

Reports

Reduced zoonoses and improved nutritional profiles: interrogating cultured meat and its alleged health benefits

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Cultured meat is being marketed as a multi-faceted improvement over traditional meat production. Some proponents claim that cultured meat reduces the potential spread of zoonotic disease; others further claim that cultured meat can be made more nutritious than traditional meat. This paper demonstrates – through a review of citations regarding proponent claims surrounding cultured meat’s potential to reduce zoonotic disease spread and improve nutritional possibilities – that cultured meat’s alleged health benefits are not based on quantitative data, nor based on well-developed theoretical research. Claims are often based on presumptions held throughout the literature; this paper calls these presumptions into question by investigating theoretical questions related to how cultured meat will be produced. Importantly, the paper also examines the recent emergence of “exotic cultured meat,” positing that proponent ambitions for diversified food experiences are not exempt from concerns about zoonotic disease spread and nutritional value. Healthcare professionals need to be aware of the limited evidence available for health-related claims which are being used to promote cultured meat. While such a conclusion does not require dismissing cultured meat’s potential, greater scrutiny is needed at this time, especially as cultured meat inches closer to becoming publicly available. This paper develops cultured meat research further by identifying the need for: deeper consideration of the interaction between humans and animals throughout the supply chain; greater care to be taken regarding the use of various sources as definitive proof of cultured meat’s alleged health benefits; and critical consideration of the implications of exotic cultured meat production.

Recently, the Food and Drug Administration (FDA) granted approval to the eventual sale of cultured meat; it is speculated that the United States Department of Agriculture (USDA) will grant similar approval in the coming months. Cultured meat has been considered, by many, as an exciting prospect, able to rectify environmental and ethical conundrums related to meat consumption, but without requiring societies and individuals to suddenly reject the cultural practices and economic incentives which perpetuate large-scale meat eating.¹ However, despite the hype, cultured meat is still a theoretical possibility, and has not been subject to particularly rigorous assessment of many of its promises. This paper calls attention to claims, made by cultured meat proponents, that cultured meat will drastically reduce the spread of zoonotic diseases, while also opening up new possibilities for creating meat with an “improved nutritional profile.” This paper argues that neither claim can currently be validated; furthermore, numerous underlying factors are going unaddressed in such claims. Consequently, health care professionals need to take great care in engaging with cultured meat, and should be calling for a significant burden of proof from companies and proponents.

CONTEXT

Current meat production practices are facing greater scrutiny for a variety of reasons, primarily related to sustainability concerns, resource use, and matters of human health. Zoonotic disease spread has become a point of special concern since the onset of the COVID-19 pandemic, but has been a longstanding issue in meat production. As noted by Espinosa, Tague, and Treich, bushmeat and backyard (local) farming increases the risk of disease transmission between wild and domesticated animals (which can spread to humans through consumption), while intensive industrial animal agriculture increases the risk of zoonotic disease spread due to

“the high density, genetic proximity, increased immunodeficiency, and live transport of farmed animals.”²

Hybridized farms can address some issues with each approach, but are not considered guaranteed solutions to zoonotic disease transmission. The increasing global demand for meat creates a “zoonotic disease trap:” as an example, animal agriculture can intensify management by putting animals in industrial settings, rather than on open

land, to reduce the risk of zoonotic disease spread by way of deforestation – however, intensive management often confines animals in increasingly smaller spaces alongside animal waste, increasing the potential for a different form of zoonotic disease spread.³ The careful management required for balancing increased production and decreased risk of zoonotic disease spread – especially if consumers do not make an active choice to decrease their meat consumption – will require considerable global coordination and company efforts; the FAIRR Initiative argues that companies are not taking effective enough action to prevent zoonotic pandemics, even following COVID-19.⁴ Ali and Alsayaqh stress that pathogenic microbes, spread through food consumption, can have a range of impacts, from mild (such as diarrhea) to fatal (such as cancerous conditions); the entirety of this range must be taken seriously as an issue of public health, especially in the interest of preventing the overloading of health care systems.⁵ While further alignment of goals under the One Health framework is seen as a necessary response to zoonotic disease issues, biotechnological innovations continue to receive attention.

Cultured meat has seen considerable interest since a prototype burger was unveiled in 2013, especially in the face of the modern climate crisis. Though debate exists as to industrial (and non-industrial) meat's exact environmental and social impact(s), it has become increasingly clear that current practices of meat production have become unsustainable. There is also considerable debate regarding how to resolve sustainability issues, ranging from minimal reductions in meat consumption to outright rejection of the practice. Each approach creates considerable cultural, societal, and economic conflict, which has prompted considerations of potential biotechnological pathways and food innovations to circumvent such difficulties. Plant-based meat has seen noteworthy interest as a viable way to transition consumers to more sustainable practices, but there is mixed evidence as to the effectiveness of this strategy, and recent market downturns raise the possibility that the boom is slowing down.⁶ Insect meat has also been considered a potential way to rectify meat's sustainability issues, but consumer adoption in numerous contexts seems unlikely, and questions of scale and production methods remain contentious, especially when compounded by ongoing cultural rejection of the practice in certain political spaces – even assessments which are supportive of insect meat tend to frame its adoption as a mediator of animal protein's environmental harms, rather than as a direct replacement under a new food future, due to various quandaries related to inputs, land use, and cultural practices.⁷

