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Biotechnological fixes and the Big Three urgent moral challenges facing the global livestock industry

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The current global food system, and in particular the livestock industry, has been effective at providing low-cost calories to large segments of the population, but it also causes significant harms and poses serious risks. In particular, the global food system currently likely causes billions of animals to suffer every year, significantly contributes to climate change, and threatens public health via the possibility of zoonotic disease. There are many other problems that have been identified with the livestock industry, but these three threats, which I refer to as the Big Three, are among the most urgent moral issues in the world. Significant progress could be made to address all three of these risks if the global population moved to a primarily plant-based diet. However, there are reasons to believe this possibility is unrealistic given current consumer preferences and political realities. As an alternative, one could ask whether an approach relying entirely on novel biotechnology could be used to address the urgent moral challenges of the global livestock industry without substantially changing the consumer experience or facing political backlash. In this paper I consider what such a scenario would look like, and argue that failing to address any one of these three major issues would be a serious moral failing. Though many other suggestions have been made looking at how biotechnology might address individual issues, this paper suggests that in order to avoid the need for difficult behavioral and political changes, biotechnological solutions would ultimately need to be developed that address welfare, environmental, and public health concerns.

KEYWORDS

biotechnology, bioethics, gene-editing, animal ethics, livestock production, antimicrobial peptides, global food system, food ethics

Introduction

The current global food system, and in particular the livestock industry, has been effective at providing low-cost calories to large segments of the population, but it also causes significant harm and poses serious risks. Some of the harms associated with various aspects of the current meat industry include the treatment of workers in meatpacking plants (Human Rights Watch, 2004, Oxfam America, 2016), water and air pollution (Environmental Protection Agency (EPA), 2001; Springmann et al., 2018), loss of biodiversity caused by land use practices, and the widespread adoption of unhealthy diets that features overconsumption of red and processed meat by many segments of the global population (Willett et al., 2019). Though each of these issues is important and worthy of discussion, they will not be the focus of this paper. Instead, I will argue that three issues in particular are the greatest moral hazards associated with modern meat production and among the most urgent moral issues in the world today.

My argument is based primarily on a consequentialist perspective that holds that the rightness and wrongness of actions can be determined primarily by the consequences they produce (Sinnott-Armstrong, 2022). In particular, I will focus on the negative consequences of suffering and the prevention of positive experiences as the primary criterion to evaluate how serious various moral threats are. Though consequentialism is just one approach to evaluating ethical choices, I nevertheless think it identifies harms that most ethical theories would agree are serious harms, and as such presents a case that is relevant to most other theories.

Given this framework, I consider the following to be among the most urgent moral issues in the world today. First, modern livestock production is dominated by intensive confinement conditions for many animals (Ritchie, 2023). Taking pigs and chickens as examples, sentient animals are subjected to procedures such as debeaking, tail docking, and castration often without anesthesia or pain relief (Rossi and Garner, 2014). They are also confined in small cages or crowded environments that restrict their natural behaviors and cause physical and psychological suffering (Rossi and Garner, 2014). 202 million chickens and 3.8 million pigs are slaughtered for meat each day, meaning 73.7 billion chicken and 1.4 billion pigs slaughtered each year (Ritchie, 2023). Selective breeding focused on maximizing economic efficiency by causing rapid growth has also resulted in serious welfare problems such as painful lameness caused by abnormal development and increased risk of organ failure (SCAHAW, 2000). Given fairly straightforward arguments that many of these animals suffer a great deal, this amounts to amassive amount of suffering every year.

Second, it has been found that global animal product production makes a significant contribution to climate change (Springmann et al., 2018; Willett et al., 2019). A recent study found that shifting half of current diets to plant based meat and milk substitutes could reduce greenhouse gas emissions by the equivalent of transitioning the global fleet of automobiles to 100% electric vehicles (Kozicka et al., 2023). Climate change is one of the most important moral issues of our time because, on our current trajectory, it is likely to have a profound and far-reaching impact on human life due to its capacity to disrupt ecosystems, increase the frequency and severity of extreme weather events, threaten food and water security, exacerbate health risks, and displace vulnerable populations. Rising temperatures, melting ice caps, and sea-level rise will likely result in coastal flooding, loss of arable land, and the extinction of vital species. These changes not only jeopardize global economies but are also likely to intensify conflicts over dwindling resources and create mass migrations, potentially leading to social and political instability. Climate change is, therefore, a profound threat that demands urgent and concerted efforts to mitigate its effects and adapt to the changes already underway, as its consequences will significantly impact the well-being and survival of human societies worldwide.

