Comparing the potential of meat alternatives for a more sustainable food system

Tom Bry-Chevalier - 30/08/2023

Global food system emissions could preclude achieving the 1.5° and 2°C climate change targets

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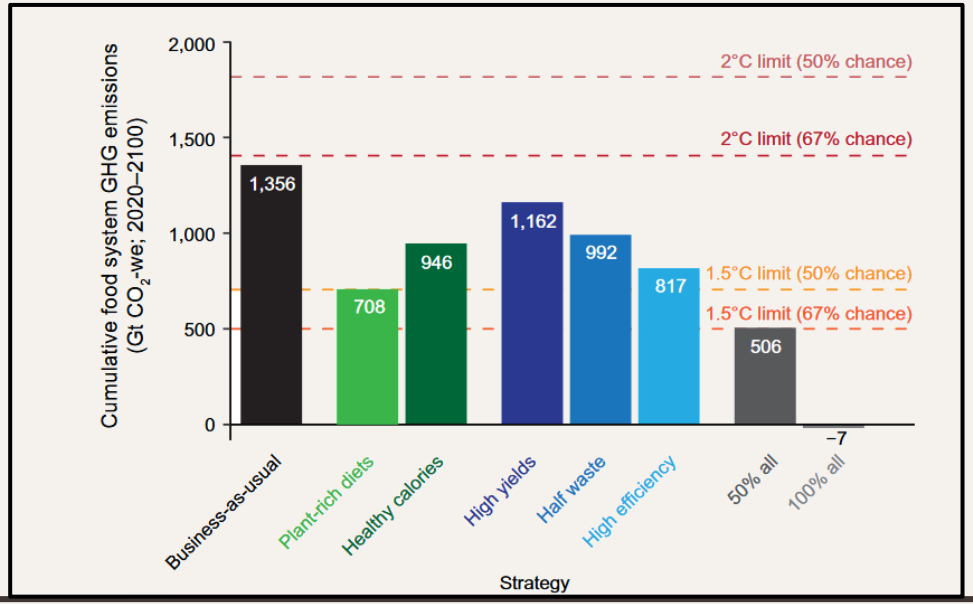
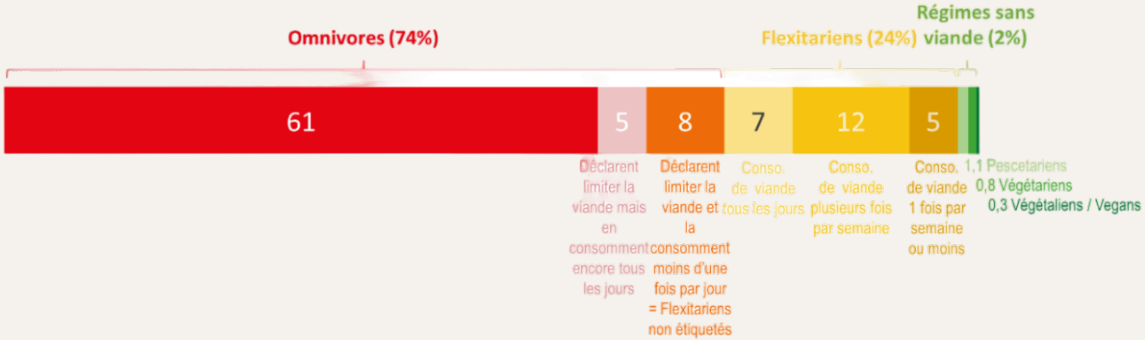
Even though, animal-derived products supply only **18% of global food and around 37% of proteins** (Poore and Nemecek, 2018), animal agriculture occupies **77% of all agricultural lands**, **30% of all water resources, and 12-20 % of human-induced GHGE** (*González et al., 2020; Xu et al., 2021*).



Changing dietary habits is difficult



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Pushing consumers to eat less meat is a key element in limiting global warming and other environmental impacts. However, policymakers are reluctant to implement coercive measures because they are often less accepted by the public (*Espinosa and Nassar, 2021*).

Carbon taxes often face very low levels of public support (*Millot and Muller, 2020*) and officials are reluctant to implement plant-based options in canteens.

Could alternative proteins come to our rescue?

