SYNTHETIC IMITATION OF FOOD: PROS & CONS

Diverging points of view

Pros as presented by the industry

The industry created several narratives around synthetic imitation of meat.

From the general point of view, the industry frames its communication exploiting the sense of urgency created by the climate crisis to position itself as part of the solution. The synthetic imitation of meat producers argue that both consumers and public institutions must bet on their products - thus, their vision for the future of food - to revert the negative impacts on the environment of agricultural systems.

The developers of lab-grown imitation meat self-brand themselves as one piece of the puzzle to solve the climate crisis, with their products claimed to be as nutrient as the original ones, yet less impactful on the environment and on animal welfare conditions. They are ambitious in their visions, with statements about "putting out of business" animal agriculture (CEO of Impossible foods, Patrick Brown) or visions of the future where "all rich countries should move to 100% synthetic beef" (Bill Gates[1]).

The following paragraphs analyze the industry's narratives around synthetic imitation of meat, reported as the industry does:

"'Lab-grown' stands to meat as renewables to fossil fuels"

Lab-grown protein producers claim to use less inputs (less water, land, energy), thus, the overall emission of greenhouse gasses is lowered (and methane ones are annulled) during the production process. It is derived that the environmental impact of synthetic imitation of meat would be lower compared to the traditional production methods.
The synthetic replacement food industry often compares itself to the renewable energy industry, hoping to attract public acceptance and investments as this one did in the past. Following their communication, synthetic imitation of food stands to the traditional meat as the renewables stand to fossil fuels. Renewable energies were -and still are- strongly supported by governments around the world due to their promises for a cleaner, resilient, more sustainable energy sourcing, and were heavily financed in their early industry development stages in the 1990's and 2000's. For the same reason, synthetic imitation of meat industry argues that massive public funding should be made in alt-meat products.
Synthetic imitation of meat industry-financed Life Cycle Assessment (CE Delf, GFI) find that if the energy used in the process were to be fully sourced from renewable origins, growing meat in labs would result more environmentally-friendly.

[1] The vision of the future of food of Bill Gates and its philanthropic organization is well explained in the report of the Institute for the Future -commissioned by the Bill & Melinda Gates Foundation -, as well as in the projects that are financed through the Breakthrough energy fund, created by the same Bill Gates

"Healthier than real meat"

The industry claims that protein grown in labs are healthier than traditional ones because cultivated in a controlled and aseptic environment, thus, free from possible contaminations and food poisoning. Moreover, it argues that no antibiotics are needed to combat possible diseases (that can spread instead amongst live animals) tackling the concerns rising antimicrobial resistance issue, nor hormones that could potentially be transferred to humans with negative consequences. Nevertheless, growth hormones are used in the production process, notably in the growing serum where cells replicate.

"Victim-free"

Strong of the fact that no animal is killed in order to produce the cells, the industry claims that its products are "victim-free". Animal welfare issues, thus, are completely avoided and position the product in a narrative of respects towards the animals, thus, avoiding ethical questioning.

"Taste is great"

Being replication of meat cells, the industry uses the narrative of taste as being unchanged compared to traditional meat.

"It is not the silver bullet"

Representatives of the lab-grown replica meat repeatedly stated that their products will not completely replace the traditional meat market. Instead, they want to position themselves as an alternative product and to be part of an omnivore diet that includes very little amounts of real natural meat. In their ecological narrative, however, the industry foresees a drastic reduction of traditional livestock agriculture due to climate reasons.

In a nutshell, the narratives used to support synthetic replacement of food argue to be sustainable in the sense that it strongly defines and separates, in an ascetic way, what is 'nature-made' and what is 'human-made', and puts these two concepts in two separates boxes that do not interact with each other.

On the contrary, the vision of the food that traditional systems imagine includes nature within it, making nature and human-made solutions all-in-one in a mutually beneficial interactive relation.

What science-based facts say today

Environmental impact

The main claim about synthetic replacement of meat production lies in its positive environmental impact compared to traditional livestock farming. However, the studies and the environmental assessments that are used mainly focus on GHG emissions, without considering the impacts on biodiversity loss, micronutrient deficiencies, hunger, land use, etc. As the report from IPES Food underlines, "the potential of lab-grown meat to cut GHG

emissions is contingent on the decarbonization of energy systems, in light of its high energy requirements; the complexity of comparing CO2-only lab systems with the combination of methane, nitrous oxide, and CO2 in livestock systems also clouds the picture". Besides, lower emissions from the lab-grown imitation of meat industry would only be possible if the energy that is used in the process is 100% sourced from renewable energies (CE Delf LCA assessment) -aside of the fact of the high land-use that renewable energies infrastructures would require to be produced-. Hocquette (2020), citing the study of Lynch et al. raises the following additional point, reasoning on the fact that "global warming will be less with cultured imitation of meat than with cattle initially, but not in the long term because CH4 [methane] does not accumulate as so long in the atmosphere unlike CO2 [carbon dioxide]. In some cases, cattle systems are characterized by a greater peak warming compared to in vitro meat. However, their warming effect will decline and will be stabilized with new emission rates of cattle systems. On the other hand, warming due to the long-lived CO2 gas from in vitro meat will persist".