Cultured meat – the practice of performing a biopsy on an animal, immersing the cells in a culture medium, and exercising them to simulate physical movement, all within a bioreactor environment – has positioned itself as being able to overcome issues which stem from industrial, plant-based, and insect, meat. Allegedly, cultured meat can drastically reduce resource use, minimize land use, and provide ethical resolutions to long-standing problems. Others have raised concerns that environmental claims are overblown; ethical issues are resolved only within highly specific fram-

ings; and the cost to scale cultured meat production may be so astronomical as to render the practice essentially ineffective. As I have highlighted in a recent review of cultured meat literature, there has been considerable promise before the necessary proof has been offered, leading to a discourse which presumes cultured meat: is closer to being market-ready than it likely is; will be able to live up to its promises; and will have a minimal negative impact in any sort of unforeseen sense.¹ However, within the usual concerns of cultured meat researchers – environment, ethics, consumer acceptance, ontology – there is occasional mention of health benefits which should be considered further.

PROPONENT HEALTH CLAIMS

There are two primary claims that proponents make regarding the (potential) health benefits of cultured meat. The evidence for both claims is, as of now, nonexistent, as cultured meat has yet to be produced at large-scale, and the final nature of each product is undetermined at this time; even GOOD Meat's "cultured chicken bites," sold exclusively at select locations in Singapore, have an unclear composition of animal and plant cells.⁸ The inability to validate cellular information on the only cultured meat product currently available points to a need for considerable care to be taken with any claim surrounding cultured meat that has not been through rigorous assessment. Yet, both health claims have been part of the discussion surrounding cultured meat's potential benefits for some time, necessitating a response despite the inability to make any definitive claims.

The first claim, I posit, has seen more widespread attention. Cultured meat is alleged, by virtue of the way it is produced – in a sterile lab – to reduce the chance of zoonotic diseases and their spread. My previous review of 200+ academic papers, and 1,000+ media publications, affirmed that these claims are widespread.¹ Much of this literature is "summative," focused on presenting, to unfamiliar individuals, what cultured meat is, and what its potential benefits and issues might be, as understood in reference to current ideas. The claims of reduced zoonotic disease spread have been long-standing; this paper focuses on academic engagement with the claims, but media sources have reiterated these notions as well. In 2013, for example, Welin argued that

*"another potential advantage is related to health. Many animal diseases have made it clear that meat from animals has its dangers. In cultured meat production, it will be easier to keep control of pathogen contagion."*⁹

This claim, despite not having a corresponding citation, has been reiterated by Schafer and Savelscu, Verbeke et al., Arshad et al., Swartz, Sachs & Kettenman, Bryant, Hansen et al., and Lähteenmäki-Uutela et al., also without adequate corresponding citations.¹⁰⁻¹⁷ This small sample indicates an acceptance of the proposition that cultured meat, by virtue of being produced in a sterile laboratory, will reduce the spread of zoonotic disease.

However, even when there are citations to back such claims, there are issues which must be considered. Some authors cite papers which do not produce original research making such claims, and, instead, reiterate authors who are basing their claims on other authors making claims not based on original studies; or, occasionally, authors cite papers which are entirely theoretical as if they are definitive proof. For example, Zhang et al. claim cultured meat “will” decrease zoonotic disease risk.¹⁸ This claim is backed up by a citation of Dattar and Betti; however, these authors posit that

“controlled conditions would theoretically eliminate product losses from disease animals.”¹⁹

Dattar and Betti’s work did not prove anything about zoonotic disease, as the study was an entirely theoretical conceptualization of cultured meat production, and, furthermore, the study was not intended to prove such claims in the first place, especially prior to the existence of the first prototype. Another example is seen with Krings et al., who posit that

“clean meat is grown under laboratory conditions, which are significantly cleaner and safer than traditional livestock farms, reducing or even eliminating disease risks.”²⁰

The authors cite Bryant and Barnett, and Post, to reinforce this claim, but neither study is a comparison of laboratory and livestock farm settings. Bryant and Barnett’s paper is a review of consumer acceptance literature, and Post’s publication is a short-form, theoretical declaration of cultured meat’s alleged benefits.^{21,22} Lee claims that cultured meat can reduce zoonotic disease occurrence and improve the nutritional profile of meat; the evidence stems from an entirely theoretical 2011 Life-Cycle Analysis conducted by Tuomisto and de Mattos, which has been widely cited, yet questioned because of its specific framework and subsequent challenges to its conclusions.^{1,23–28} O’Riordan et al. claim that Bhat and Bhat’s paper perpetuates a narrative that cultured meat reduces interspecies disease spread and antibiotic resistance; in contradiction, Bhat, Khumar, and Bhat argue that the 2011 paper presents a situation in which

“in vitro meat may have a completely different risk profile and much attention would [sic] require to be paid to the safety of added substrates and other compounds of the culture medium.”^{29–31}

The Bhat and Bhat paper is too interpretable to be seen as “proof.” Finally, Galusky’s paper cites New Harvest’s rationale for cultured meat, which supposedly allows for better disease control by

“eliminating waste generated by animals or ecological systems.”³²

New Harvest cites Edelman et al.’s paper which provided the theoretical foundation for cultured meat development. This paper was published eight years before the first prototype, and does not even have a dedicated section to the

matter of zoonotic disease; instead, the prospect is identified in a single sentence in the paper’s conclusion.³³

There has, to date, been no research which compares, in quantitative, measurable terms, the production of cultured and traditional meat so as to measure the safety therein, nor has there been a study which proves that cultured meat reduces zoonotic disease spread. That is not surprising, given that cultured meat has yet to be produced at any scale. However, because of this matter, and the inability to measure the incidence of zoonotic disease in cultured meat animals, claims that cultured meat “will reduce” zoonotic disease spread cannot, and should not, be accepted at face value. Refined and qualified claims are possible. As will be discussed later in this paper, there are other matters to consider, but at this juncture, a basic review indicates that these claims must be treated with greater care.