A long history shaken by recent transformations

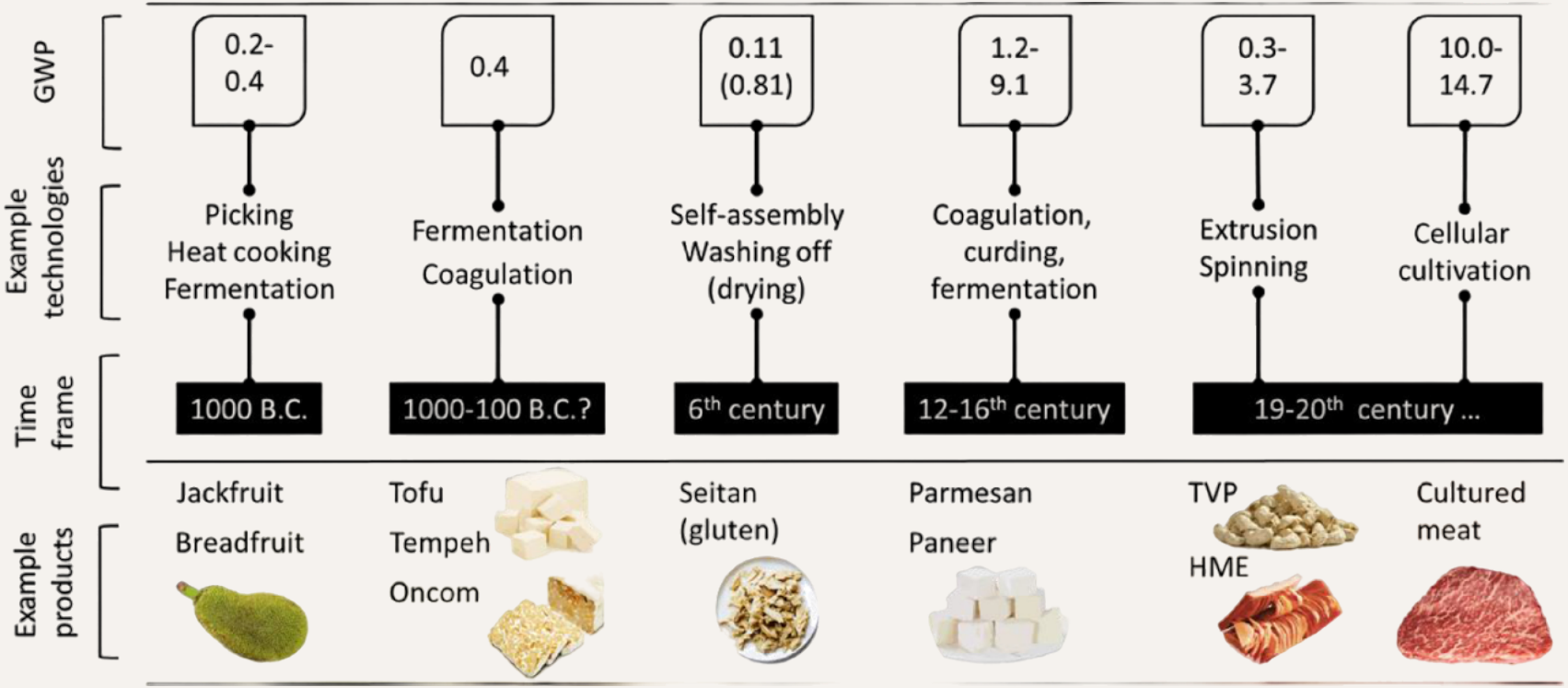


Figure from *Smetana et al., 2023*

Fragmented data and rare comparisons

Potential of alternative proteins is often measured on only one dimension
→ There is Need for multi-dimensional approach to really appreciate the potential of meat alternatives.

Soylent Green : probably good environmental impact but low acceptability and hard to scale
→ low chance of replacing a significant part of meat consumption

Alternative proteins are rarely compared with each other. Although some alternative proteins may be complementary they may also compete with each other for funding during the R&D phase or purchases in shops. For example Slade (2018) finds that preferences for plant-based burgers and cultivated meat are broadly, though not perfectly, correlated.

Plant-based substitutes

Plant-based meat substitutes have on average 50% lower environmental impact than meat (*Smetana et al., 2023*)
→ Processed plant-based meat substitutes have on average 1.6-7 times higher environmental impact than less processed plant protein sources (*Santo 2020*).

