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Pseudo-food made in a Petri dish

Why artificial products grown in a lab are not a solution to the food and climate crisis

I. A system teetering on the edge

The industrialisation of Western food systems in the 1950s and 1960s was not only a blessing for the rapid growth of food security, availability and storage , but in the long run also a curse for biodiversity on agricultural land and the diversity on our plates. The rising demand for pesticides and mineral fertilisers to increase production turned out not to be the right path. The loss of biodiversity[1] , the impoverishment and erosion of soils[2] , the climate crisis and the concentration of world trade in the hands of a few food corporations amply illustrate this point. Furthermore, in the case of industrial agricultural production, the finite nature of resources and financing are important factors to consider: the production of pesticides and artificial fertilisers requires a very high energy input. At the same time, pesticides lead to a decline in the insect population and poison vital resources like water, soil and air.[3] In organic farming, on the other hand, organic manure from the farm is used as fertiliser, which can supply the plants with nutrients evenly as well as over the long term, while synthetic chemical pesticides are not used at all.

Yet, ecosystems are not the only victims of these developments: we are, too.. The sharp increase in civilisational diseases - such as diabetes, high blood pressure and cardiovascular problems - is directly linked to the degree of industrial processing of the food we eat.[4] Fresh and natural diversity hardly ever makes it onto the plates of industrialised nations. Instead, 30 plant species provide 90 percent of the calories in our diets[5] and ten large corporations

[1] https://www.boell.de/de/2021/10/06/oekosysteme-artenvielfalt-und-genetische-diversitaet-die-vielfalt-der-natur-schuetzen
[2] http://www.martin-haeusling.eu/images/Bodenstudie_BESTE_Web.pdf
[3] https://www.sarah-wiener.eu/pestizidmythen/
[4] https://www.cambridge.org/core/journals/public-health-nutrition/article/un-decade-of-nutrition-the-nova-food-classification-and-the-trouble-with-ultraprocessing/2A9776922A28F8F757BDA32C3266AC2A
[5] Best, "Proposal for Biodiversity Indicators for Agriculture" (2008), available online https://www.gesunde-erde.net/media/beste_indikatoren-zur-erhaltung-der-biologischen-vielfalt.pdf

provide most of the food on supermarket shelves.[6] At the same time, we are consuming more and more calories. Too much fat, salt and sugar - together with lack of exercise and stress - are responsible for numerous chronic inflammatory diseases. The enormous consumption of sausages and meat is a particular problem: In Austria, this amounted to 60.5 kilograms per year and per capita in 2020[7] . In Germany, it was 57 kilograms. [8] This has significant repercussions for our health. According to a Swiss study from 2018, excessive meat consumption causes 285 billion Euros in additional costs for health systems worldwide.[9] Furthermore, animal welfare and husbandry as well as the environment suffer due to our immense appetite for meat.

In order to produce as cheaply as possible, we rely on very one-sided breeding practices that cause a radical shrinking of the gene pool among farmed animals and promote husbandry systems that are anything but appropriate for the natural needs of animals. In short: we knowingly accept animal suffering. We overbreed the few breeds we still farm so that they produce more meat, milk or eggs, even if this drastically shortens their lifespan. Thus, we accept the occurrence of deformationsand diseases, depriving animals from birth of any possibility to live a healthy life in line with their natural needs. Medicines, including antibiotics, are often propagated as the solution to this problem, but in fact, they only cause the next life-threatening epidemic: multi-resistant germs.

The provision of feed in agro-industrial animal husbandry systems is similarly disastrous and fraught with social injustice: two thirds of the grain in the EU ends up in the feed troughs of industrial animal farming.[10] For this, we import an enormous amount of raw materials from abroad, which in turn leads to the deforestation of hectares of high-biodiversity rainforest. We are damaging the lungs of the Earth to satisfy our hunger for meat. Yet, this is only one of the many consequences for the environment: Polluted groundwater, soil erosion and climate-damaging greenhouse gas emissions can be directly attributed to industrial animal husbandry. No wonder that our current food system is no longer sustainable for the environment, farm animals, the climate, and for our own health.

