The ethics of farm animal genome editing: exploring the added value of Foucauldian 'biopolitics' to the debate

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Word Count: 10,874 Words
Submission Date: 26-10-2022
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Abstract

The altering of farm animal genes with genome editing technology can be relevant to all of humanity. Techniques to edit livestock genomes are now more accessible to many farms. The increasing availability of bioengineering in farm animal handling requires humans to consider ethical questions relating to such methods. The ethical dimensions have been recognised in the literature and reflected in public debate. Nonetheless, this paper shows the need to broaden the use of concepts and explore the added value of Foucault's approach to technology. To elaborate on this, this paper first presents CRISPR/Cas9, a system used to edit genomes, and the history of genetic engineering in farm animals. Next, the needs of the animal agriculture sector are addressed, with an emphasis on breeding selection in the farm animal industry and the position of bioengineering. Then, the current state of the ethical questions and debates around livestock bioengineering are shown and analysed. Foucault's approach towards the handling of populations is identified as a framework that can add value to the debate. His approach may result in new perspectives and answers to ethical questions in the debate. A review of Foucault's concepts of 'biopower' and 'biopolitics' then follows. Finally, these concepts are applied and their impact on the ethical debate is analysed. Foucault's ideas cast the ethical debate on farm animal genome editing in a new light. The debate is broadened through the discovery of multiple assumptions within the systems of animal agriculture and behind the foundations of the farm animal industry. Furthermore, new perspectives were uncovered within the debate, and answers to some of the ethical questions were found. This helps in informing the debate and addressing a variety of ethical issues around the use of bioengineering in farm animals. Finally, the application of Foucault's approach raises new questions and debates. They include the analysis of the farm animal genome editing ethical debate using different lenses within Foucault's framework, using 'biopolitics' to examine the impact of bioengineering on animal dignity, and how governments and society can use Foucault's concepts to take informed positions in the ethical debate.

Introduction

The editing of farm animal genomes is a significant advance in technology that has the potential to revolutionise the lives of humanity and the animal world. The farmers working in animal agriculture are starting to utilise this method to change the face of breeding selection practices. However, it is important to examine the ethical questions surrounding this technology due to the novelty of the technique and the fact that it is applied to animals. Advanced ethical debates are taking place around the use of tech in the farm animal industry, with the use of genetic engineering as the newest and least developed of these debates. The ethical debate on the bioengineering of livestock must be expanded and developed further to allow for more informed choices to be taken at a societal and individual level by the governments and farmers that can use this technology to effect change. Thus, a literature study is the chosen method to address the debate.

Understanding how to further develop the ethical debate requires knowledge of the following topics that will be addressed in this paper: genetic engineering and how it has been applied in the farm animal industry to date, the animal agriculture sector and its breeding selection procedures, and the current state of the ethical debate on farm animal genome editing. The findings of this paper indicate that the Foucauldian concepts of 'biopower' and 'biopolitics' may be relevant and valuable to the debate. Therefore, the Foucauldian approach is addressed and explained in this paper as well. Finally, the concepts of Foucault are applied to better inform the ethical questions swirling around the genetic engineering of livestock and explore how 'biopower' and 'biopolitics' add value to the ethical debate.

When contemplating all of the above, the main research question is: What could be the added value of the Foucauldian 'biopolitics' approach to the debate on the ethical and socio-political issues of using farm animal genome editing in animal agriculture?

What is genetic engineering and how can it be applied in animal agriculture?

Genome editing allows for the modification of organisms at the genetic level. Successful older methods include transgenesis, meganucleases, zinc finger nucleases and TALENs (Khalil, 2020). Their utility was variable, as they tend to be relatively expensive and lack precision for regular practical use. Most modern genetic engineering uses the CRISPR/Cas9 system, which allows for the insertion or removal of genetic material at specific sites in an organism's genome with precision and low cost (Khalil, 2020). There are some examples of the use of genome modification and genetic engineering techniques in farm animals that are important to address so that the potential of the technologies can be put into context (Tait-Burkard et al., 2018).

On CRISPR/Cas9 genome editing

CRISPR/Cas9 uses synthetic guide RNAs to direct a Cas9 nuclease, allowing it to cut DNA at a specific location in the genome of a cell. It originates from the immune system of bacteria, where these nucleases combat infections from viruses and other threats that act upon the bacterial genome. Different Cas nucleases can be guided by synthetic guide RNA to target many sorts of RNA or DNA, indicating the adaptability of the technology. However, for most of the purposes of modern genome editing the Cas9 nuclease is the type with the most demonstrated success in research.

