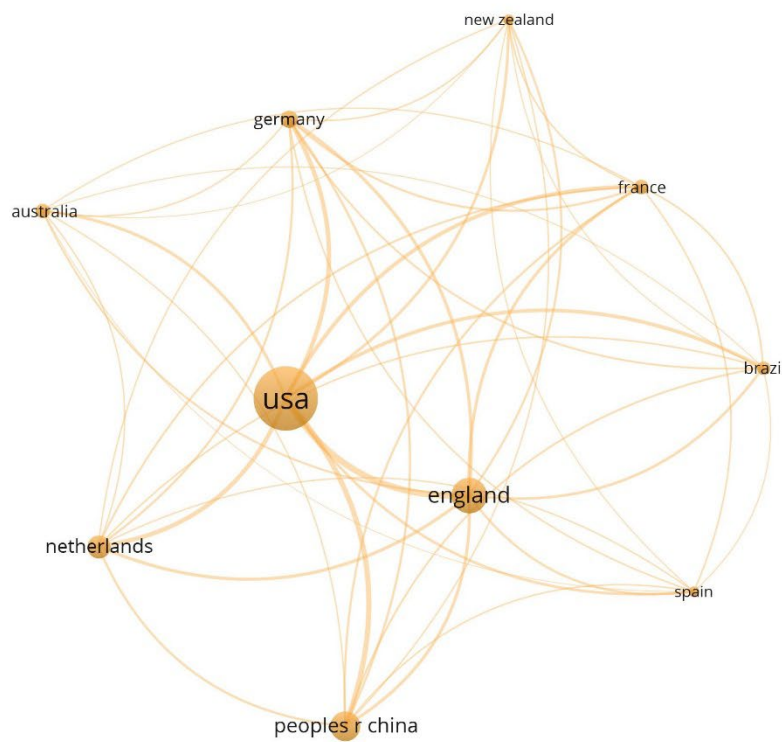


Figure 1: Extant studies on cultured meat by countries (Number of publications is reflected in the circle size)

Conceptual theories

The last seventeen years has seen considerable research on cultured meat. Building on Table 3, the bibliometric review of literature of 410 studies with a total of 1991 distinct keywords suggests that the two most frequently used keywords by authors are ‘cultured meat’ (69% of studies) and ‘challenges’ (26% of studies use this keyword). This is also demonstrated by the size of the circles in the network map (see Figure 2). Moreover, extant studies endeavour to identify various ‘future’ (14% of studies use this keyword) challenges related to cultured meat production and selling to estimate consumer acceptance (23% of studies) of cultured meat as a viable and sustainable food (14% of studies use this keyword) option for consumption (2.5%).

Keyword	Occurrences
cultured meat	282
challenges	107
food	68
in-vitro meat	66
future	56
Consumer acceptance	95 (acceptance 51+ consumer acceptance 44)
consumption	49
differentiation	41
cellular agriculture	36