For all these problems caused by the agro-industry, this very same industry now claims to have found the solution: Edible artificial products, so-called surrogates, which are created as cheap substitutes for complex foods. An example of this are cheese analogues. When the first of these products came out many years ago, we vocally opposed them.[11] Now these heavily processed products - and particularly meat produced in a laboratory - are supposed to herald a new era for nutrition and, at the same time, solve the problems of this world. **I would like to demonstrate in this paper why that is a fatal misconception and a dangerous hope.**

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[6] https://www.focus.de/finanzen/news/unternehmen/nestle-danone-unilever-diese-zehn-mega-konzerne-kontrollieren-fast-alles-was-wir-essen_id_3974394.html

[7] https://www.wwf.at/nachhaltig-leben/fleisch/

[8] https://de. statista. com/statistics/data/study/36573/survey/per-capita-consumption-of-meat-in-germany-since-2000/

[9] https://journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0204139

[10] https://ec.europa.eu/info/food-farming-fisheries/plants-and-plant-products/plant-products/cereals_de

[11] https://www.zeit.de/zett/2016-06/der-analogkaese-ist-zurueck-als-kaese-ersatz-fuer-veganerinnen or: https://www.agrarheute.com/land-leben/bruessel-verbietet-analogkaese-479811

II. Market and Power

The first meat burger grown in a European laboratory was presented in 2013. The Dutch company MosaMeat led this project[12]. It predicts a great future for artificially grown meat substitutes: according to MosaMeat, by 2030 around ten percent of the current global meat production will be provided by lab-grown meat. In 2022, the company also wants to be the first to bring lab-grown meat to the market in Europe, but before that, it has to undergo a strict approval process.

MosaMeat presented the first lab-grown meat burger from European production. On its website, the company presents itself as climate-friendly.

In the European Union, lab-grown meat falls under the Novel Food Regulation (EU) 2015/2283.[13] All products must therefore be reviewed by EFSA, the European Food Safety Authority, before they reach supermarket shelves. It can take months for EFSA to issue a scientific opinion on a product. The legal framework in the EU is much more restrictive than in the USA or even in Asia. In Singapore, for example, artificial chicken nuggets were already approved for sale at the end of 2020.[14]

It comes as no surprise that the industry is developing even more rapidly globally: More and more meat-processing corporations are striving to gain power over the lab meat market. For example, the German poultry breeder and processor PHW Group, North America's largest meat producer Tyson, the agricultural group Cargill, Nestlé, and the Brazilian meat processor JBS (José Batista Sobrinho Sociedade Anônima)[15] are fighting for supremacy on the market. That these companies in particular are interested in in-vitro products is hardly surprising. The monopolists are increasingly facing headwinds. JBS, for example, was criticised only last autumn. The company was accused of working with suppliers that clear rainforest area to raise cattle. In this way, the company indirectly threatens the territories of Brazilian indigenous peoples.[16] Several large supermarket chains, such as Lidl, reacted to this and removed Brazilian meat products from their shelves.[17] Substitute products from the laboratory now offer large corporations like JBS an easy way to show themselves in a positive light and distract from the real flaws in the system. In 2021, for example, JBS founded a new research centre for laboratory meat in Brazil and acquired the Spanish laboratory meat company BioTech Foods.

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[12] https://mosameat.com/the-mission

[13] https://eur-lex. europa. eu/legal-content/EN/TXT/?uri=CELEX%3A02015R2283-20210327

[14] https://www.theguardian.com/food/2021/jun/16/eat-just-no-kill-meat-chicken-josh-tetrick