CRISPR/Cas9 can be used to knock in and knock out genes. The knocking-in of genes involves the insertion of a DNA sequence at a specific point in the genome after the inducement of a double-stranded break in the genome. This allows the new DNA sequence to be ligated into this point of the broken genome by repair mechanisms within the cell, resulting in the insertion of the new sequence. The inserted DNA can also come from other sources than the edited organism, and this insertion of foreign DNA results in the creation of a transgenic organism. The knocking-out of genes works by removing a DNA sequence from a specific part of the genome with the inducement of double-stranded breaks in the DNA, and the subsequent ligation of the broken genome by repair mechanisms within the cell. Both the knocking-in and knocking-out of genes result in the creation of a genetically modified organism. Attempts to knock in or knock out genes that are needed for the survival of the organism are usually unsuccessful as it is unlikely to create a viable organism that can survive independently.

The feasibility of this new technology has cast the debate on genetic engineering in a new light, as the widespread use of genome editing for various applications is now possible and is occurring in many fields (Khalil, 2020). Amongst these fields is the editing of farm animal genomes, with numerous possible applications for this technology in the animal agriculture sector. There is a long history of genetic modification and genome editing in farm animals, with older methods like transgenesis being used before the modern genetic engineering technologies that have been used more recently. The advent of the CRISPR/Cas9 approach has increased the use of farm animal bioengineering.

Genetic modification in livestock before modern genome editing

There are many instances of genetic modification in farm animals before the development of modern genome editing tools, with studies showing variable success (Tait-Burkard et al., 2018). One example is the DNA microinjection of growth hormone (GH) and insulin-like growth factor 1 (IGF1) into porcine zygotes to create transgenic versions of the animals that can grow more efficiently in theory. The GMO pigs grew faster, converted their feed into mass more effectively, and were more muscular and less fatty when compared to the control group. However, the genetically modified swine suffered welfare concerns such as a reduced ability to deal with stress, gastric ulcers, lameness and lethargy (Pursel et al., 1990). A further study was conducted with the insertion of only IGF1, and this population of transgenic pigs were simply more muscular and less fatty than the control group, thus making the adverse effects seen in the initial study attributable to the GH (Pursel et al., 1999).

A similar approach with farmed salmon was more successful, with the creation of the AquAdvantage strain that grows quicker than wild-type fish in farming conditions. The genetically modified strain was created by inserting a GH gene obtained from a Chinook salmon and pairing it with a promoter taken from an ocean pout to increase the expression levels of GH. This genetically modified fish made history as the first transgenic animal to be approved by the FDA for consumption by humans and therefore the first genetically modified organism (GMO) to be sold on the open market for consumers to buy and eat in their homes (Waltz, 2017).

Another example of porcine genetic modification was the insertion of the *fat-1* gene of *C. elegans* into the pig genome to change the Omega-6 and Omega-3 fatty acid ratios. This was done with success and the fatty acid ratios in these GMO pigs changed in favour of Omega-3 fatty acids (Lai et al., 2006). A more environmentally friendly approach was taken when microbial genes were inserted into swine to make them emit less phosphorus and nitrogen. This was done by the introduction of a phytase gene from *E. coli*, allowing for the full digestion of dietary phytate in the transgenic pigs and eliminating the need for phosphate supplements in their diet (Golovan et al., 2001). A further study happened in which genes encoding for microbial phytase, xylanase and

beta-glucanase were inserted into the porcine genome, making the bioengineered swine grow around 20% faster and reducing their phosphorus and nitrogen emissions by almost 50% (Zhang et al., 2018).

A successful application of genetic modification in chickens is of great importance as well, where avian influenza transmission was reduced by the introduction of a transgene allowing the bioengineered chickens to express a short-hairpin RNA. This short-hairpin RNA was designed to block the avian influenza virus polymerase and thus remove the ability of the virus to replicate and spread effectively. This was somewhat successful in preventing the spread of the virus to transgenic chickens (Lyall et al., 2011; Luo, Danetz & Krystal, 1997).

An example in goats involves the avoidance of mastitis, where the transgene for human lysozyme was inserted into them to stop the propagation of the pathogens. This was successful in inhibiting the growth of the pathogens while at the same time having no adverse impact on the bacteria important for the production of dairy products downstream (Maga et al., 2006; Maga et al., 2003). Another similar example to that of transgenic goats is the creation of GMO cattle that express lysostaphin in their milk. Lysostaphin is an antibiotic that helps in preventing infections by *S. aureus* and thus makes cows resistant to mastitis (Wall et al., 2005). All of these examples involved the use of older genetic modification technologies such as DNA microinjection into zygotes and somatic cell nuclear transfer to cause transgenesis and make GMOs.

