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University of Pretoria, South Africa

## \*CORRESPONDENCE

Aviad Raz  
✉ [aviadraz@bgu.ac.il](mailto:aviadraz@bgu.ac.il)

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# Considering the alternatives: lessons from Israel's meat substitutes initiatives

Rafi Groszlik, Aviad Raz\*, Danit R. Shaha and Nir Avieli

Ben-Gurion University of the Negev, Be'er Sheva, Israel

As one of the industry leaders in the field of alternative proteins, Israel provides an interesting and important test case for examining explicit and implicit agendas in the professional and public debate regarding sustainable pathways for alternative proteins. Based on in-depth interviews with key stakeholders in the Israeli food-tech ecosystem and analysis of two recent reports (The Good Food Institute-Israel's report on the State of Protein Alternative Innovation and the Israel Innovation Authority report), we elucidate and highlight institutional, socio-cultural, socio-technological, and nutritional aspects inherent to the debate on meat substitutes. Looking at the socially constructed classification of meat substitutes in Israel, we explore the regulatory challenges and public discourses and scrutinize sustainability considerations in the context of meat substitutes. Finally, we advocate for diverse solutions to address the multifaceted issues intertwined with meat substitutes, emphasizing the need for more comprehensive research to understand the intricate interplay among distinct categories of meat alternatives.