Finally, Concentrated Animal Feeding Operations (CAFOs) could potentially contribute to the emergence of pandemics that would threaten global public health. CAFOs often house a large number of animals in close proximity, creating conditions conducive to the rapid transmission of diseases among animals. They have often been described as a breeding ground for the creation of new super viruses (Stathopoulos, 2010; Hollenbeck, 2015). Close confinement of animals can facilitate the exchange and mutation of pathogens, including viruses and bacteria, and many infectious diseases that affect animals in CAFOs have the potential to mutate in such a way as to infect humans, becoming zoonotic diseases (Espinosa et al., 2020). If and when these diseases jump from animals to humans, they can lead to outbreaks in human populations. Examples of zoonotic diseases that have been found in CAFOs include avian influenza (bird flu), swine flu, and various strains of antibiotic-resistant bacteria. Additionally, in CAFOs, antibiotics are often administered routinely to promote animal growth and prevent disease. Moreover, the widespread use of antibiotics creates selective pressure, favoring the development of antibiotic-resistant bacteria. These drug-resistant pathogens can infect both animals and humans and are difficult to treat, increasing the risk of severe and untreatable infections.

This combination of factors has the potential to lead to future pandemics (World Health Organization, 2023), and differences in transmission or mortality rates could result in consequences even worse than what was seen with COVID-19. Workers in CAFOs may be at increased risk of exposure to infectious agents due to their close contact with animals and contaminated environments. Animals and animal products from CAFOs are often transported long distances and across borders and this movement can facilitate the geographic spread of diseases, potentially leading to outbreaks in different regions and countries. In our interconnected world, diseases can spread rapidly across continents due to international travel and trade. If a novel infectious agent with pandemic potential emerges in a CAFO, it could be carried to different parts of the world by infected animals or humans.

These three concerns underscore profoundly significant moral dilemmas. Among them, two present dire threats to human welfare. Some even label climate change and the risk of future pandemics "existential threats," though it is doubtful they would entirely eliminate human civilization. Nevertheless, their magnitude is so great that it's easy to see how the label can be applied to them, even if it is not fully accurate. The other issue, however, pertains to an astonishing magnitude of daily suffering produced in the modern

livestock industry. The amount of animals slaughtered for human consumption every day is difficult to fully appreciate, and if those animals are suffering then this results in an astounding moral deficit. On any ethical perspective that places significant weight on suffering and the loss of positive experiences, these three issues are extremely and urgently important. In other words, for livestock production to attain even a semblance of ethicality, we need comprehensive solutions for each of these formidable challenges.

The straightforward solution

While each of these challenges is formidable, and there is no flawless "silver bullet" solution to completely eradicate all existing moral issues within the current food system, there does exist a relatively straightforward yet challenging step that could significantly alleviate each of the Big Three concerns. If individuals were to transition toward predominantly plant-based diets, reducing reliance on livestock farming, it would represent a substantial stride toward tackling these multifaceted problems. Since many wealthier countries currently consume more meat per capita and have the means to more easily shift to plant-based diets without sacrificing access to nutrients, I will assume going forward that the burden of shifting toward plant-based diets on this approach falls primarily on wealthy countries.

The straightforward solution address the Big Three as follows. First, reducing the number of animals consumed would of course mean that many fewer animals are kept in poor conditions and slaughtered. Thus, even if livestock continued to live net negative lives, the scale of suffering would be massively reduced. Since the numbers involved are already almost incomprehensibly big, these reductions would be extremely morally important on a consequentialist framework.

Second, since 90% of the agricultural land in areas such as states in the US Midwestern corn belt is currently used inefficiently to grow corn and soybeans for animal feed and corn ethanol rather than growing food directly for humans (Schnitkey et al., 2020), a large scale shift toward plant based diets would mean that the food needed for humans could be grown on a much smaller amount of land. In other words, land currently being used to grow animal feed (e.g. corn and soybeans) could instead be used to grow grains for human consumption or be returned back to wetlands and natural areas that protect water quality and act as carbon sinks (Johnston, 2014; Hunt et al., 2020). As has been noted, some portion of land currently used by ranchers is suitable for livestock grazing but not commercial crops. Using only this land for grazing animals would be consistent with an approach where animal products become more of a luxury product consumed only occasionally, as it has been for much of human history, and could allow for livestock systems not subject to the pressures of intensification and where animals could graze and enjoy natural behaviors. As such, an approach need not be entirely plant-based to result in dramatic welfare improvements, although it likely would require a large shift. This "reduction rather than elimination" approach is also important to note because in some regions of the world animal consumption may be the only viable way of obtaining micronutrients (Alders et al., 2023), though this is not true in most of the developed world connected to the global food system.