The second claim is not particularly widespread, but has seen enough attention to be noted. Some have posited that cultured meat can be made more nutritious than traditional meat, a selling point which not only generates public hype, but might also be considered by investors as a reason to invest in cultured meat companies. In 2017, Bhat et al. claimed that

the first important advantage of producing cultured meat is better control over meat composition, fat content, and ratio of saturated to polyunsaturated fatty acids through composition of the culture medium or coculturing with other cells types.... [B]y adding factors to the culture medium which might have an advantageous effect on the health, like certain types of vitamins, health aspects of the in vitro meat could be enhanced.... [B]y culturing meat under the controlled and manipulable conditions, we can obtain designer meat with a suitable nutritional profile.³¹

This proposal is entirely theoretical; the sources cited by the authors include a (previously mentioned) theoretical paper by Bhat and Bhat, and the original patent filed by Willem Van Eelen in 1999, when a proof-of-concept did not yet exist. Tuomisto and de Mattos made similar claims that

“controlled conditions also enable the manipulation of nutritional, textural, and taste profiles. The quantity and quality of fat can be controlled, and, therefore... nutrition-related diseases, such as cardiovascular diseases, can be reduced.”²⁴

This notion is purely speculative, with no cited studies, as none existed at the time, and there is yet to be a study which proves these claims accurate; the assumption is that, by virtue of the laboratory setting, cultured meat can be made more nutritious. Yet, this point is reiterated by Tomiyama et al. when they refer to the possibility of adjusting saturated and unsaturated fats in cultured meat; while they are clear that this point is only a theory, the discussion does not thoroughly highlight the lack of available data.³⁴ However, companies are using this promise for promotional ends. Profuse Technology recently promoted their culture medium by claiming that it leads to cultured meat

“with up to 2-2.5 times more muscle, 4-5 more protein, reduced production times, and the potential to achieve price parity with conventional meat.”³⁵

The company has yet to produce any documentation – that is publicly available, at least – to prove their claims accurate, and FDA approval has yet to be granted. However, the claim is likely to contribute to investor interest in the company, and potential sales/collaboration with cultured meat producers. Ivy Farm also uses the promise of nutritional improvement to promote its efforts, though its claims are much more reserved, citing “equivalent protein levels” between traditional and cultured meat, “slightly higher” amino acid and iron levels, and the

“ability to enable a better ratio of saturated to unsaturated fats, so we could have a higher ratio of omega-3 fatty acids.”³⁶

Care should still be taken, as company claims are based entirely on internal data at this time, lacking outside replication or investigation. Consequently, despite the even more limited evidence and spread of these claims in cultured meat discourse, attention should be given to this proposed benefit. Bearing in mind the dual claims of reduced zoonotic disease spread and nutritional profile improvement, the next section will raise further concerns about these claims.

REASONS FOR CONCERN

At this juncture, it is clear that claims regarding cultured meat’s potential benefits should be treated in a critical and cautious manner. Medical professionals, of all sorts, should not welcome cultured meat with open arms, but should demand of its proponents a reasonable level of data and detail; that burden of proof rests with researchers and proponents. However, there are other matters to consider.

I begin this section considering cultured meat’s alleged possibility for creating a “superior nutritional profile” to traditional meat production. Who determines the superiority of this supposed profile? At this juncture, it is not health care professionals, but private enterprises and interested proponents who are in competition with traditional meat producers. This competition exists within a capitalist system, in which marketing does not rely on claiming to be “less and inferior” to a competitor, but “more and better.” Consumers are, by virtue of this system, caught in the fray, left to make decisions on the basis of potentially limited knowledge and saturated exposure to advertising and private sector messaging.

This matter must be considered in tandem with increasing concerns that many countries are consuming excessive protein.³⁷⁻⁴⁰ If cultured meat is marketed as “the same taste, but nutritionally superior,” how are consumers to determine how much they should be consuming? Cultured meat companies presumably will not encourage consumers to consume less meat, as that would likely impact their profit margins if consumers are buying less meat than they would normally. In order to reach price parity and com-

petitive possibility with traditional meat, producers will – presumably – market cultured meat similarly to traditional meat, and will aspire to provide consumers with similar serving sizes and familiar products. If these sizes and products have five times as much protein, and are consumed as frequently as traditional meat, it is fair to raise concerns that the “over-proteinizing” of societies could be compounded by cultured meat’s presence and the efforts of its proponents. This point is pertinent when considering consumers who frequently consume meat, but do not consider the nutritional information provided on any packaging; it also worth considering individuals who are deeply invested in workout culture, using protein supplements, shakes, etc., to attempt to improve performance. Both groups may be especially vulnerable to consuming excess protein, if for different reasons, raising concerns about cultured meat’s presence on store shelves, and how companies communicate about their products. While cultured meat companies would be obligated to provide nutrition information on their packaging, there is no guarantee that consumers will be able to make sense of this information vis-a-vis the differences between cultured and traditional meat. Even if companies “improve” the nutritional profile of cultured meat through genetic modification, and are obligated to convey this information on packaging, that does little to offset concerns of cultured meat’s (theoretical) impact on excessive protein consumption.