[15] https://www.agrarheute.com/management/agribusiness/wiesenhof-investiert-labor-fleisch-541553
https://www.topagrar.com/schwein/news/jbs-uebernimmt-laborfleischhersteller-bio-tech-foods-12756953.html
https://www.welt.de/wirtschaft/article230832431/Clean-Meat-Jetzt-beginnt-die-echte-Fleischlos-Aera.html
https://www.handelsblatt.com/unternehmen/mittelstand/familienunternehmer/groessten-familienunternehmen-der-welt-investitionen-in-laborfleisch/24864764-2.html?ticket=ST-11318371-GZrCBG3FKOBNoBbButyx-ap2
https://www.foodaktuell.ch/2021/07/13/nestle-forscht-an-laborfleisch/
https://agfundernews.com/memphis-meats-raises-17m-series-cargill-gates-branson-musk

[16] https://reporterbrasil.org.br/2021/12/exportacoes-de-carne-conectam-desmatamento-no-brasil-a-grandes-varejistas-globais/

[17] https://www.infosperber.ch/umwelt/vielfalt-tiere-pflanzen/mehrere-haendler-verzichten-auf-brasilianisches-rindfleisch/

Other well-known players in the agro-industry are also trying to clear their names using laboratory products. Patenting of production processes by a few, large companies (Tyson, Hormel and Cargill) is underway and market concentration is foreseeable. **It is therefore crucial to limit private patents on lab-grown meat now and prevent a few, small companies from capturing the market.**

III. Production: culture media and bioreactors

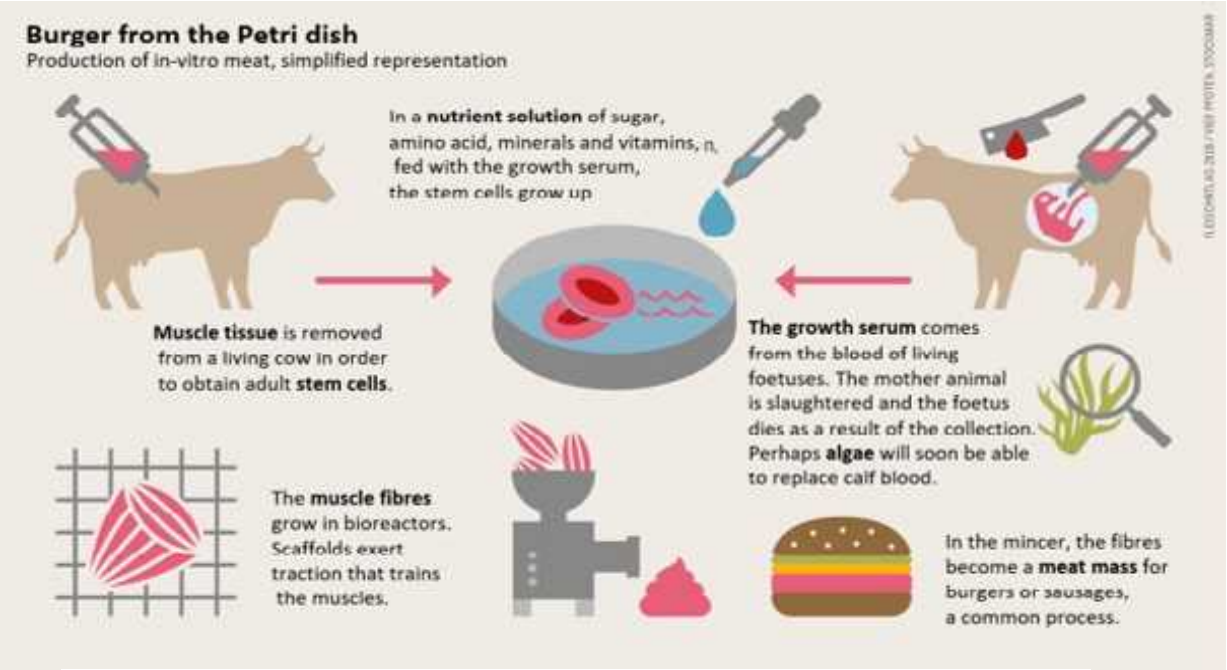
There are two methods for creating artificial products -and above all meat- in the laboratory. The first is the use of genetically modified algae to imitate blood. The result is "The Impossible Burger", which contains no meat, but can still bleed. A second possibility is the growing of artificial muscle cells in the laboratory. For this, muscle tissue containing stem cells is cut out of a living animal. These stem cells form the basis of the meat substitute. In order to be able to multiply, they need two things: a cell culture medium and a bioreactor.