Considering that studies on the environmental impact of synthetic imitation of meat are scarce and mainly based on hypothetical production processes, and that the lack of consistent data might undermine the results of available analysis (Rodriguez Escobar et al, 2021), many studies find that the environmental impacts of synthetic copycat of meat production are non-linear, and that their process' high needs of water and energy contribute to a negative Life-Cycle-Assessments (LCA). As Warner (2019) resumes: "Mattick et al (2015) compared beef, pork, poultry and cellular meat production […] and their modelling showed that **the predicted global warming potential of cellular meat production was approximately equivalent to […], or higher than […] that of pork and poultry production**. […] **The predicted energy usage of cellular meat production was four times higher than that of pork and poultry and beef production**". Those findings are supported by the analysis made by Lynch and Pierrehumbert (2019) concluding that "**replacing cattle systems with cultured meat production before energy generation is sufficiently decarbonized could risk a long-term, negative climate impact**". As resumed by Warner (2019), "the environmental impact of cell-based meat may be comparable, or even worse, than traditional forms of animal-based production systems, especially if compared to pork and poultry" (figure 1). However, the same study from Mattick et al (2015), as well as Tuomisto (2019) find that for land use and greenhouse gas emissions, lab-grown replica meat offers better trade-offs. Tuomisto (2019) raises an interesting point, when **commenting on the use of the released land from livestock production: in fact, the researcher writes, if pasturelands were to be converted into arable land, "the net impacts on climate change might […] be negative**".

	Chicken	Dairy	Cellular-based meat	Insect-based	Gluten-based	Soya-based	Myco-protein-based
(a) Resources used							
Electricity (MJ)	49.78	12.27	103.5	10.762	8.94	10.002	21.32
Tap water (kg)	16.3	4.2	420	1.34	0.954	0.73	40
Transport (km)	850	360	110	128.5	141.1	2791	215.45
(b) GHGEs and non-renewable energy							
GHG, kg CO_2 eq./kg (FU)[12]	5.2–5.82	4.38–4.95	23.9–24.64	2.83–3.02	3.59–4.03	2.65–2.78	5.55–6.15
Range in values for other references (no. of references)	1.3–5.5 (*n*=7)	3.8–6.2 (*n*=1)	1.8–10 (*n*=2)	2.7–20 (*n*=2)	1.55 (*n*=2)	0.34–3.72 (*n*=2)	2.4–2.6 (*n*=1)
Non-renewable energy use, MJ/kg (FU[1])	51.64–63.4	48.79–59.1	290.7–373	32.0–40.4	39.7–49.2	27.78–36.9	60.07–76.8
Range in values for other references	1.3–54	55.5	25.2–31 700	34–170	1.4–2500	1.5–3000	38

Figure 1: Resources used for meat production by category. Source: Smetana (2015)

Uncertain nutritional value

Despite the synthetic imitation of meat industry claims about their product's similarity to meat in all its compounds, the nutritional aspect of meat that is grown in a lab is still uncertain. According to studies (reviewed in Warner, 2019), it might lack some of the micronutrients and biocomponents that characterize the nutritional outlook of meat (such as vitamin B12 and iron). The works of Chriki, Hocquette (2020) and Fraeye, Kratka, Vandenbourgh, Thorrez (2020), underline that "it is also uncertain whether the biological compounds in lab-grown meat will have the same positive and synergistic effects as conventional meat products on human health. Uptake of micronutrients by lab-grown cells has yet to be fully understood. Chemicals additives may be required to ensure that lab-grown meat contains comparable nutritional value to its conventional counterpart". Warner (2019) admits that "skeletal muscle cells can make many bio-available proteins, fatty acids, growth factors and cytokines", but "vitamin b12 is not produced by muscle cells in culture", besides, synthetic imitation of meat "does not have high levels of iron", nor many of the healthy n-3 fatty acids and poly unsaturated fatty acids, which are normally generated by the animal diet.

Monopoly risk

Development of synthetic imitation of meat production runs the risk to create a monopoly of the proteins. Considering that the development of replica food products grown in a lab is protected by intellectual property and patents, only few would have the legal right to produce meat, rising ethical questions and putting at risk the stability of meat production by patenting a whole category of food, rather than the process.