Beyond nutritional modification, though, cultured meat holds other possibilities. As I have identified in previous work, a small group of companies (and proponents) are promoting “exotic” cultured meat, produced by using the cells of animals who have not been domesticated for food consumption.¹ Elephants, tigers, lions, etc., have all been the subject of efforts, by companies like VOW Foods and Primeval, to promote a possible future in which consumers have access to a wide variety of meat. Primeval has even implied that current meat animals are not consumed for reasons of nutrition, but ease of domestication; cultured meat is imputed to allow for the consumption of more exotic, potentially more nutritious, meat. At this juncture, there has been no study on the nutritional benefits (or deficits) of exotic, undomesticated animals, compared to domesticated livestock, within the theoretical (or practical) context of cultured meat production; company claims are, consequently, not substantiated. It would be ideal for medical professionals to demand a burden of proof from these companies to clarify what they mean by “improved nutrition,” and by what means/methods they have determined the supposed benefits of their products. This point is especially important if these formerly undomesticated animals possess more protein than domesticated livestock; again, will consumers be aware of such a matter, or might a possible increase in protein consumption be imaginable?

It is important to also look at the zoonotic disease claims in greater detail, as even if cultured meat can be rendered more nutritious, while simultaneously not contributing to the over-protein concerns facing many countries, there are other points to consider. Cultured meat’s surface logic makes it seem as if it is inevitable that cultured meat will

reduce zoonotic disease spread by drastically reducing the number of animals on earth, and drastically reducing human contact with them. However, both claims need to be considered carefully. Early in cultured meat's history, some theorized that animal populations, for meat consumption, could be reduced to single digit territory, especially when immortal cell lines are utilized; more recent estimates have single-product animal populations closer to 20,000+ for the global food supply.⁴¹ It is unclear whether such estimates will increase in the future; as the production process becomes clearer, and more animals are potentially integrated into food production systems, it is theoretically plausible that cultured meat, while still drastically reducing the global animal population, does not do so in a way that proponents previously envisioned (nor in a way investors envisioned).

One must also consider the factors that lead to zoonotic disease spread. Are zoonoses spread just because of the number of animals in the world, or because of how these animals are raised and slaughtered? Though the number of animals is obviously a factor, poor housing conditions, water quality, overcrowding, and cross-species contact, all contribute to breeding zoonotic diseases, often prompted by a company desire to maximize profit and minimize expenses. The reasoning for why cultured meat companies will not follow a similar path remains unclear. While cultured meat production may, in theory, drastically reduce land use, that prospect does not guarantee a lower chance of zoonotic disease spread. Companies may still crowd animals into concentrated confinement operations, not just to save costs, but also, theoretically, because the land no longer in use for feedgrains and livestock grazing may instead be urbanized for the purposes of development and housing, especially as land preservation efforts are, globally, weak. The theoretical reduction of land use could also prompt more human and wild animal contact, often considered a major way for zoonotic diseases to propagate.⁴² Furthermore, if animals are used for cell-culturing for longer than they would be alive in a traditional production system, it is fair to raise concerns about the vulnerability of older animals to become vectors, or source points, for zoonotic disease spread. This point is especially worth considering in light of Melzener et al.'s conclusion that slaughtering animals – once they reach a point in which they cannot be cultured further—is environmentally and economically sensible for cultured meat producers.⁴¹

Others have also claimed that zoonotic disease spread will be lowered by virtue of reduced contact with animals, but this point should be reconsidered. Though Buscemi claims that cultured meat marks the separation of animal production from living animals, that is not accurate; living animals are still required.⁴³ The slaughtering of the animal may not be part of this dynamic, but the living animal is still a key aspect of cultured meat production. Consequently, interaction with animals is still necessary. Some, however, believe that cultured meat can further (re)connect animals and humans by virtue of greater interaction. Wurgraft proposes a vision of “the pig in the backyard/town square,” in which small communities can harvest cells from

a locally known animal that can be regularly interacted with; he goes so far as to posit that this pig can be fed apples to

“help with the human process of becoming.”⁴⁴

In making new cultural practices of “connecting” with animals, especially at a local level, questions of health and safety monitoring come into play. Will these “town squares” be regulated at a national or international level? By what standards? Can communities be expected to maintain certain standards, especially when considering access to resources and financial stability? This point is especially noteworthy when one considers that it may not be a single “pig in the backyard,” but numerous pigs. Culturing local animals is not inherently guaranteed to reduce zoonotic disease spread; it is also possible that the way zoonoses spread may change. Without any sort of study at this time – even a theoretical one – it is impossible to properly claim that cultured meat reduces the points of human/animal interaction, especially when industrial animal agriculture already minimizes such contact to a significant degree. Finally, in light of argumentation by Hemsworth and Coleman, there is a paradox, in that the pursuit of healthier meat will depend on some degree of interaction with animals who are killed for meat; even if cultured meat does not require said death, the minimization of contact with animals may still not produce meat that is as satisfactory as meat produced when animals are physically connected with.⁴⁵