Modern genetic engineering in domesticated animals

The applications of modern genome editing technology are numerous and allow for even further types of modifications in transgenic farm animals that are of great relevance and interest to the animal agriculture sector (Tait-Burkard et al., 2018). A prime example of this is the modification of the myostatin gene (*MSTN*) in many farm animals, a gene responsible for the speed of farm animal growth and musculature development. The editing of this gene has been done in goats, cattle, pigs and sheep to create farm animals that grow faster and are more muscular (Proudfoot et al., 2015; Crispo et al., 2015; Wang et al., 2018). Most studies on the editing of myostatin have been done in pigs, and mutations and knockouts of the gene have been associated with numerous adverse effects on porcine welfare. Issues with the health of these genetically engineered swine include abnormal leg development, inability to stand and walk, leg weakness and death soon after birth (Kang et al., 2014; Matika et al., 2019; Kang et al., 2017; Wang et al., 2015). However, fewer adverse health effects were reported in breeds known for having higher fat levels, suggesting some potential viability for the successful bioengineering of porcine myostatin genes with positive economic effects and minimised adverse effects on pig well-being (Wang et al., 2017; Cai et al., 2017).

A more animal-centric approach to genome editing is seen with the genetic engineering of bovines to ensure that they are not horned from birth, as compared to physically removing their horns. The dehorning of cattle reduces their injury risks, aggressive behaviour and competitive behaviour for food. The physical removal of the horns causes great pain and risks injury to the cows and thus represents a significant animal welfare concern (Ahola, 2015). The Pc POLLED allele was identified as a potential determinant as to whether the cows would be horned or not. The introduction of the allele successfully ensured that the calves resulting from the genetic engineering of bovine embryo fibroblasts lacked horns, and thus they did not need to go through physical dehorning (Carlson et al., 2016).

The avoidance of surgical castration in pigs has a similar animal welfare component to the dehorning of cattle, however, the reasons for wanting to castrate swine are primarily economical. Boars can be aggressive and produce androstenone and skatole, the accumulation of which causes their organoleptic properties to be unpleasant

to consumers. The genetic engineering of swine by knocking out the *KISS1R* gene resulted in the boars not going through puberty regularly and thus no development of the testicles. With hormone treatment they did have their testicles increase in size, however, it is unknown and unlikely that these swine can become fertile or that their development would be unaffected (Sonstegard et al., 2016; Große-Brinkhaus et al., 2015). Another related bit of bioengineering was done in farmed Atlantic salmon, with the targeting of the *dnd* gene to ensure their sterility and thus removing the risk of their escape and breeding with wild-type fish (Wargelius et al., 2016).

Like with the old methods, there is also the potential to genetically engineer farm animals to resist diseases more effectively, with a prime example of this being the genetic engineering of swine to resist PRRSV infection. They already have some natural resistance to PRRSV in the form of the *GPB5* gene, however, the reasons why this is the case are unclear (Koltes et al., 2015; Boddicker et al., 2014). An alternate and more reliable approach is seen with the knocking-out of the *CD163* gene, thus conferring resistance to PRRSV in the GMO pigs (Van Gorp et al., 2010). Removal of the SRCR5-encoding genome section by the deletion of exon 7 allowed for resistance to PRRSV to occur while maintaining the biological function of the *CD163* gene (Burkard et al., 2017; Burkard et al., 2018). The bioengineering approach gives total resistance to PRRSV, while the natural variations in the *GPB5* gene only give partial resistance. It is also possible to use genome editing to resist diseases in cows, with a single amino acid change in the bovine CD18 protein resulting in the resistance of foetuses to *M. haemolytica* infection and cytotoxicity (Shanthalingam et al., 2016). Another quick example in cows would be the conferred resistance to bovine tuberculosis by inserting a resilient *NRAMP1* allele, significantly reducing the impact of the disease on cattle health (Gao et al., 2017).

A final example of how genome editing in farm animals can be used is not within the animal agriculture sector, but rather in the healthcare industry. It is possible to remove porcine endogenous retroviruses from the genome of swine to allow for their organs to be able to be used in humans, a process known as xenotransplantation (Moalic et al., 2006; Yang et al., 2015; Niu et al., 2017). This would reduce concerns over the transmission of retroviruses from pigs to humans while solving problems related to the lack of human donors for necessary organ transplantation procedures in healthcare.