The cell culture medium: Fetal bovine serum (FBS) is usually used for this. This is the blood of an unborn calf taken from a pregnant cow during slaughter. The foetus dies in the process. This is not exactly free of animal suffering. That's why manufacturers are already trying to replace fetal bovine serum with non-animal alternatives: A study published in January 2022, which was commissioned by MosaMeat, shows that the differentiation and growth of muscle cells can also function without FBS and genetic modifications. The basis here is a purely chemically defined medium.[18] The company has already applied for a patent on the process.

The bioreactor: This is a container that can provide optimal environmental conditions for the growing cells. For instance, the oxygen content and temperature are precisely controlled in order to be able to produce artificial meat. So far, such bioreactors have only been used sporadically in clinical trials and are not designed for mass production.[19] However, it is already clear that these bioreactors are not exactly climate-friendly. Apart from the enormous resources that their construction would consume on a large scale, the greenhouse gas footprint of bioreactors is also not convincing (see next chapter).

[18] https://www. nature. com/articles/s43016-021-00419-1

[19] https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2020-06-25_trendanalyse_fleisch-der-zukunft_web_bf.pdf



Muscle mass from live animals and blood from unborn calves: What sounds like the ingredient list for a rather questionable magic potion also ends up producing an in vitro burger
/ Graphic: Bartz/Stockmar, CC BY 4.0

IV. Ecological footprint

It is often said that the production of laboratory meat is more climate-friendly than current animal husbandry. The products from the petri dish are presumed to emit fewer greenhouse gases, but also use less water and land than conventional animal husbandry. This is questionable for two reasons: On the one hand, this has not been scientifically proven in a consistent manner.[20] On the other hand, this consideration is incomplete. Apart from industrial factory farming, there are other animal husbandry systems that are much better - and arguably even necessary - for protecting the climate and biodiversity. To put it bluntly: the cow is not in itself a climate killer. If animals are farmed in sustainable, species-appropriate pasture grazing systems, they can fulfil important functions in our ecosystem.

[20]https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2020-06-25_trendanalyse_fleisch-der-zukunft_web_bf.pdf

For example, the grassland on which animals graze stores about 34 percent of the world's organic carbon available on land[21]. We need ruminants to protect this valuable cultural landscape. Why? Grazing triggers growth impulses in the grass. In addition, the animals' dung can promote the build-up of humus and contribute to healthy soil life in sustainable pasture management. Even insects benefit from sustainable pasture management.[22] For instance, a long-term experiment at the University of Göttingen found that grazing cattle significantly shape the biodiversity of grassland: "Grazing animals create certain patterns of vegetation structure that shape the habitat of many insect species such as grasshoppers and butterflies".[23] Animal husbandry - especially the organic variant - thus creates important ecosystem services as well as added value for biodiversity and species diversity. It closes natural cycles and cannot simply be replaced by manipulated cells from the laboratory.

Sustainable pasture management not only contributes to humus build-up, but also protects our most important carbon store: grassland.

Apart from this, recent studies conclude that the climate-relevant emissions from the production of laboratory meat are not lower than those from conventional animal husbandry. According to a study by Mattick et al. from 2015, each 100 grams of in vitro meat results in a CO_2 footprint of 0.75 kg. This is significantly higher than 100 grams of pork (0.41 kg) or chicken (0.23 kg).[24] A report by the German Federal Environment Agency also concluded that the energy consumption for the production of artificial beef is 35 percent higher than that of conventionally produced meat.[25] **Although studies on other farming systems are still lacking, this already casts serious doubts on claims that products from the Petri dish will be the salvation for the climate crisis.**