Exotic animal meat must also be considered in further detail. Companies like Primeval and VOW Foods are promising potential consumers a wide variety of “umami” experiences. At this juncture, these companies have not made clear how they are obtaining their cells. Even if these companies are currently getting their cells from laboratories or zoos, there is the possibility that, in order to pursue the “99.6% of undomesticated animals,” said companies will have to venture into the various wilds of the world to obtain cells. By virtue of how these cells would be obtained, human and wild animal contact would theoretically increase. There is also the possibility that wild animals would be captured and transported from one country to another so that the cells can be harvested, should there be difficulties in transporting cell lines; there is no study, at this time, as to the effectiveness of exotic animal cell cryopreservation. Though companies like ATA Scientific and Cellbox stress that innovative new methods for cellular transportation – which match the laboratory environment – are on the rise, they have not offered commentary on the viability of these methods for cultured meat purposes.^{46,47} If animal transportation is preferable to cellular transportation, one should consider whether the transported animal is carrying a pathogen, or comes down with considerable stress leading to illness –there is a need to consider the potential spread of zoonotic disease in this regard. At this time, due to the minimal presence of these companies in cultured meat discourse, there is not much consideration being given to this potentiality, but as this section has demonstrated, claims that cultured meat “will”

result in a decrease of zoonotic disease spread must be treated with greater care.

Finally, it is important to reiterate Bhat, Kumar, and Bhat's point to the unknown nutritional profile of cultured meat.³¹ Currently, while production facilities are being built, any prototypes which are being produced are contained within small-scale facilities. Eat JUST, responsible for the Singapore chicken bites, is currently producing using a bioreactor smaller than 10,000 L. The question of scalability haunts the cultured meat experiment, and with this haunting, there are concerns about what might happen in larger bioreactors. Chriki and Hocquette note that

*"it is the cells, not animals, that live in high numbers in incubators to produce cultured meat.... [S]ome authors argue that the process of cell culture is never perfectly controlled and that some unexpected biological mechanisms may occur. For instance, given the great number of cell multiplications taking place, some dysregulation of cell lines is likely to occur as happens in cancer cells.... [T]his may have unknown potential effects on the muscle structure and possibly on human metabolism and health when in vitro meat is consumed."*⁴⁸

Though the authors note that deregulated cell lines need not be considered as an issue, it is clear that the lack of available information, data, and insight raises key questions as to cultured meat's potential health impacts. This point is especially pertinent when one looks at the proposed scale of cultured meat production. Currently, Eat Just is producing in a 1,200 L bioreactor; Humbird argues that sterility is extremely difficult, if not impossible, to manage for animal cells in a 1,000 m³ (1,000,000 L) bioreactor, meaning sterility is better managed in a maximum 200 m³ (200,000 L) bioreactor.^{8,49} However, even this scaling-up is difficult to envision given the scale of management and room for error. In 2021, the CEO of Eat JUST, Josh Tetrick, admitted that no company has

"ever designed and engineered a 100,000 liter reactor for animal cell culture,"

the maximum being 25,000 liters.⁵⁰ This point makes Tetrick's recent announcement – that his company will construct "ten 250,000 liter bioreactors" by 2025 – all the more concerning.^{51,52} Not only is the question of possibility completely unanswered, but can animal cells be safely managed at such a never-before-seen scale? Are there unforeseen health issues at such a scale that have yet to be predicted? And are there ways to theorize potential impacts at this juncture, rather than waiting for the bioreactors to be constructed, and producing, before any issues are realized and accounted for? The inability to answer these questions should be treated with some alarm, given the supposed imminence of large-scale cultured meat production. If proponents are accurate that cultured meat will compete with traditional-industrial meat production, necessitating previously unseen bioreactors and scales, there is valid reason to be concerned about unforeseen consequences and unknown unknowns. Even if zoonotic disease and nutritional profile questions can be answered, the innovation of

cultured meat production does bring with it concerns of the previously unimagined.

CONCLUSION

This paper may come across as alarmist, which is not the intention. Cultured meat may, or may not, be able to meet the promises of its proponents, depending on future developments. However, this paper demonstrates that there are too many unanswered questions, surrounding theoretical cultured meat production, which remain unaddressed. Health care professionals, at all levels, should be aware of: the extent to which cultured meat proponent claims are not based on data-driven evidence; the potential implications of these claims; and where research, even of a theoretical nature, is necessary going forward. At this stage, the claims of cultured meat companies and proponents should not be accepted without considerable scrutiny, and especially without calls for proponents to meet a certain burden of proof before any health care professionals endorse cultured meat.

For those who are engaged with zoonotic disease issues, cultured meat seems theoretically sound, but matters surrounding bioreactor design are compounded by questions of where animals will be housed, how much contact there will be between human and animal, and whether certain proponent/company efforts could actually open new pathways for zoonotic disease spread, especially when considering exotic animals. For those engaged with nutrition and protein-related issues, cultured meat holds promise, but must be clarified in the context of company promotional efforts, different types of consumers, and ongoing narratives surrounding protein needs which do not necessarily match scientific consensus. The matter of nutritional profile is also important for all medical professionals to consider as cultured meat production (attempts) to scale-up. Can proponents guarantee cellular health, and what happens if companies sell products from a potentially contaminated cellular batch? Are there un-theorized health implications relative to increasing bioreactor size? Numerous questions can be asked, but it is important to conceptualize the relationship between scalability and health.