As noted above, the livestock industry currently contributes a substantial amount to global greenhouse emission. As such, dramatically reducing animal product consumption in favor of plant-based meals would result in a significant reduction of global greenhouse emissions. So a shift to plant based diets would also make an important contribution toward one of the defining moral issues of our time. And it is important to note that this shift need not entail a wholescale adoption of vegetarian or vegan diets. A recent student estimated that while a hypothetical global adoption of a vegetarian diet would result in a 63% reduction of greenhouse gas emissions from the food system, even just reducing the amount of per capita meat consumption to match current global dietary guidelines would result in a 29% decrease (Springmann et al., 2016).

And finally, several of the factors that make animal agriculture a public health threat would be reduced in this scenario and possibly eliminated entirely. Of course, if no animal products were consumed, then the risk of zoonotic disease at least from this particular industry would be completely eliminated. But even a large enough reduction where animals were no longer raised in intensive conditions under high stress (Moberg and Mench, 1997; Silbergeld et al., 2008) would eliminate the "petri dish" effect of modern CAFOs where animals are housed in conditions that facilitate the transmission of disease, in close quarters and under high stress. And any reduction in the mass numbers of animals transported globally would also reduce the risk of fast and widespread disease transmission.

In sum, a shift to a mostly plant-based global food system could address the three most important moral issues associated with the livestock industry. Nevertheless, many are skeptical that this approach can succeed given current public attitudes and political realities.

The central difficulty with the straightforward solution

Though the straightforward approach could address the Big Three problems, there are a number of difficulties that arguably make it unlikely to occur anytime soon. First, there are serious political challenges. Powerful food industry lobbies often resist regulatory changes and shifts toward sustainable or healthier food production. Their influence can shape policies and slow down efforts to reform the food system. Governments may be resistant to implementing new regulations or policies due to concerns about economic impacts or fear of backlash from industry stakeholders and consumers. Food system issues can become politically polarized, making it difficult to build consensus and pass meaningful legislation, and partisan divides can hinder efforts to address problems such as climate change, food security, or nutrition. And the influence of large agribusinesses on campaign financing can discourage politicians from advocating for food system reforms that may disrupt the status quo (Samuel, 2021; Vallone and Lambin, 2023).

Even aside from politics, though, there are many psychological and behavioral barriers to food consumers around the globe shifting

to a plant-based diet en masse. Many consumers are unaware of the ethical, environmental, and health issues associated with the food system (Neff et al., 2018). Even among those who are aware, many may resist adopting healthier or more sustainable diets if they perceive changes as inconvenient (Perez-Cueto et al., 2022) or expensive (Gupta et al., 2021). Food choices are often deeply ingrained in cultural and social contexts which makes it even more difficult to ask people to change their diets (Enriquez and Archila-Godinez, 2022). And behavioral change can be impeded by psychological factors such as inertia, cognitive biases, and the perception of immediate costs (e.g., higher prices) compared to delayed benefits (e.g., improved health or environmental sustainability) (Ainslie, 1992). Additionally, people are strongly influenced by the eating habits and attitudes of those around them, which amplifies the power of the current status quo (Schubert et al., 2021). And all of these issues are amplified by the fact that aggressive marketing by the food industry, often promoting unhealthy or unsustainable products, can influence consumer choices and make it difficult for individuals to adopt healthier and more ethical diets (Martinho, 2020).

A biotechnological approach to the Big Three problems

Because achieving this level of behavioral change seems nearly impossible, we need to consider whether these problems can be better addressed via a biotechnological fix. If biotech advancements occur that address the problem without forcing retailers or consumers to change their behavior or confront the political challenges, many of the above difficulties would be avoided. Given the magnitude of these problems, these biotechnological solutions need to be considered.

However, specific biotechnological fixes are usually only suggested in regard to one of the Big Three Challenges at a time, not all three. If, as I have argued, each of these Big Three is an urgent moral challenge, then addressing only one of them will not be enough to justify continued livestock production. In other words, we would need biotechnological fixes for each and every one of the Big Three issues in order for the industry to avoid serious wrongdoing. It is therefore worth taking stock of how likely it is that we will see biotechnological solutions to these problems in the near future.

In regards to welfare, there are a number of ongoing research ideas that could improve welfare in the modern livestock industry. Gene editing has been used to create polled cattle who no longer need to be painfully dehorned (Carlson et al., 2016), and similar proposals have been made in regards to creating pigs with no tails or chickens with no or altered beaks that would eliminate painful procedures. Gene editing is also being explored as a way of avoiding diseases from occurring (Menchaca et al., 2020), diseases which result in suffering and death of animals. But most directly, proposals have been put forward that would result in animals whose capacity to consciously feel pain or suffer is greatly diminished or entirely eliminated (Shriver, 2009; Shriver and McConnachie, 2018). Many technological and epistemological challenges remain, but this is at least a live possibility that could, if universally adopted, eliminate the animal welfare challenge of the modern livestock industry.