V. Taste and Culinary art

As a chef, food is much more than an annoying necessity to me: food is identity, culture and social glue. What ends up on our plates also connects us to our environment. At least that's how it's supposed to be. Yet, the increasing processing of our foods also has a negative impact on taste and culinary experience. Convenience food is often not only too greasy and overladen with sugar; it is also full of artificial flavours that are supposed to imitate a variety of taste experiences. 170,000 tonnes of flavouring are used in our food in the European Union every

[21] White, R.P., Murray, S., Rohweder, M., (2000): Pilot analysis of global ecosystems - Grassland ecosystems. World Resources Institute, Washington D.C

[22] Neely, C., Bunning, S., & Wilkes, A. (2009). *Review of evidence on drylands pastoral systems and climate change*. Rome: FAO.
https://www.martin-haeusling.eu/images/Klimaschutz_kleiner_RZ_copi.pdf

[23] https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2664.12244

[24] https://pubs.acs.org/doi/pdf/10.1021/acs.est.5b01614

[25]https://www.topagrar.com/magazin/epaper/3/9/3/1/0/3/4/index.html#/html5/d42e6222ad/dR395isvikSCu/article/ad4ba8142f8049b9916a9492770595c2

year.[26] Thus, our food is becoming an increasingly uniform mash: of the 10,000 flavouring substances that have been identified in nature so far, only 2,500 are used for the artificial production of flavours.[27]

This impoverishment of our taste buds reaches its peak with products grown in the laboratory. In-vitro products cannot be put on a par with diversity: for instance, an egg substitute by the start-up "Eat Just" consists mainly of mung beans. These are supposed to allow the creation of authentic egg dishes - without fuelling climate change[28]. However, the fake eggs are nothing more than yellow sauce without a shell that you can pour from a bottle. The artificial chicken nuggets produced by the same start-up are a similarly poor imitation:, cultured cells from the lab have been brought into shape with the help of vegetable proteins, meat glue and fat.[29] In fact, this merely mimics waste from the meat industry. It is very different from real meat with its complex structure of fibres and muscles, where the whole is more than the sum of its parts. Clearly, the matrix of a natural food is not comparable with -laboratory-produced - individual parts. **Nature cannot be copied as easily as we are led to believe.**

Egg yolks from the bottle? The artificial substitutes are mostly just a cheap copy of nature.

VI. Health

The understanding that in vitro products are, at best, a poor copy is crucial when it comes to assessing the effects on health. Our diet has a direct impact on our diverse gut microbiome: these bacteria need to be well nourished in order for their excretions to help make our entire immune system resilient and. They not only utilise ingested nutrients, but also act as our "in-house pharmacy" by producing vitamins. In addition, the gut microbiome is related to our hormone balance and has an anti-inflammatory effect. A high diversity of microorganisms is crucial for human health.

If, on the other hand, the microbiome is impoverished, it has a negative impact on our overall health and is directly related to the chronic diseases mentioned above. These include inflammatory bowel diseases or type 2 diabetes, as well as obesity or problems with the cardiovascular system.[30] In our latitudes, such diseases are increasing rapidly. On average, Europeans have a significantly poorer microbiome than indigenous peoples.[31] There are several reasons for this, two of which I would like to illustrate in more detail:

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[26] https://taz.de/Kuenstliche-Aromen-in-Lebensmitteln/!5167704/
[27] https://www.topagrar.com/landleben/land-und-leute/aromen-die-welt-des-geschmacks-9486442.html
[28] More about the artificial eggs: https://www.ju.st/
[29] https://goodmeat.co/proof/first-table
[30] More information on the microbiome and its role: https://www.sarah-wiener.eu/unser-mikrobiom/
[31] Cone (2016). The rulers of the world: How microbes determine our lives. Dumont.

The Western diet and convenience food: The increasing degree of processing of (convenience) food has a negative impact on our microbiome. Therefore, the precautionary principle should always apply when using artificial preservatives and additives, so that the naturalness of our food does not disappear (for more information, see my position paper on the degree of processing of food[32]).