Table 3: Top 10 keywords used in extant studies on cultured meat

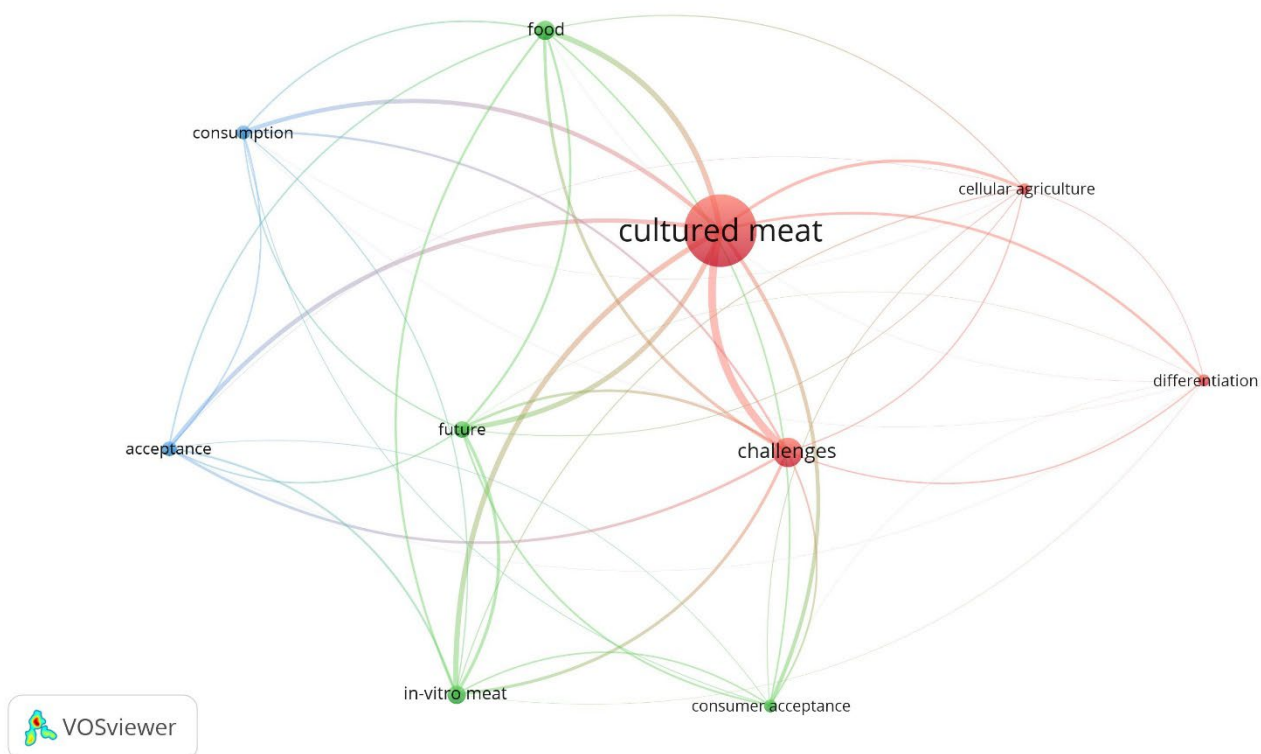


Figure 2: Extant literature on cultured meat by co-occurrence of top 10 frequently used keywords (Number of publications is reflected in the circle size)

Bibliometric Coupling

Bibliometric coupling is a technique that considers the similarity of document reference lists (van Eck and Waltman, 2014), which helps to develop a homogeneous association between articles. This transpires whenever two papers cite the same third article in their references (Pandey and Bajpai, 2022). The unit of analysis for this section is ‘document’ and the ‘full counting’ method is employed. Due to many documents (410), the minimum threshold for the number of citations is set to 100, which resulted in 20 documents (see Table 4) out of which 16 are closely linked (see Figure 3). Thus, three clusters (Red, Blue, and Green) are obtained. Pandey and Bajpai (2022) note that clustering helps unfold the perceptible dimensions of themes that are present in the extant literature, specifically when research articles are grouped together considering their similitude to study themes (Xu et al., 2018). Cluster 1 (red cluster) contains 9 articles; Cluster 2 (blue cluster) contains three articles; and Cluster 3 (green cluster) contains four articles. The size of the circle is directly proportional to the number of citations an article has obtained.

It is important to note that in a bibliometric coupling analysis a link indicates an association or connection between two articles. A positive numerical number is used to denote strength rating of each link. A higher strength suggests stronger relationship (Pandey and Bajpai, 2022). VOSviewer counts all links related to a single article that helps in determining their numerical strength values. The cluster-wise description is as follows:

Cluster-1: Environmental Impacts of Cultured Meat

Articles grouped together under this cluster primarily endeavour to study the environmental impacts of cultured meat production and consumption.

Cluster-2 : Consumer Acceptance and Consumption of Cultured Meat

Articles grouped together under this cluster primarily endeavour to study cultured meat acceptance and consumption among consumers.

Cluster-3: Consumer Perceptions of Cultured Meat

Articles grouped together under this cluster primarily endeavour to study consumer perceptions of cultured meat production and selling as a food choice.

Cluster	document	citations	total link strength
Cluster-1 (Red) <i>Environmental Impacts of Cultured Meat</i>	Hocquette (2016)	101	67
	Slade (2018)	161	56
	Roos et al. (2017)	149	38
	Lynch and Pierrehumbert (2019)	131	33
	Parodi et al. (2018)	112	31
	Mattick et al. (2015)	149	28
	D'Odorico et al. (2014)	224	22
	Van Vuuren et al. (2018)	307	21
	Smetana et al. (2015)	204	15
Cluster-2 (Blue) <i>Consumer Acceptance of Cultured Meat</i>	Siegrist et al. (2018)	122	63
	Siegrist and Sutterlin (2017)	118	33
	Verbeke et al. (2015)	177	32
Cluster-3 (Green) <i>Consumer Perceptions of Cultured Meat</i>	Onwezen et al. (2021)	154	56
	Van Loo et al. (2020)	115	38
	Bryant et al. (2019)	155	34
	Tuorila and Hartmann (2020)	111	33

Table 4: Extant literature on cultured meat by bibliometric coupling of documents based on a minimum of 100 citations