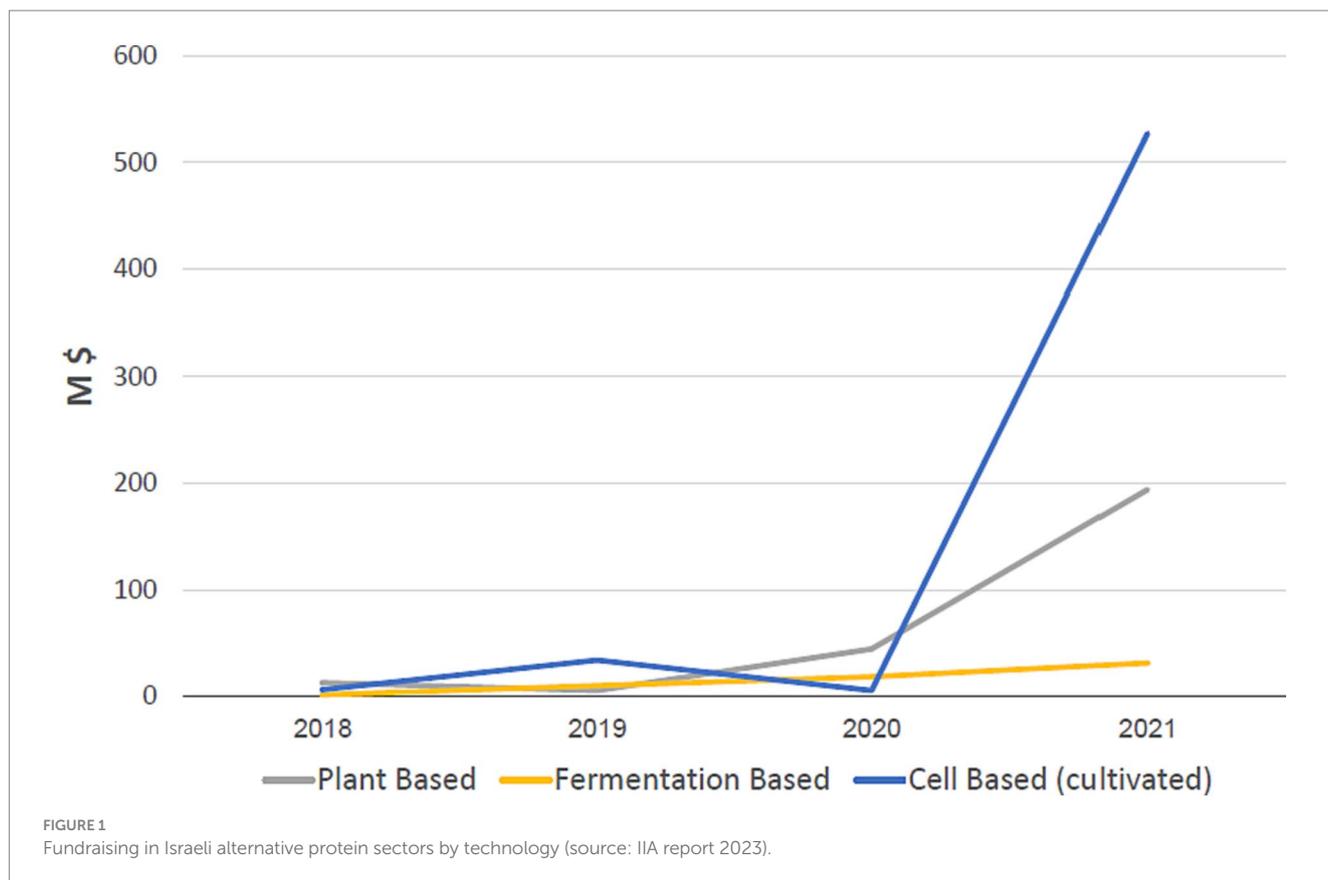
## KEYWORDS

meat substitutes, cultured meat, plant-based meat substitutes, new food acceptance, regulation, Israel

## Introduction

The emergence of substitutes for animal-based meat products has sparked a global influx of scientific research, product development, and private and public investments (Guthman et al., 2022). The burgeoning "alternative protein industry" (Abrell, 2023) and its meat substitute (MS) products can be classified into four principal categories: plant- and protein-based meat alternatives; cell-cultured meat alternatives; proteins and components originating from both animal and plant sources manufactured by microorganisms; and proteins and components derived from insects as an alternative food source (IIA, 2023; for more on cataloging and categorizing protein alternatives see: Ismail et al., 2020; Guthman and Biltekoff, 2021; Lonkila and Kaljonen, 2021; Boccardo et al., 2023). This burgeoning field has recently garnered recognition for its transformative potential, giving rise to "promissory narratives" (Sexton et al., 2019; Manning et al., 2023). This sector is witnessing a surge in attention for its potential contribution to environmental sustainability, animal welfare, and food insecurity (Smetana et al., 2015). According to Israel's Ministry of Science and Technology,<sup>1</sup> Israel's plant-based protein

1 [https://www.gov.il/en/departments/news/most\\_news20221114](https://www.gov.il/en/departments/news/most_news20221114); website contents updated on Nov. 14, 2022.



sector accounted for 22% (\$161 million) of the global investment in the field in 2022. In fermentation-derived protein, Israel ranks second (after the U.S.), with \$152 million – representing 38% of the global investment. Israel is also second after the U.S. as an investment target in cultured meat, with \$320 million, accounting for 18% of the investment worldwide. Cultured meat (animal cell-based products and plant-based growth factors products to be used in cultured meat production), the youngest runner-up in the race for alternative proteins, has by far the highest fundraising compared to the more established and more extensive sectors of alternative protein production (Figure 1).

A frontrunner in stem-cell research, tissue engineering, and microbiology, Israel is currently streaming this expertise into food-tech innovations, which are moreover supported by State-funded academia-industry consortiums, accelerators, and incubators, molded after the prosperous Israeli “start-up nation.” With more than 100 companies in all categories of alternative protein (GFI, 2023), all competing for investment and recognition, Israel provides a test case for comparing the plausibility of different meat substitutes’ (MS) socio-technological pathways (van der Weele et al., 2019). Indeed, over the past year, two comprehensive reports on the Israeli food-tech scene have been trying to do just that: The GFI (Good Food Institute)-Israel’s report on the State of Protein Alternative Innovation (GFI, 2023) and the Israel Innovation Authority report (IIA, 2023).<sup>2</sup>

Aiming to unveil explicit and implicit agendas, along with the institutional, socio-cultural, and socio-technological aspects inherent

in the pursuit of meat substitutes, as exemplified by the Israeli case, we critically analyzed reports from GFI-Israel and the Israel Innovation Authority (GFI, 2023; IIA, 2023). Additionally, we conducted 12 in-depth interviews with key Israeli food-tech policymakers, regulators, and entrepreneurs.<sup>3</sup> Subsequently, we draw lessons highlighting the blind spots and paradoxes characterizing the discussion of MSs.

We start by examining distinctive challenges and prospects inherent in the major categories of MSs, as delineated by the Good Food Institute-Israel and the Israel Innovation Authority (GFI, 2023; IIA, 2023). Next, we describe the inquiries that surface within the realm of regulatory challenges and in the public discourse concerning alternative proteins. We also scrutinize considerations surrounding sustainability and alternative proteins.

## Classification and comparison of meat substitutes

The dynamic classification of alternative proteins is key to their current prioritization and future labeling. The GFI (Good Food Institute)-Israel’s report on the State of Protein Alternative Innovation (GFI, 2023) focuses on the Israeli food-tech’s fundraising by product classification and specific companies, comparing three product

<sup>2</sup> <https://innovationisrael.org.il/view-research-publication> (in Hebrew).