In regards to public health, again gene editing might be relevant. As noted above, gene editing might be used to directly create animals who are immune to certain disease states (Salvesen et al., 2022). Additionally, efforts are currently underway to use antimicrobial peptides to fight various diseases as an alternative to traditional antibiotics (Li et al., 2022). Antimicrobial peptides are created in all different animal species, but researchers are currently using sophisticated techniques to sequence these peptides and to determine if they can be used to fight disease in different organisms. Antimicrobial peptides could potentially save humanity from the grave threat of antibiotic resistance which has been exacerbated by the rampant administration of antibiotics to livestock. Again, as with the welfare problem, there is no certainty that biotech can address this problem, but there are very promising avenues currently being explored.

Finally, can biotechnology reduce livestock's impact on climate change? A path for biotechnology to fully address this challenge is arguably even more dubious than the other two. These have had mixed results so far. There are researchers exploring how gene editing could be used to reduce methane emissions from livestock. In theory, many proposed gene edits that would increase agricultural productivity in the sense that the input to output ratio would also have a positive impact on climate change. Overall, however, it is not yet clear that there's one approach that would eliminate the contribution of the livestock industry to climate change to the extent that gene editing might address the experience of negative welfare states and antimicrobial peptides might address the risk of antimicrobial resistance.

In summary, possibilities exist for biotechnological solutions to each of the Big Three challenges, though varying degrees of uncertainty exist for each. If a biotech solution could be implemented for each challenge, then we could in theory solve these moral crises without needing to change consumer behavior or to challenge concentrated political power, which would make success far more likely.

However, it is worth pointing out that there is an asymmetry between the difficulties facing the straightforward solution and those facing to the biotech solution. The difficulties facing the biotech solutions are technological issues and a limited scope where one or more of the Big Three challenges is not addressed. It is also the case that if the relevant technology is not produced, the Big Three challenges will not be addressed at all. In such cases, it would be a bad idea to put all of one's eggs in one of those baskets. On the other hand, the difficulties facing the straightforward solution are primarily difficulties involving human psychology and people's willingness to change their behavior. And since individuals changing their behavior can make some difference, even if not fully addressing the problem, then it seems like there's a strong argument that if any particular people are capable of shifting their own behavior, they should do so. In other words, if one is able to change one's own behavior, then waiting or hoping for a biotech solution is not a good excuse to avoid doing so.

Conclusion: the upshot

Each biotech approach to the Big Three problems mentioned above is currently only in an exploratory phase, and for each there exists uncertainty about whether they are possible at all, even after years of additional research. Nevertheless, when we compare a biotech solution to one particular issue or problem (e.g. the pain of dehorning, or the risk of antimicrobial resistance), the biotechnological solution may appear attractive given the substantial political and psychological challenges facing solutions that require big changes in consumer behavior. These particular comparisons might be appropriate in certain circumstances: for example in some situations we might be faced with a clear choice of implementing new technology that will significantly reduce the risk of antimicrobial resistance in agriculture, and in such a case it would be hard to argue against taking whatever steps we can to prevent future pandemics.

It's also possible that there may be biotech solutions that do address all three issues. Consider, for example, lab-grown or cultivated meat, meat that is produced synthetically but is indistinguishable from, or at least equally as attractive as, conventional meat. If meat could be produced without current land use practices and without current animal use practices, many of the problems above could be avoided. There would, of course, be new concerns about ensuring that the cultivated meat produced itself is safe from the risk of pathogens, and the practice is very energy intensive, so the impact on the environment would depend on our success in shifting to clean energy. There also are currently questions about just how likely we are to solve the technological hurdles needed to ensure success. But if this is technologically possible, then it seems at first glance to be a biotech solution that simultaneously solves each problem.

I hope to have illustrated that if we are examining food systems at a holistic level, looking only at one of the Big Three problems at a time is not sufficient. Each one of the Big Three represents a morally urgent problem among the most important issues facing us today, and there can be no ethical global food system that does not address each of these issues. As such, when we compare technological approaches to addressing the moral issues of the food system, risks and benefits of solutions such as citizens in wealthy countries shifting to plant-based diets need to be compared with attempts to address *all* of the Big Three problems, rather than just one.

I do not here intend to offer an assessment of the comparison between the straightforward approach and the biotech approach, but I hope to have demonstrated that apples to apples comparisons require more than looking at only one of the Big Three at a time. If a particular biotechnological solution merely delays an inevitable reckoning with the need for behavioral change and political reform, this may suggest that it is better to immediately pursue the straightforward solution despite its difficulties. On the other hand, if prospects for biotechnological solutions to *all three* of the challenges seem viable enough, then the biotech approach can be preferable. But either way, it is important to keep in mind that when it comes to the modern livestock industry, the impact on animal welfare, the risks to our climate, and the threat of pandemics are each too great to be ignored.

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

AS: Writing – original draft.

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Conflict of interest

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