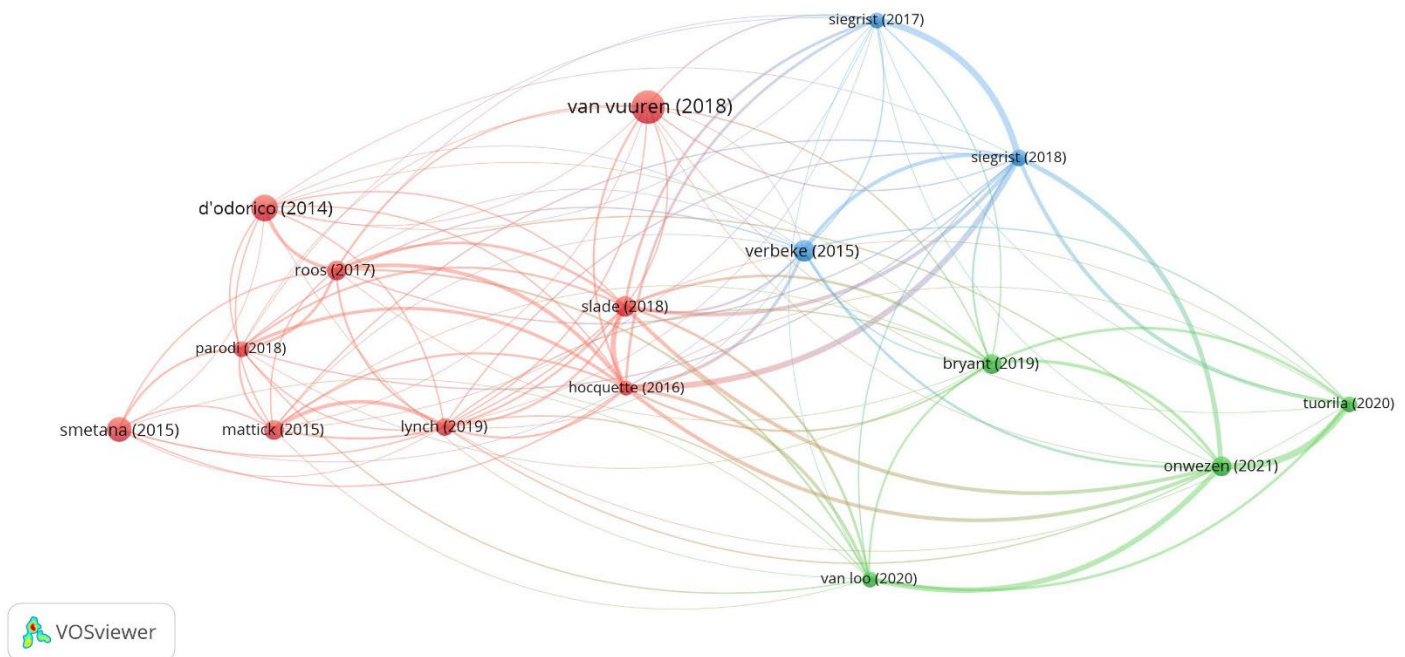


Figure 3: Extant literature on cultured meat by bibliometric coupling of documents based on a minimum of 100 citations (Number of documents is reflected in the circle size – *some documents are not visible in the map as these documents in the network are not connected to each other*)

4. Conclusion and Future Research Agenda

Cultured meat, as a disruptive sustainable alternative to traditional meat, has the potential of revolutionising the meat industry (Lupton and Turner, 2018) in line with the 2030 United Nations Sustainable Development Goals (SDGs). With nearly 10 billion people to feed by 2050, cultured meat allows increased meat production, all within our planetary boundaries (Rockström et al., 2009). Thereby, it moves the meat industry towards more sustainable production and consumption futures (SDG 12) whilst also achieving food security by ending hunger and improving nutrition (SDG 2). Hence, from the preliminary literature review and the bibliometric analysis, the following four future research opportunities are proposed:

- a. **Comprehensive influencers:** A significant shortcoming of the extant literature is that there has been heavy emphasis on very specific factors that influence consumer acceptance of cultured meat, and as a result there is a lack of understanding about the more comprehensive factors that influence how consumers perceive cultured meat/food. Therefore, to get a better understanding of consumers' perceptions of cultured meats, it will be valuable to explore how spatial, visceral, and temporal factors influence consumer acceptance of cultured meat. Further, the construal level theory and psychological distance by Liberman and Trope (1998) could help us understand the *why* behind cultured meat perceptions.
- b. **Developing world context:** The primary focus of most of the cultured meat literature has been in developed western countries (particularly Europe and the USA). However, given that meat consumption is projected to increase significantly more in developing Asia, this would warrant more studies done to understand consumer acceptance of cultured meat from a developing country perspective (Bryant and Barnett, 2018). Further, cross-cultural studies would be beneficial to identify why perceptions towards cultured meat differs across different countries/cultures, and thus suitable marketing strategies can be tested to overcome these socio-cultural barriers.

- c. Scarcity of marketing communications research: The bibliometric analysis reveals that there is a paucity of research on advertising cultured meat. In other similar novel food contexts, such as ugly foods, marketing communications plays a significant role in influencing purchase and preference for ugly produce (Rohm et al., 2017). Hence, future research should apply advertising theories to uncover the best practice communications strategies to encourage preference for cultured meat.
- d. Relationship marketing: Whilst research into consumer perspectives and the engineering of cultured meat has burgeoned (Chriki and Hocquette, 2020), exploration of how traditional meat growers and suppliers are impacted by this new food technology has been ignored. As the cultured meat and traditional meat industries are expected to closely compete for consumer demand by 2040 (Kearney, 2021), it is imperative that researchers also explore how the traditional meat industry stakeholders are adapting to the threat posed by the cultured meat industry.

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