The FDA approval of cultured meat is not the end-all-be-all of cultured meat's relationship to public health. While future cultured meat products may be found safe to consume, exposure to zoonotic diseases will remain a public health concern. It is unclear how cultured meat will resolve the "zoonotic disease trap" identified by Hayek, as zoonotic disease spread is possible at all levels of meat production within both industrial and non-industrial contexts.³ The safety of cultured meat currently depends on cultured meat companies who are funded by venture capital and are maintaining secrecy in a competitive space; it is unclear what steps are being taken to ensure that public health is a primary concern of companies. The efforts of public health proponents to combat disinformation, or lack of information, will likely not be assisted by claims of "improved nutritional profile" so long as the power to establish such claims rests with private companies, rather than public

health practitioners, especially in reference to concerns about excessive protein consumption. However, companies should also consider how the public perceives its health in relation to lackluster information; contradictions, such as Tetrick's rhetoric surrounding bioreactors, may lead to concern from consumers as to company transparency and theoretical health risks. It is in the interests of both the public and private sector to greatly improve how cultured meat's relationship to health is understood and discussed.

Going forward, however, is difficult, especially because cultured meat is still essentially a theoretical prospect. While that may deter research on the basis of potential "disprove-ability," the lack of both theoretical and practical research on cultured meat is not leading to caution in pro-cultured meat argumentation. Claims that cultured meat producers "don't expect to use antibiotics – or at least large amounts," do not adequately clarify the potential use of antibiotics in cell isolation and cell line establishment, nor the non-use of antibiotics in the proliferation/differentiation phases of cell culture.^{53,54} There is a need for careful research and, importantly, far greater clarification even in theoretical settings. Theoretical research may not always end up being right, but with so much rhetoric surrounding cultured meat, it is time to call said rhetoric to account, especially when the health of the public is a selling point for certain proponents. Theoretical research can better help proponents clarify what makes cultured meat beneficial, relative to other forms of meat production; what data is being used to make these claims; and what can be

done if there are concerns that can be identified. Because of cultured meat's theoretical prospects, many fields have yet to give cultured meat consideration; however, as production progresses, it is time for the health care field to begin focusing on cultured meat's prospects, possibilities, and inconsistencies.

