16 Trade-Offs

Comparing Meat and the Alternatives

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In 2019 Impossible Foods won a United Nations Global Climate Action Award for production of a plant-based “climate-positive burger” (United Nations Framework Convention on Climate Change, 2019).

The Rise of Faux Meat

The case “against” animal meat is compelling. Overconsumption has been connected to heart disease, cancer, and obesity, among other health concerns. Several countries issue dietary guidance that advises reduced meat consumption, particularly red meat, with the Netherlands going so far as to advise its citizens to limit meat consumption to 500 grams per week, of which no more than 300 grams should be red meat (Kromhout *et al.*, 2016). Just as the human health implications of eating beef, pork, and chicken vary, so too do the implications of various production regimes that produce those foods. For example, a grass-fed beef operation produces, on a per cow basis, far less methane than a grain-fed beef operation; use of antibiotics varies by species (e.g., in the USA in 2018, 42% of medically important antibiotics were used in cattle, 39% in swine, and 4% in chicken) (US Food and Drug Administration Center for Veterinary Medicine, 2019). Despite many real differences that exist, altogether global meat consumption and production add up to alarming impacts on human and planetary health. And as bad as things are, they are projected to get worse. The dietary transition now underway, brought on by rising Gross Domestic Product and urbanization, is expected to result in increased global meat consumption and a corresponding 80% increase of greenhouse gas (GHG) emission from animal agriculture by 2050, among other life threatening impacts (Tilman and Clark, 2014). Given the valid concerns about meat, it is not surprising to see emergence of faux meat which expands choices for vegetarians/vegans and provides options for meat eaters.

What is Faux Meat?

The term “faux meat” describes a category of products that range from plant-based and other non-meat alternatives to laboratory produced cellular meat and is a logical extension of the historical usage of “faux fur” and “faux leather,”

both terms describing non-animal-based alternatives that came into vogue in response to consumer demand.

Start-up companies are introducing a range of faux meat products that are gaining market traction in the USA, Europe, Australia, New Zealand, Canada, Israel, and increasingly in Russia and China. While this trend has not significantly impacted overall meat consumption in the developed countries where they are sold (e.g., per capita meat consumption in the USA in 2018 was 221.1 lbs.)—an increase for the fifth year in a row—and was projected to rise to 222.6 lbs. in 2020 prior to the coronavirus disease (COVID-19) pandemic (Food and Agricultural Policy Research Institution, 2020)—consumer interest in faux meat is growing. So too is the range of product offerings. To provide a glimpse of this emerging market, this chapter considers the spectrum of faux meat burgers that range from traditional plant-based burgers (e.g., Beyond Meat) to those genetically engineered to mimic the taste of meat (e.g., Impossible Foods) to cellular options not yet commercially available (e.g., Memphis Meats).

We begin with a brief description of faux meat burgers by category. Plant-based faux meat burgers have been in the market for many years, and the ingredients vary. Plant-based burgers have mostly been made of soy, with several companies choosing to use and label products as made from non-genetically modified organism (GMO) soy protein. In addition, wheat, chickpeas, black beans, mushroom, and pea protein are commonly used, as are, to a lesser extent, jackfruit, oats, algae, and seaweed. As a highly processed food, the plant-based Beyond Meat burger has a total of 18 ingredients, including 380 mg of sodium.

A more recent development is using genetic engineering to create a heme-enriched faux meat as represented by the Impossible Burger, a first in class product with significant intellectual property behind its processes. (As mentioned, it was recognized by the United Nations with a Global Climate Action Award). The Impossible Burger is a highly processed food with a total of 17 ingredients, including 370 mg of sodium. The distinguishing attribute in this category of faux meat is the introduction of heme—the molecule that gives blood its red color and which is abundant in animal muscle, creating the taste that we associate with meat. Heme also exists in plants, particularly legumes. Impossible Foods has succeeded in deriving heme from leghemoglobin—the protein found in nodules attached to the roots of soybeans which is extracted through a process using genetically engineered yeast.