<sup>3</sup> Following IRB approval, the privacy of all interviewees has been preserved, and they have provided informed consent to participate in the study.

categories: plant-based (with 53% of Israeli companies), fermentation-based (31%), and cultivated meat (16%). The Israel Innovation Authority (IIA, 2023) adds a fourth classification, protein derived from insects.

However, in intriguing contrast to its strategy, the IIA, 2023 report on alternative proteins estimates that cultivated meat has only one (!) potential advantage compared to other MS categories – its hoped-for organoleptic likeness to animal-derived meat. Unlike the other MSs, it may presumably attract carnivores – a supposition we criticize below. Yet in all other criteria, cultivated meat falls behind the other MSs, including limited scalability, higher costs and pricing, longer distribution and marketing processes, complex regulation, and potentially providing a less environmentally sustainable alternative (IIA, 2023).

The common metrics used in the report for comparing the plausibility of alternative proteins are protein conversion efficiency (PCE, the amount of protein obtained in relation to the amount of protein supplied) and life cycle assessment (LCA, assessing environmental impacts associated with all the stages of the life cycle of a product). In terms of PCE analysis, all MSs are claimed to have a considerable advantage. Chicken, the most efficient among livestock, is at 20% PCE, whereas plant-based MSs and cultured meat are over 70% (cf. Alexander et al., 2017). The production of cultured meat is also anticipated to, once optimized, require fewer agricultural resources and emit less waste (cf. Rubio et al., 2020). Favorable life cycle assessments (LCA) cited in the report have been provided by several companies for their plant-based MS products. According to the report, eutrophication potential and land use requirements for plant-based MSs are projected to be significantly lower than metrics reported for factory-farmed animal-based beef, pork, and chicken. Similarly, plant-based MSs have better greenhouse gas emissions and energy consumption metrics. Increased water consumption in plant-based MS is mainly due to the processing after the harvest of raw protein sources. Cultured meat, in contrast, has been assessed to have the (predicted) highest energy consumption of all MSs, with more greenhouse gas emissions than other MSs. Cell-based meat is also estimated to have a 47% energy feed conversion efficiency and 72% protein feed conversion efficiency, values lower than plant-based meat and insects but higher than animal-based meat (Alexander et al., 2017).<sup>4</sup>

The IIA report concludes that cell-based meat might be a plausible alternative only in relation to beef, yet the organoleptic limitations of the more sustainable plant-based and insect MSs would prohibit wide adoption and reduction of animal-based meat consumption. According to the report, the implication is that Israeli food-tech companies focusing on cell-based beef should be prioritized in principle, signifying that the IIA report accorded paramount importance to considerations encompassing taste, consumerism, and marketing, emphasizing these factors over other essential aspects. However, since Israel is not a significant beef grower, the overall environmental gain for Israel derived from IIA's recommendations is not expected to be significant.

The reports issued by the Israel Innovation Authority (IIA, 2023) and The Good Food Institute-Israel (GFI, 2023) are conspicuous for their omission of comprehensive scientific data pertaining to essential parameters critical for evaluating the viability and sustainability of meat substitute products. Notably absent from these reports are

analyses of nutrient content, bioavailability, exposure to contaminants, utilization of hormones and antibiotics, as well as the inclusion of other food additives that may be introduced during the production process. Furthermore, an examination of the economic accessibility and affordability of various meat substitute alternatives is absent from the reports.<sup>5</sup> Comprehensive nutrition data for cell-based meat would hopefully become available with the launch of initial products, scale-up, and additional demand from the scientific community.

As per fermentation-based MS—another innovative segment of MSs—the IIA report claims that micro-organismic fermentation can produce “protein powder.” However, it also claims that this product currently cannot substitute animal-based meat. The complex and intriguing socio-demography of groups and individuals who use such protein powders is not mentioned (see Table 1).

We now discuss these blind spots as reflecting central paradoxes characterizing the current discussion of MSs.