Bioengineering is a technology that has many applications within the animal agriculture sector. However, to understand why this tech is important to the farm animal industry it is worthwhile to look at how farming businesses work and why genome editing is regarded as a revolutionary technique in this field.

On livestock farming and the role of breeding technologies

It is important to discuss the context within which the ethical debate around farm animal genome editing takes place. Animal agriculture is one of the oldest industries of human civilisation, and it involves the use of animals for the production of food and non-food products and the optimisation thereof by using technology to breed animals. It would first be prudent to discuss the practices in use for production in the farm animal industry, and then examine in detail the technologies that are useful in the field of breeding selection.

The animal agriculture sector

The animal agriculture sector is of great importance to humanity worldwide, as the consumption of farm animals and products derived from them are a key component of the human diet in most parts of the world. The techniques used to raise and cultivate the

animals differ broadly depending on the local environment in the area, the scale of the farm and the number of animals. Traditional farming styles mainly have to do with transhumance or variations thereof, where humans and their livestock move between two or more pastures depending on the season (Jones, 2005). Amongst more modern methods there are extensive, intensive and semi-intensive farming (Rust, 2019; Moorby & Fraser, 2021).

Extensive farming involves the free movement of farm animals and can be done with or without the observation of farmers. Examples include ranching in the Americas and Australia, as this type of farming mainly occurs in areas with swathes of land for the herd to live off of. This way is the closest to the traditional transhumance style but differs in terms of the scale of the operation and the ability of farmers to protect their livestock as compared to raising their animals fully in the wild (Rust, 2019). Intensive farming works by restricting farm animals in such a way that the meat and dairy obtained from them are homogenous, cheap and high-yield. This is also known as 'factory farming' due to the number of variables that are controlled when raising the animals. Examples of some of the technologies used in intensive farming include feedlots, climate-controlled buildings, cages and specific feeding (Rust, 2019; Moorby & Fraser, 2021). Finally, semi-intensive farming is done by allowing farm animals outdoors to graze depending on the season. It is also characterised by increased farmer involvement when food is more scarce by providing the animals with feed, hay, fertiliser, and a seasonal indoor space depending on their needs (Moorby & Fraser, 2021).

The concerns relating to extensive and semi-intensive farming primarily regard the handling of predators, thieves and diseases, as all of these factors affect the health and well-being of the farm animals. However, there are fewer wider animal welfare concerns like the ability of livestock to perform behaviours specific to their species, as the herds can exhibit natural behaviours without any restrictions and thus they live relatively well in these conditions. There are environmental considerations with these types of farming as vast expanses of land are required to maintain the herds and ensure their sustenance, with the consequences of this a problem for the environment as a whole. Intensive farming, on the other hand, has many concerns relating to animal health and well-being. Infections and parasites are common troubles that are generally addressed through veterinary care, quarantine and vaccination. The animal welfare issues in intensive farming come from the restriction of the stock to the point where they cannot exhibit their natural behaviours in any meaningful way, resulting in high stress and painful lives for them. Things are done to the farming stock that harms them in favour of providing higher yields of meat and dairy, which is not good for the health and well-being of the animals. Environmental worries also exist due to the massive amount of carbon and nitrogen emissions from intensive farms and the need for feed causing indirect environmental damage (Rust, 2019; Moorby & Fraser, 2021).

In contrast, the current benefits of the modern animal agriculture sector are its economic value, food security role, efficiency and cultural values. The farm animal sector is a key part of the economy in many countries around the world that employs many people (Fernandes et al., 2021; Buller et al., 2018). In turn, there are many related economic sectors that either provide tools and expertise or make use of products that are derived from the farm animal industry. The security that the animal agriculture sector provides to people lies mainly in its ability to provide food to the world population and thus ensure that humanity can eat well. The impact of the agricultural complex is also seen in the many nonfood products derived from domesticated animals used in various sectors, such as leather in the clothing industry. It is also an industry that has shown a propensity to increase its efficiency regularly over time with technological and scientific advances, thus allowing for more food and nonfood products to be obtained from animals with fewer resources needing to be used to get this increased output. Finally, the cultural

aspect of the animal agriculture sector manifests itself as a way of life for many farmers over many generations, with family farms being a large part of the farming culture. However, this has been changing due to the rise of intensive farming and the factory-like processes increasing the scale of such farms to the point where the regular family farm is slowly but surely dying out.