Cellular meat (also known as clean meat, in vitro meat, lab-grown meat, or cultured meat) is still under development, although cell cultures have been used for a long time to produce food enzymes (e.g., microbial rennet for cheese-making), food ingredients (e.g., monosodium glutamate [MSG]), vitamins (e.g., B12) as well as flavors and fermented foods and beverages (Stephens *et al.*, 2018). The first lab-grown burger was developed in the Netherlands in 2013, at a cost of €220,000; in the USA, Memphis Meats, founded in 2015, has attracted significant venture capital and is finding ways to reduce the cost of producing cellular meat, but it is far from commercially viable. The high cost mostly stems from the use of fetal bovine serum (FBS) which is extracted from cow fetuses and then mixed with growth-inducing proteins, with companies

keeping the exact composition of their serum processes secret (Reynolds, 2018). Companies are racing to find ways to forgo use of FBS; Just Inc. has developed a method to grow cultured chicken meat without FBS, but there are no announcements yet about red meat. Because it is extremely difficult to develop cellular meat that mimics complex muscle meat, like steak, expectations are that the first commercialized products will be meat fillers/ingredients and likely burgers. An interesting twist may be 3D food printing: cultured cells (along with added flavor, vitamins, and iron) are the ingredients and a 3D printing technology merges fat and tissue to produce a cut of meat that mimics what consumers see in grocery stores. In 2018 Novameat succeeded in printing an entirely plant-based steak through this method (Shieber, 2019).

Together with start-ups, big business is engaged across the spectrum of faux meat innovation. The venture arm of the iconic chicken giant, Tyson Foods, has invested in Beyond Meat, Memphis Meats, and Future Meat Technologies. According to CB Insights, Tyson is looking to pivot from being solely a meat producer to also having plant protein brands (CB Insights, 2020). Cargill has invested in Memphis Meats. Fast food giants Burger King and White Castle are serving the Impossible Burger; McDonald's is testing Beyond Meat burgers in Canada and Nestlé's Awesome Burger in Germany; Unilever has acquired the Vegetarian Butcher; Starbucks has added meat alternatives to its breakfast menu; and Sysco Corp is introducing the soy based Simply Burger.

The US Plant Based Food Association (a trade group representing nearly 200 plant-based food companies) estimates that the US plant-based meat category in 2019 was worth \$939+ million, with 2019 sales up by 18% overall, and the driver for this market—refrigerated plant-based meat—was up by 63% (Plant Based Foods Association, 2020). This is compared with a 2.7% growth rate in the conventional meat category during the same period (Plant Based Foods Association, 2020). Overall, the association claims that in 2019 plant-based meat accounts for 2% of retail packaged meat sales in the USA. The faux meat trend is also reaching into Asia. In 2017 China announced a \$300 million deal to import cellular lab-grown meat from three Israeli-based companies as part of a larger plan to decrease the country's meat consumption by 50% (CB Insights, 2020).

Exploring the True Cost of Faux Meat

Comparing “real” meat with faux meat is complicated (Santo et al., 2020; Ritchie *et al.*, 2018, Smetana *et al.*, 2015). First, the faux meat industry is nascent, with much room for innovation, so today's analysis of the subsector might not prove true tomorrow. For example, pea protein costs are high because once the protein is extracted, there is significant unused byproduct, but this could change. Second, the wide range of current livestock practices means that there is a corresponding wide range of true costs for the various kinds of operations. For example, we can expect the true cost of a rotational grazing beef operation to vary considerably from a beef confined animal feeding operation (CAFO). Third, while animal agriculture is not new, it too is innovating. The potential to feed cattle seaweed (to reduce methane

emissions) and insects (to replace forages grown with pesticides) are just two examples under development. Undertaking a full True Cost Accounting (TCA) of faux meat is beyond the scope of this chapter, as such an effort will require transdisciplinary teams tackling time-consuming and complicated research that pairs and analyzes specific faux meat products and production processes to various kinds of meat products and production regimes. But it should be done, and there are clear advantages to doing so now before the faux meat industry takes hold, for better or worse.

This chapter is intended to illuminate the potential impacts of a shift, of any magnitude, from animal agriculture to faux meat production and consumption. To simplify potential considerations and identify, at a very high level, major issues for consideration by the four capitals, the following discussion focuses on beef and faux meat substitutes for beef. Similarly, comparisons could be made between livestock and faux chicken, faux pork, and faux seafood, all of which are either on the market or expected soon.