As with greenhouse gas emissions, land use is generally lower for plant-based meats than for their meat counterparts. (*Saerens 2020; Seves 2017; Van 2022*).

Scaling up has been demonstrated on many types of products, but strong investments are still needed to capture a significant share of the meat market (*GFI 2022*).

29–51% of Europeans reported that they were very or extremely likely to try plant-based meat substitutes if they become widely available, tasty and affordable (*Proveg 2021*).

Cultivated meat

Very few LCA are available and none of them use data from an industrial production process. The conclusions that can be drawn are therefore fragile.

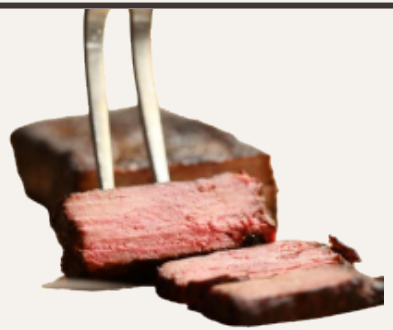
Although early studies were very optimistic about the environmental impact of CM, more recent studies nuance these results. The energy mix used is a major determinant (*Sinke 2023*).

Cultivated meat capturing 0.4 % 2030 meat market share would require ~22x current global bioreactor capacity of the current global pharmaceutical industry (*McKinsey 2021*).

Even in the most optimistic scenarii, production cost is still quite high ~~$17-35 (*Negulescu 2023*)

55 % of the respondents from 6 Europeans countries reported that they were likely to try CM if everything was the same as conventional meat (*Eurogroup for Animals 2022*).

Fermentation-based proteins



Very broad category including products and technologies with different levels of maturity. Very few studies available at this time overall.

The GWP of mycoprotein products have been determined to be in the range or lower than that of chicken and pork. Energy, land and water used are significantly lower (*Smetana et al 2018*).

“Power-to-food” products can reach lower land occupation, eutrophication, and blue-water consumption impacts compared with soybean production (*Sillman 2020*).

Little data is available on the investments required for large-scale production, but mycoprotein products have already been commercialized for 30 years.

There are still very few studies on the acceptability of mycoproteins, however it is reasonable to believe that it would be close to that of the plant substitutes to which they are close.

Insect-based proteins

While earlier studies find excellent environmental performance, more recent work tend to find results similar than that of chicken on GWP (*Vauterin et al 2021*).

However, these results could be contingent on several factors, most notably the type of resources used to feed the reared insects (*Smetana et al. 2016; Bosch et al. 2019*).

Most studies finding good environmental performance generally assume the use of organic waste but it's an ambitious assumption (competition for use, legal and sanitary barriers, etc.)

Most studies that explore the feasibility of insect farming study insects fed a commercial diet, which is not competitive nor sustainable at a large scale according to Thevenot et al. (*2018)*

The acceptability of eating insects remains relatively low, with generally only 1/4 of the participants expressing interest and up to 60% expressing disgust and refusal to try.

Provisional conclusion

Plant-based meats and proteins produced by fermentation appear as the most promising.

Cultivated meat may be an interesting addition if it appeals to a different category of consumers, but it cannot be considered a solution for the immediate climate issues.

Insects probably have the lowest potential because of the difficulties in maintaining their environmental benefits as well as their very low acceptability.

	Environment	Acceptability	Scalability	Animal Welfare
Plant-based meat	+++	++	++	+++
Cultivated meat	+	+	-	++
Insects	+	- -	-[1]	- -
Single cell proteins	+++	+	+	+++

[1] For insects, the challenge is not so much scaling up per se as maintaining the environmental benefits observed at small scale

Limitations and recommendations

While we are getting a large number of studies on the environmental impact of plant-based meat substitutes, there is still a huge gap regarding other types of alternative proteins. Furthermore, data from industrial production will be needed to draw more definitive conclusions.

Studies on the feasibility of scaling up certain products such as cultivated meat, insect-based foods or some kind of fermentation-based proteins are too few to draw strong conclusions.

Studies regarding the acceptability of these products are numerous, but most are based on hypothetical statements or WTPs. Substitution effects between different types of alternative proteins are understudied but needed.

The ethical implications of the transition to more alternative proteins are rarely discussed by scientists, especially in the case of insect consumption.