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REFERENCES

1. Giles R. *Under the Skin: Assessing the Ideological Underpinnings and Material Reality of Cultured Meat*. Dissertation. University of Waterloo; 2023. <https://uwspace.uwaterloo.ca/handle/10012/18926>
2. Espinosa R, Tago D, Treich N. Infectious Diseases and Meat Production. *Environ Resource Econ*. 2020;76(4):1019-1044. [doi:10.1007/s10640-020-00484-3](https://doi.org/10.1007/s10640-020-00484-3)
3. Hayek MN. The Infectious Disease Trap of Animal Agriculture. *Sci Adv*. 2022;8(44):1-8. [doi:10.1126/sciadv.add6681](https://doi.org/10.1126/sciadv.add6681)
4. FAIRR Initiative. Meat Industry Performs Poorly on Pandemic Prevention. FAIRR Initiative. Published 2022. Accessed May 31, 2023. <https://www.fairr.org/article/meat-industry-performs-poorly-on-pandemic-prevention/>
5. Ali S, Alsayeqh AF. Review of Major Meat-Borne Zoonotic Bacterial Pathogens. *Frontiers in Sustainable Food Systems*. 2022;10:1-17.
6. Creswell J. Beyond Meat is Struggling, and the Plant-Based Meat Industry Worries. *The New York Times*. <https://www.nytimes.com/2022/11/21/business/beyond-meat-industry.html>. Published 2022. Accessed May 31, 2023.
7. Mulia RN, Doi H. Global Simulation of Insect Meat Production under Climate Change. *Frontiers in Sustainable Food Systems*. 2019;91(3):1-11.
8. Coyne A. Leading the Charge – the Companies at the Cutting Edge of Cell-Based Protein Product Development. *Just-Food*. January 27, 2022.
9. Welin S. Introducing the New Meat. Problems and Prospects. *Nordic Journal of Applied Ethics*. 2013;7(1):24-37.
10. Schaefer GO, Savulescu J. The Ethics of Producing In Vitro Meat. *J Appl Philos*. 2014;31(2):188-202. [doi:10.1111/japp.12056](https://doi.org/10.1111/japp.12056)
11. Verbeke W, Sans P, Loo EJV. Challenges and Prospects for Consumer Acceptance of Cultured Meat. *Journal of Integrative Agriculture*. 2015;14(2):285-294. [doi:10.1016/s2095-3119\(14\)60884-4](https://doi.org/10.1016/s2095-3119(14)60884-4)
12. Arshad MS, Javed M, Sohaib M, Saeed F, Imran A, Amjad Z. Tissue Engineering Approaches to Develop Cultured Meat From Cells: a Mini Review. *Cogent Food & Agriculture*. 2017;3(1):1320814. [doi:10.1080/23311932.2017.1320814](https://doi.org/10.1080/23311932.2017.1320814)
13. Swartz E. Meeting the Needs of the Cell-Based Meat Industry. *CEP*. Published online 2019:41-45.
14. Sachs A, Kettenmann S. A Burger By Any Other Name: Regulatory Challenges and Opportunities for Cell-Cultured Meat. *The SciTech Lawyer*. 2019;15(2):1-5.
15. Bryant CJ. Culture, meat, and cultured meat. *Journal of Animal Science*. 2020;98(8):1-7. [doi:10.1093/jas/skaa172](https://doi.org/10.1093/jas/skaa172)
16. Hansen J, Sparleanu C, Liang Y, et al. Exploring Cultural Concepts of Meat and Future Predictions on the Timeline of Cultured Meat. *Future Foods*. 2021;4:100041. [doi:10.1016/j.fufo.2021.100041](https://doi.org/10.1016/j.fufo.2021.100041)
17. Lähteenmäki-Uutela A, Rahikainen M, Lonkila A, Yang B. Alternative Proteins and EU Food Law. *Food Control*. 2021;130:108336. [doi:10.1016/j.foodcont.2021.108336](https://doi.org/10.1016/j.foodcont.2021.108336)
18. Zhang C, Guan X, Yu S, Zhou J, Chen J. Production of Meat Alternatives Using Live Cells, Cultures and Plant Proteins. *Current Opinion in Food Science*. 2022;43:43-52. [doi:10.1016/j.cofs.2021.11.002](https://doi.org/10.1016/j.cofs.2021.11.002)
19. Datar I, Betti M. Possibilities for an In Vitro Meat Production System. *Innovative Food Science & Emerging Technologies*. 2010;11(1):13-22. [doi:10.1016/j.ifset.2009.10.007](https://doi.org/10.1016/j.ifset.2009.10.007)
20. Krings VC, Dhont K, Hodson G. Food Technology Neophobia as a Psychological Barrier to Clean Meat Acceptance. *Food Quality and Preference*. 2022;96:104409. [doi:10.1016/j.foodqual.2021.104409](https://doi.org/10.1016/j.foodqual.2021.104409)
21. Bryant C, Barnett J. Consumer Acceptance of Cultured Meat: an Updated Review (2018–2020). *Applied Sciences*. 2020;10(15):5201. [doi:10.3390/app10155201](https://doi.org/10.3390/app10155201)
22. Post MJ. Cultured Meat from Stem Cells: Challenges and Prospects. *Meat Science*. 2012;92(3):297-301. [doi:10.1016/j.meatsci.2012.04.008](https://doi.org/10.1016/j.meatsci.2012.04.008)
23. Lee A. Meat-ing Demand: Is In Vitro Meat a Pragmatic, Problematic, or Paradoxical Solution? *Canadian Journal of Women and the Law*. 2018;30(1):1-41. [doi:10.3138/cjwl.30.1.1](https://doi.org/10.3138/cjwl.30.1.1)