Natural Capital

The 2019 International Panel on Climate Change (IPCC) Special Report attributes 21–37% of total GHG emission to the overall food system (International Panel on Climate Change, 2019), with greater precision in the attribution to crop and livestock production, estimated as 9–14% within the overall food system total (Mbow *et al.*, 2019). Methane from ruminants is of greatest concern, and for this reason, beef and dairy CAFO operations have an especially high contribution. As stated above, there is a need to differentiate costs between the dominant production method of feedlots with various kinds of grass-fed operations, as GHG impacts will vary. A report by the Land Stewardship Project finds that shifting 25% of ruminants to well-managed grazing operations and 25% of cropland to perennial cover, diverse rotations, and cover crops could offset US GHG emissions by as much as 9% (Boody, 2020).

There is an absence of serious critique of plant-based burger ingredients. For crops used in plant-based meat as well as cattle feed, common use of pesticides and nitrogen fertilizers, and their resulting pollution, must be factored in. It has been suggested that fertilizer that is used to support grain-fed animal agriculture generates nearly twice as much nitrous oxide for crops destined for direct human consumption owing to the double whammy of crop fertilization for animal feed and disposal of manure in concentrated livestock operations (Davidson, 2009).

Land use is a consideration for both faux meat and beef, and in some cases, the impact could be related, as much of cropland used to produce cattle feed is also used to produce the crops that become core ingredients in plant-based meat. Cellular meat does not require significant land, and as a result, it might be possible to repurpose land that is currently in production or let it lie fallow if cellular products become a significant source of protein. Yet 40% of global terrestrial land, because of lack of moisture, steepness, and/or heat, is best suited for animals that convert plant materials indigestible for humans into meat.

Water use is a factor in faux meat and beef. As with energy, embedded water needs to be assessed for each ingredient in faux meat and compared with embedded energy and water in beef produced in various production systems.

Produced Capital

Soil health promotion to sequester carbon is widely discussed as a potential strategy to combat climate change and reward farmers for environmental stewardship. For example, practices such as crop rotation, cover cropping, and adaptive paddock management contribute to healthier soils. A 2018 National Academy of Sciences report (The National Academies of Sciences Engineering Medicine, 2019) suggests the potential to remove 250 million metric tons of carbon dioxide per year in the USA alone. Researchers are devising methodologies to measure soil carbon while policy designers and farm advocates are debating market mechanisms to reward ecosystem services to financially reward regenerative agriculture. US-based Indigo Ag is signing up farmers to sell carbon credits; The Nature Conservancy raised \$20 million to set up a carbon marketplace. The production of soil carbon and related financial rewards may variously apply to plant-based and heme-infused faux meat (depending on cropping practices) as well as animals produced in regenerative systems.

Profits will be had by companies and shareholders of successful faux meat companies. However, faux meat products currently sell at a significantly higher retail price on a per-pound basis than beef and might be out of reach for many consumers in developed countries and out of sight in developing nations. Looking way into the future, if we consider the cost of faux meat made from cereal crops, such comparisons could shift: the IPCC projects that, based on several models, cereal prices could increase from between 1–29% in 2050 owing to climate change, which could greatly impact the cost.

Energy needs to produce cellular meat are huge—well beyond any other faux meats or beef production. This is even true when considering the embedded energy in feedstuffs for cattle, with the typical conversion rate of six pounds of grain to produce one pound of meat gain. Methane digesters are used by some livestock producers to dispose manure, capture methane, and sell energy to the electrical grid and/or power their operations.

Human Capital

Health factors must be evaluated. Consumption of faux “red” meat is generally comparable to beef in terms of calories and saturated fat, although it is somewhat higher in carbohydrates. While faux meat lacks many vitamins and minerals found in beef, because it is processed, many of these missing components can be, and are, added as ingredients. A significant health concern is sodium, with significantly higher sodium levels across the entire faux meat category compared with real meat with no sodium other than what might be added in cooking. As for beef, the biggest health concern comes from eating it

raw or undercooked, risking exposure to *E. Coli*, which makes people sick and, in worst cases, causes death. Of course, overconsumption of both faux meat and beef lead to other health impacts. In terms of production, faux meat does not entail the use of hormones and/or antibiotics (with the possible secondary impact on cow fetuses). Much of faux meat is made from row crops (e. g., soy, wheat), meaning that core ingredients are typically grown with synthetic pesticides and fertilizers (as pointed out in the Natural Capitals subsection above), which can end up in food and water and can have negative health impacts on the farm and beyond. Growing animal feed could cause similar negative impacts (e.g., corn, sorghum, alfalfa). Notably, GMO corn and soybeans are produced using glyphosate, classified by the World Health Organization as “probably carcinogenic to humans” (World Health Organization International Agency of Research on Cancer, 2017) and the subject of legal suits brought by pesticide applicators suffering from Non-Hodgkin Lymphoma disease (Baum Hedlund Aristei Goldman, 2020).