In the case of lab-grown meat, however, it is still completely unclear to what degree the finished products will be processed and what preservatives and additives will be used in the production process. It is also not known to what extent laboratory-grown meat can absorb the micronutrients that are necessary for human health. This applies in particular to vitamin B12 and iron.[33] The fact that previous meat substitutes were sometimes less healthy than the originals is an additional reason for scepticism: mineral oil, controversial additives and too much salt have been discovered in substitutes for e.g. sausages. Why should lab-grown meat be any different?[34]

High use of antibiotics: The fact that antibiotics are prescribed too easily and frequently in our parts of the world causes problems for the microbiome, which is made up of bacteria. Sterile products from laboratories could cause additional problems: Due to their lack of a natural microbiome, they probably not only provide little nourishment for our microbiome, as described above, but are also much more susceptible to germ contamination. This may lead to antibiotics being used in the production of lab-grown meat. Even though some companies already profess not to go to market with products containing antibiotic residues, there are hardly any guarantees for this.

The increasingly artificial nature of food has not done us any good. Whether in vitro products produced in sterile conditions can meet the complex requirements of our microbiome and our bodies remains questionable. Artificial modifications cannot change this: The first researchers are already dreaming of target-group-specific meat. Artificial burger patties that are exclusively enriched with folic acid for pregnant women and steaks that are bursting with vitamin D.[35] Artificial enrichment is supposed to make meat from the lab healthier. The fact that there is a danger of overdosing, for example on artificial vitamins, is not even considered. Nor is it ever mentioned that none of this would even be necessary if we relied on natural products.[36]

[32]https://www.sarah-wiener.eu/wp-content/uploads/2021/06/Positionspapier_Lebensmittelkennzeichnung_SarahWiener.pdf
[33] https://www.frontiersin.org/articles/10.3389/fnut.2020.00007/full
[34] https://www.geo.de/wissen/ernaehrung/vegane-ersatzprodukte-nicht-gesuender-als-ihr-original-31726744.html
[35] https://www.3sat.de/wissen/nano/220127-laborfleisch-nano-100.html
[36] https://www.foodwatch.org/de/aktuelle-nachrichten/2016/studie-mit-vitaminen-beworbene-lebensmittel-sind-ungesund/

VII. Conclusion

To conclude, I would like to emphasise that meat from the laboratory will not improve the life of a single animal. On the contrary; the growing of artificial products further removes humans from nature, the consequences of which are hardly foreseeable. In addition to an impoverishment of taste and the loss of sovereignty over our bodies, we would also be giving up an entire profession when turning to mass production of laboratory meat. Farmers would become laboratory workers who grow meat in resource-devouring bioreactors.

The solution to the problems in our food system is obvious: more colourful, vegetarian diversity on our plates from the soil, forest and field. We need land-based animal husbandry that is less harmful to the climate and return to the consumption and utilisation of the whole animal instead of just "prime" cuts. We must bring forward alternative, sustainable forms of cultivation from organic farming to permaculture and sustainable agroecological and agroforestry systems. Such diverse, robust agricultural networks prevent future crises and keep nature healthy. Why shouldn't we use this for the good of all?

Artificial foods, on the other hand, can only play a marginal role in this scenario. If we were to opt for a partial substitution by in vitro products, we must consider a whole plethora of factors:

- Artificial products must be produced sustainably and without genetic engineering (see Impossible Burger) - this also applies to the additives that are used.
- A uniform, EU-wide ban on FBS (fetal bovine serum) as a component of the culture media for cell cultures is essential.
- There needs to be more transparency about how lab meat and other artificial products are produced. In addition, independent, scientific investigations into the food safety of lab-grown meat are indispensable. Educational campaigns and mandatory origin and nutrition labelling are hugely important to give consumers transparency and help them make healthy food choices.
- Private patents on lab-grown meat must be restricted to facilitate access to this technology and prevent a few large companies from capturing the market.
- Cultural landscapes must be included and taken into account. Small-scale, sustainable agriculture must not suffer because of thisnew technology.
- Only renewable energies may be used for the production process.
- Planned bioreactors must be comprehensively assessed against pre-defined sustainability standards to ensure a sustainable, site-appropriate use of resources