24. Tuomisto HL, Mattos MJT. Environmental Impacts of Cultured Meat Production. *Environ Sci Technol*. 2011;45(14):6117-6123. [doi:10.1021/es200130u](https://doi.org/10.1021/es200130u)
25. Mattick CS, Landis AE, Allenby BR. A Case for Systemic Environmental Analysis of Cultured Meat. *Journal of Integrative Agriculture*. 2015;14(2):249-254. [doi:10.1016/s2095-3119\(14\)60885-6](https://doi.org/10.1016/s2095-3119(14)60885-6)
26. Mattick CS, Landis AE, Allenby BR, Genovese NJ. Anticipatory Life Cycle Analysis of In Vitro Biomass Cultivation for Cultured Meat Production in the United States. *Environ Sci Technol*. 2015;49(19):11941-11949. [doi:10.1021/acs.est.5b01614](https://doi.org/10.1021/acs.est.5b01614)
27. Lynch J, Pierrehumbert R. Climate Impacts of Cultured Meat and Beef Cattle. *Front Sustain Food Syst*. 2019;3(5):1-11. [doi:10.3389/fsufs.2019.00005](https://doi.org/10.3389/fsufs.2019.00005)
28. Escobar MIR, Cadena E, Nhu TT, Cooreman-Algoed M, De Smet S, Dewulf J. Analysis of the Cultured Meat Production System in Function of its Environmental Footprint: Current Status, Gaps, and Recommendations. *Foods*. 10:1-26.
29. O’Riordan K, Fotopoulou A, Stephens N. The First Bite: Imaginaries, Promotional Publics and the Laboratory Grown Burger. *Public Underst Sci*. 2017;26(2):148-163. [doi:10.1177/0963662516639001](https://doi.org/10.1177/0963662516639001)
30. Bhat ZF, Fayaz H. Prospectus of cultured meat—advancing meat alternatives. *J Food Sci Technol*. 2010;48(2):125-140. [doi:10.1007/s13197-010-0198-7](https://doi.org/10.1007/s13197-010-0198-7)
31. Bhat ZF, Kumar S, Bhat HF. In vitro meat: a future animal-free harvest. *Critical Reviews in Food Science and Nutrition*. 2015;57(4):782-789. [doi:10.1080/10408398.2014.924899](https://doi.org/10.1080/10408398.2014.924899)
32. Galusky W. Technology as Responsibility: Failure, Food Animals, and Lab-grown Meat. *J Agric Environ Ethics*. 2014;27(6):931-948. [doi:10.1007/s10806-014-9508-9](https://doi.org/10.1007/s10806-014-9508-9)
33. Edelman PD, McFarland DC, Mironov VA, Matheny JG. Commentary: In Vitro-Cultured Meat Production. *Tissue Engineering*. 2005;11(5-6):659-662. [doi:10.1089/ten.2005.11.659](https://doi.org/10.1089/ten.2005.11.659)
34. Tomiyama AJ, Kawecki NS, Rosenfeld DL, Jay JA, Rajagopal D, Rowat AC. Bridging the Gap Between the Science of Cultured Meat and Public Perceptions. *Trends in Food Science & Technology*. 2020;104:144-152. [doi:10.1016/j.tifs.2020.07.019](https://doi.org/10.1016/j.tifs.2020.07.019)
35. Southey F. Cell-Based Meat with 5 Times More Protein? Media Supplement Developed to Fill ‘Huge Whitespace’ in Industry. *WRBM Global Food*. Published online August 29, 2022.
36. Eccles L. From Pig Cell to Fork. Does Lab-Grown Meat Pass the Taste Test? *The Sunday Times*. January 9, 2023.
37. World Resources Institute. People Are Eating More Protein Than They Need – Especially in Wealthy Regions. World Resources Institute. Published 2023. Accessed April 10, 2023. <https://www.wri.org/data/people-are-eating-more-protein-they-need-especially-wealthy-regions>
38. Henchion M, Hayes M, Mullen A, Fenelon M, Tiwari B. Future Protein Supply and Demand: Strategies and Factors Influencing a Sustainable Equilibrium. *Foods*. 2017;6(7):53. [doi:10.3390/foods6070053](https://doi.org/10.3390/foods6070053)
39. Aiking H, de Boer J. The Next Protein Transition. *Trends in Food Science & Technology*. 2020;105:515-522. [doi:10.1016/j.tifs.2018.07.008](https://doi.org/10.1016/j.tifs.2018.07.008)
40. Wempen K. Are You Getting Too Much Protein? Mayo Clinic Health System. Published 2018–2023. Accessed April 10, 2023. <https://www.mayoclinichealthsystem.org/hometown-health/speaking-of-health/are-you-getting-too-much-protein>
41. Melzener L, Verzijden KE, Buijs AJ, Post MJ, Flack JE. Cultured Beef: From Small Biopsy to Substantial Quantity. *J Sci Food Agric*. 2021;101(1):7-14. [doi:10.1002/jsfa.10663](https://doi.org/10.1002/jsfa.10663)
42. Rozenbaum M. The Increase in Zoonotic Diseases: the WHO, the Why and the When? Understanding Animal Research. Published 2023. Accessed April 10, 2023. <https://www.understandinganimalresearch.org.uk/news/the-increase-in-zoonotic-diseases-the-who-the-why-and-the-when>
43. Buscemi F. From Killing Cows to Culturing Meat. *British Food Journal*. 2014;116(6):952-964. [doi:10.1108/bfj-11-2012-0288](https://doi.org/10.1108/bfj-11-2012-0288)
44. Wurgaft BA. *Meat Planet*. University of California Press; 2019. [doi:10.1525/9780520968264](https://doi.org/10.1525/9780520968264)
45. Hemsworth PH, Coleman GJ. *Human-Livestock Interactions*. 2nd ed. CAB International; 2011.
46. ATA Scientific Instruments. How to Efficiently Transport Live Cell Structures Without Freezing Them. ATA Scientific Instruments. Published 2020. Accessed April 10, 2023. <https://www.atascientific.com.au/how-to-efficiently-transport-live-cell-cultures-without-freezing-them/>

47. Cellbox. Live Cell Transport – the Rising Star? Cellbox Solutions. Published 2023. Accessed April 10, 2023. <https://cellbox-solutions.com/cellblog/the-rising-star>
48. Chriki S, Hocquette JF. The Myth of Cultured Meat: a Review. *Front Nutr*. 2020;7:1-9. doi:10.3389/fnut.2020.00007
49. Humbird D. *Scale-Up Economics for Cultured Meat: Techno-Economic Analysis and Due Diligence*. DWH Processing Consulting LLC; 2020.
50. Fassler J. Lab-Grown Meat is Supposed to be Inevitable. The Science Tells a Different Story. The Counter. Published 2020. Accessed April 10, 2023. <https://thecounter.org/lab-grown-cultivated-meat-cost-at-scale/>
51. Webb S. US Firm to Build Biggest Ever Vats for ‘No Cruelty’ Meat. *Independent Online*. May 26, 2022.
52. Watson E. GOOD Meat Strikes Deal for ‘Largest Known Bioreactors for Avian and Mammalian Cell Culture’ for US Cultivated Meat Facility. *WRBM Global Food*. May 25, 2022.
53. Rogers K. Eating Meat Without Slaughtering Animals May Be in Our Future. *CNN*. March 8, 2023.
54. Folmer D, Zhang JJ, Kaneko K, Overbey K, Hice S. Cell Culture Consultation (CCC) 000002, Cultured Gallus gallus Cell Material. Memorandum, Food and Drug Administration. Published November 14, 2022. <https://www.fda.gov/media/163261/download>