## The “natural” vs. the “cultured”

The technological process enabling to grow “meat” from cells is a dynamic development still awaiting precise labeling and classification. Indeed, there is an ongoing struggle over the definition of such products: Are they meat substitutes, the essential, “original” meat, or a completely different substance – a novel food? Although based on technologies for tissue generation developed in the pharma industries, “cultured” meat entrepreneurs propound it as the most “natural” of all MSs since it grows from the very cellular origin of meat. However, the *in-vitro* growing of cells evidently extends the natural processes beyond what nature affords. Moreover, the product is always a hybrid of plant-based protein (sometimes used as scaffolds) and of a smaller part (sometimes as small as 10%) of cultured muscle (or other) cells. Furthermore, developing immortalized cell lines for a more efficient production process highlights the contrived (which some would alarmingly associate with cancerous-like cells) technological making of cell-based meat. The challenging status of cell-based meat within our socio-cultural frameworks of classification is also highlighted in the ongoing debate in Israel regarding its (still hypothetical) kosher and halal status. According to Israel's Chief Rabbi, cultured meat is considered to be *parve* (non-dairy and non-meat), but given its appearance as meat, it should not be eaten with dairy products so that the Jewish-Israeli public does not get used to eating dairy and meat products together, which is forbidden according to Jewish law. But for other, more orthodox Rabbis, cell-based meat can be kosher only if the source animal for the original cell line has been appropriately slaughtered as required by Jewish law. Additional dilemmas of classification are expected to emerge as cell-based meat seeks halal

<sup>4</sup> For more details on the environmental impact of meat and MS technologies see: Rubio et al., 2020; Sinke and Odegard, 2021.

<sup>5</sup> Despite worldwide MS companies, including those in Israel, developing early-stage cultured meat products and providing nutritional narratives claiming equivalency with traditional ingredients, a comprehensive nutritional profile is currently lacking. For a concise summary of existing data on nutritional properties, as well as challenges, and potential solutions related to early-stage cultured meat products see: Broucke et al., 2023. For a critical discussion on the nutritional discourse surrounding alternative protein companies, see Guthman and Bittekoff (2021).

TABLE 1 Summary—different aspects of meat substitutes (MS) in Israel.

Aspect	Plant-based MS	Cultivated meat (cell-based)	Fermentation-based MS	Insect-based MS
Investment (2022)	22% (\$161 M)	18% (\$320 M)	38% (\$152 M)	Not specified
Percentage among all MS Israeli companies	53%	16%	31%	Not specified
Advantages (IIA)	Sustainability	Organoleptic likeness	Not specified	Not specified
Challenges (IIA)	High scalability	Higher costs and Pricing; technological challenges may not allow scalability	Limited scalability	Yuck factor
Time to market	Quick	Unknown, maybe slow	Quick	Quick
Regulation	Conventional	“New food,” ambiguous regulation	Conventional	Challenging in Western countries

certification for Muslim communities, as well as a ruling on whether or not observant Hindus could eat it.

The contested epistemology of “cultured meat” also challenges regulation in both local and global contexts. Regulatory routines typically stem from established labeling practices (Frohlich, 2023). However, the labeling does not yet exist in this case and must align with emerging regulatory pathways. From the local perspective, the regulatory process starts with classifying cell-based meat products under a category that the Israeli Ministry of Health (National Food Services Unit) terms as “novel food” and evaluated under the Novel Food premarket authorization process. Thus, while cultured meat companies may argue that their products are the most “natural” MS available, local regulatory processes obviously do not see them as “natural foods” but as technological and innovative products. This category of novel food,<sup>6</sup> can be viewed through a technical-procedural lens, or, to use anthropological terms, as cultural artifacts – akin to the distinction between “nature” and “culture” (Descola, 2014). In the future, the final labeling and regulation processes of cultured meat will be dynamic and depend on how it is technologically produced (Stephens et al., 2018). In addition, there is the potential for genetically modifying the cells, which would also be subject to regulation.

However, these local regulatory processes are excessively intertwined with global regulatory processes. The upstream regulatory aspects, such as cell collection, cell banks, cell growth, and differentiation, are regulated by the U.S. FDA and USDA, which oversee cell processing into food products, inspection, and labeling. Similar to the Israeli case, in the EU, cultured meat would be regulated by the Novel Food Regulation (Regulation 2015/2283 – Novel Foods).<sup>7</sup> Due to global export, local regulations must be harmonized among countries and authorities.

## The “traditional” vs. the “innovative”

While plant-based MS is considered more traditional and established, this sector (in Israel and elsewhere) also contains innovative

plant-based MS technologies such as 3-D printing and extrusion technology, which are nevertheless currently of limited scalability. Insects considered a traditional food in many east-Asian and African countries, are often perceived as an exotic novelty with a strong “yuck factor” among Westerners (Lesnik, 2018). The cell-based meat initiative attempts to straddle traditional and innovative aspects of meat, aiming to produce a new food material cultivated from pluripotent stem cells that would mimic the shape, texture, taste, and smell of traditional meat (Fischler, 1988). The reports’ analysis selectively emphasizes gastronomic neophobia to predict the low adoption of insect-based meat and protein powder, but not in relation to cell-based meat, which will supposedly cater to gastronomic neophilia (*ibid.*), and culinary curiosity while mimicking a chunk of meat. The bind of the mimetic remains cultured meat’s inherent paradox, pressing its ontological novelty into the shape of a hamburger or a steak when it so manifestly could outgrow that traditional (and Western) mold.