"Victim-free" doubts

Melzener et al (2020); Stephens et al (2018); Bhat et al. (2019) all expose the fact that the current technology used to grow cells in laboratory still requires the killing of animals, notably the fetus of bovines, in order to extract its medium: "about 50 L of bovine serum is required to make one burger, and this serum requires blood from 91 to 333 foetuses" (Warner, 2019), a collection that has to be done on pregnant cows, causing the death of the fetus.
Despite the announced funding that the industry is dedicating to find alternative (plant-based) solutions due to ethical and economic reasons (the cost of bovine fetal serum represents around 95% of production costs), no actual alternative has been developed at the time of writing. In the survey of Hocquette et al (2015), only around a third of the respondents thought that synthetic imitation of meat will "significantly contribute to reduce the animal welfare problem".

Risk if loss of biodiversity

The underlying concept of lab-grown imitation meat is the replication of few cells belonging to a single animal in an ideally infinite number of times. This process aims at stabilizing the genetic pool from which the animal's cells are replicated, stopping, by consequences, the natural evolution of the specie and the consequent creations of different breeds of livestock that we know nowadays. Tuomisto argues that "a complete elimination of all livestock production is not reasonable from the perspective of biodiversity conservation", considering that "livestock production, especially extensive cattle grazing, maintains various habitats and species", and that "in some areas, extensively grazed livestock […] provides landscape benefits by keeping highlands clear from being forested". In the long-term, the biodiversity of livestock breeds would be reduced and stopped, sourcing meat samples from 'immortal' cell-lines kept in genetic libraries.

Health risk

Several authors -Warner, 2019; Chriki & Hocquette, 2020- argue that the process of infinite and fast replication of cells allows for the occurrence of cancer cells, thus, requiring a new source of cells from animals every often time: "the high rate of proliferation required of stem cells will likely produce genetic instability which may result in sporadic cancerous cells". Similar concerns have been outlined in the work of Soice et al (2021) as well as by Ketelings et al (2021) in terms of "unintentional, possible harmful genetic alteration" that "can happen in any starting cell line" (Ketelings), and that "immortal cultured meat cell line may contain expressed oncogenesis" (Socie).

Moreover, the procedure of growing cells for human consumption uses high amounts of **hormones** during its proliferation and growth phase. The EU directive of 1981 (81/602), then confirmed by directive 2003/74, and reaffirmed in 2007 by the European Food Safety Authority (EFSA), does not allow the use of hormones in the meat production process, considering it a dangerous practice for human safety. In fact, the legal context is based on the fact that their usage can induce to hormonal unbalances as well as increase the risk of developing cancer in humans.

Furthermore, Toniyama et al (2020) argue that, if the bioreactors in which cells are supposed to grow are completely sterile, the risk of contamination by bacteria, viruses, or fungi should not be excluded (supported by Ong et al, 2021). Thus, synthetic imitation of meat producers

may have to use **antibiotics** to reduce this risk when producing at larger scale (Hocquette[2], Ong et al, 2021) persisting on the issue of antibiotic resistance.

It is an ultra-processed food

Undoubtedly, synthetic imitation of meat can be considered an ultra-process food (UPF). It is energy-intensive, requires many steps and different techniques to be produced resulting from a highly industrialized production process. Their potential use for human consumption is foreseen as ingredients of ultra-processed food or ultra-processed composite products trying to look like natural ones (for instance red meat steaks). The consequences on the environment have already been described .UPF are detrimental to human health too, and have been identified as accelerators of non-communicable disease such as some types of cancer, diabetes, hypertension, metabolic syndrome etc. (Moubarac et al 2012; NutriNet Sante, 2019; Pti et al. 2017; Steele et al. 2013).

Detachment from nature

The vision that synthetic imitation of food encloses is a vision of sustainability that opposes a nature-based conception of sustainability. In fact, it reduces biodiversity (one stem cell is replicated an infinite number of times, under controlled conditions, not allowing for the genetic pool of the species to mix and allow to evolve and adapt); it pushes nature away from humans; it detaches humans from traditional food replacing natural solutions with chemical ones. All in all, **it supposes a vision of society where food is a corollary, and not the pivotal building stone, of culture and traditions**. A concept explained by Wilson in his article of "eat[ing] in the modern world is often to eat in a state of profound sensory disconnect".

[2] Viande cultivée en labo : une fausse bonne solution ? (01/05/2020). Sciences et Avenir. https://www.sciencesetavenir.fr/nutrition/aliments/viande-cultivee-en-laboratoire-une-fausse-bonne-solution_143825