Employment shifts are likely if the faux meat market continues to grow. Smaller livestock operations are vulnerable and likely to shut down in declining markets (as seen in US dairy, which has lost market share to faux milk products (Sitzer, 2019)) and market consolidation is often accompanied by CAFO expansion and decreased competition. We can expect faux meat companies to be geographically concentrated, likely in peri-urban areas. This could contribute to the problem of declining opportunities in rural places and, certainly, a decline in the quality of life among independent farmers and ranchers, even if they are able to find jobs “in town.” Faux meat production will likely require employees with different skills (e. g., molecular engineering), and in some cases, these jobs might pay higher wages than farm and ranch work. Finally, and ironically, a shift to faux meat production could be viewed as a shift from farm to factory in the face of social push-back against factory farming.

Social Capital

Animal welfare is dramatically different between meat and faux meat. Although there is a wide range of livestock practices related to animal welfare, with some operations achieving recognition for humane care, some consumers nonetheless reject outright all livestock reared for human consumption. For such consumers, and in the many cases of operations that compromise animal welfare, plant-based and heme-infused faux meat is clearly superior. However, with the use of FBS, cellular meat remains tethered to traditional livestock systems with its reliance on extraction of bovine fetuses and, as such, will not satisfy all consumers.

Quality of religious life could be a factor. Kosher and Halal dietary law dictate animal slaughter requirements together with other rules related to what animals can be consumed and when. Most plant-based meat is consistent with Kosher and Halal rules, and the Impossible Burger has been certified as Kosher and Halal (Impossible Foods, n.d.). However, faux meat, particularly cellular forms, is challenging old frameworks, leaving religious leaders pondering how these new

technologies fit. Could there be a future for Kosher pork and shrimp? There is a possibility that faux meats could enhance food options for certain religious groups.

Governance of faux meat is murky. In the USA, for example, the meat industry is lobbying state legislatures to secure laws that prevent the term “meat” from appearing on faux meat labels. At the federal level, oversight of faux meat is shared by the US Food and Drug Administration and United States Department of Agriculture, with leaders of both institutions side-stepping contentious debates, creating regulatory uncertainty. To the extent that faux meat involves genetic manipulation of any sort, it is unclear whether and how such products would fit into regulatory frameworks for biotechnology across the globe. As the faux meat industry grows, it is reasonable to expect friction over governance within countries and between countries, with potential trade conflict emerging from different approaches to these novel products. This is not to suggest that the livestock sector is exempt from governance concerns (e.g., the years of wrangling in the CODEX Alimentarius Commission over use of ractopamine hydrochloride as an animal growth promoter (Farm and Dairy, 2012)), but the pathways for resolving issues is far clearer.

There are many associations—local, national, and international—that engage farmers and ranchers, providing them support and a sense of community and identity. Farm and ranch life can be isolating, particularly in remote areas, and associations and networks, together with related social activities (e.g., rodeos, livestock auctions) are critical to wellbeing and, often, business success. It is unlikely that such networks and associations will play a similarly significant role in the emerging faux meat industry, which will likely be concentrated in business centers and not contribute substantially to the quality of rural life.

Conclusion

While faux meat is an interesting development and holds promise, it is premature for faux meat champions to declare a sustainability victory. While not possible in this brief chapter, to ultimately declare which product(s) or category of “meat” is best, the goal has been to surface the kinds of questions that TCA would necessarily address and to build support for the kinds of analysis that provide data-infused insights currently absent from decision-making processes. Furthermore, this discussion has been focused on the developed world. A parallel discussion is necessary to consider the two-thirds of rural households globally, many of them poor and food insecure, whose well-being relies on livestock. It is time to apply TCA methodology to faux meat innovations to determine their true cost at a global scale across the four capitals, as identified by the TEEBAgriFood framework.

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