## The “green” vs. the “non-sustainable”

Considered less attractive than cultivated meat, plant-based MSs are presumed to be more sustainable (IIA, 2023) with safe and accessible ingredients, the “greenest” raw material, and possibly the best alternative in terms of the environment and the climate. Plant-based MS is also the most plausible in terms of the degree of social-institutional and technological changes required. The technological innovations entailed by the other MSs mostly pertain to water and energy-intensive processing and transformation of raw materials that reduce potential sustainability gains. Other studies have also found that plant-based MS, and especially pulses (that include beans, lentils, and peas), are the most plausible and desirable MS. In the Israeli case, hummus – a popular Middle Eastern dish often hailed as the “national Israeli dish,” could thus be the most sustainable MS. However, lacking a powerful supporting actor coalition, this option suffers from relative neglect while many resources are spent on technologically challenging hypotheses with a lower sustainability potential.

## The “ethical” vs. the “non-ethical”

Another important paradox inherent in cultured meat (and other MSs) is ethics. Put succinctly, if traditional meat production ought to be reduced due to various ethical concerns, then it would seem even more sensible to persuade people to embrace more familiar and

<sup>6</sup> Specifically, “novel food” pertains to food items that had not been substantially consumed by the population in Israel prior to February 19, 2006, when the inaugural Regulation on novel food in Israel was enacted.

<sup>7</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015R2283>

accessible plant-based MSs. It would be equally, or even more ethical, to endorse sustainable agriculture and the temperate consumption of traditional meat at a level conducive to good health, environmentally responsible, and enabling the ethical treatment of farmed animals. Indeed, following this line of argument, it would be unethical for investors and governments to increase funding for cellular agriculture based on its proponents' promises, while more proven approaches to improving the sustainability of food systems receive less support (Howard, 2022). Israeli cell-based meat entrepreneurs feel obliged to emphasize its ethics since surveys, both in Israel and elsewhere, show that many meat eaters think it is unsafe and unnatural, and leaders of the livestock sector denounce it as "fake meat." But which ethics should we emphasize? The recent Israeli reports highlighted here provide an interesting choice of what is considered a plausible ethical argument and what is not. The reports emphasize considerations of environmental ethics, which can be backed by seemingly empirical, though to a large extent speculative and uncertain, metrics of life-cycle assessment. Other ethical arguments—such as animal welfare, human and non-human health, as well as labor conditions, food security, or equity in nutritious food distribution – are not mentioned.

## Conclusion

Exploring the joint associations between the organizational pathways and nutritional, ethical, health, and environmental outcomes of different MSs enables an assessment of plausible transition pathways. Whereas investors tend to crown a single front-runner MS, recently targeting cultured meat for this purpose, it would perhaps be better to pursue multiple solutions simultaneously and promote various efforts to address meat-related problems to provide a range of products and offer a range of economic, socio-cultural and political possibilities to serve disparate segments of this field. Critical attempts to assess the pathways of the holy grail of alternative proteins, cultured meat, have already concluded that while it may someday be "food," currently it is part of what investors in Silicon Valley often call "the food space," an area of enterprise and investment that links high hopes regarding environmental sustainability, human health, and the welfare of animals (Wurgalt, 2020). Our analysis suggests a need to associate innovation processes in the food sector more systematically with societal and sustainability gains and less with technological novelty *per se*. National policymakers tend to measure the cost–benefit of alternative food-tech investments from the point of view of local interests. This highlights the importance of independent academic analysis for developing pathways toward sustainable food systems that can bridge local and global perspectives (Wood et al., 2023). While the classification and comparison we described have conceptualized each alternative in isolation, in reality, they are part of a complex and interacting field. For example, there are opportunities for plant-based and cell-based hybrid products, such as combining plant-based MS

with cell-cultured fat to potentially improve the sensory properties of the analog while remaining less costly than a pure cultured meat product. Another example is the use of micro-organismic fermentation of MS, which essentially combines plant- and animal-based cells. As our cross-pathway analysis suggests, whereas the most plausible MS is plant-based, actors in the Israeli food-tech eco-system (and, perhaps, elsewhere) promote a view of "meat supremacy".

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## Author contributions

RG: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – review & editing. AR: Conceptualization, Formal analysis, Funding acquisition, Investigation, Writing – original draft, Writing – review & editing. DS: Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – review & editing. NA: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – review & editing.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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