Breeding technologies

One way in which to combat some of the issues in the farm animal sector could be by looking at breeding methods. They are of extreme importance within the animal agriculture sector, with many businesses working towards the selection of specific traits in various ways (Farstad, 2018). The current technologies available by which breeding selections occur are phenotypic selection, genomic selection and genome editing (Andersson, 2001; Tan et al., 2017; Tait-Burkard et al., 2018). Artificial selection is a key component of the farm animal industry and is used to ensure that animals exhibit more characteristics beneficial to businesses that would make the animals either grow more, develop more quickly or use fewer resources. The main goal of the farmers is to obtain more meat, dairy or nonfood products for a lower amount of resources, or to make the animals easier to handle and more adaptable to optimised farming conditions.

Phenotypic selection is the traditional way of conducting artificial selection. With this, farmers choose breeding animals by eye, judging for certain observable traits that they believe serve as predictors by which they can expect offspring more suited to their farms. This type of selection has been an effective method as changes in the farm animals have been observed over time, however, it is not guaranteed to be successful in every generation. There is a lot of room for error because it is the farmer's intuition by which breeding choices are made, thus there is a degree of bias and a lack of control over important factors in the scoring of the farm animals involved, therefore making it difficult to objectively prove that the choices made are good ones (Farstad, 2018; Andersson, 2001; Holloway & Morris, 2008).

Genomic selection is considered the current state-of-the-art approach. It works by observing desired markers in the genome that are analysed to give breeding values. Farm animals with a high breeding value are expected to pass on more favourable traits to their offspring, thus making them more valuable to the farm. The accuracy of the method depends on the processing of genomic data relating to herds or flocks of animals to gain information about beneficial genetic characteristics and their correspondence to phenotypes. This data-based approach provides insights into which genetic profiles are good to select for, with the insights gained crucial when making breeding selection choices resulting in optimal pairings. The main flaw with this comes from the room for error in the data set, as the genotype may not match the phenotype when the technique is used at farms, as the control group used for the data set may have its own biases and issues in reliably showing which genetic markers result in specific desired phenotypes (Tan et al., 2017; Andersson, 2001; Holloway & Morris, 2008; Brito et al., 2020).

Genome editing has been tested in the animal agriculture sector with success in the recent past. There are examples of successes in using this technology to bioengineer farm animals to exhibit particular traits that may have been impossible to select for with phenotypic or genomic selection. Genetic engineering has become very precise, with the targeting of certain characteristics by knocking out or replacing parts of the genome at specific points proving very effective in ensuring that the animals show desired traits. The problems with genome editing are either ethical or have to do with a lack of knowledge regarding the types and amounts of genes affecting phenotypes (Tait-Burkard et al., 2018). This technology can be revolutionary for the farm animal industry when it comes to breeding selection methods for domesticated animals. The ethical component of genetic engineering is recognised as a massive issue due to the novelty and accessibility of this

modern tech, with the implications of the technique's use still to be scrutinised in full and the ethical debates surrounding the use of bioengineering in farm animals still ongoing (de Graeff et al., 2019).

The ethical debate around the use of genetic engineering in farm animals

In this section, the state of the current ethical debate around the use of genetic engineering in farm animals is addressed and analysed. This debate has mainly identified and addressed seven topics of great importance; efficiency, human health, potential risks, public acceptability, environmental impacts, animal welfare and animal dignity (de Graeff et al., 2019; Borgdorf & Meijboom, 2022). Each of these topics has an impact and bearing on the breadth of the ethical debate surrounding the bioengineering of farm animals.

The current ethical debate around farm animal bioengineering

First of all, the efficiency of genome editing is seen as a major positive aspect, in that the genetic engineering of stock can allow for the animals to give higher yields of food and non-food products, and thus benefit humanity significantly. The low cost of modern genome editing is another aspect to be contemplated, as it is now economically viable to make use of bioengineering to obtain animals that are more suited to the needs of the animal agriculture sector. There is also the consideration of environmental gain from genetic engineering due to increased efficiency, as it would allow farms to consume fewer resources and emit fewer pollutants into the environment for the same or larger levels of product output. However, the other side of the efficiency topic is the gigantic environmental impact of agriculture on climate change to ponder; stopping agriculture could reduce carbon dioxide emissions this century to 32% of the estimated value (Eisen & Brown, 2022). Genome editing can mitigate this impact and help its achievement without stopping certain farming activities, however, the agriculture sector itself would still contribute significantly to climate change unless bioengineering technologies advance further in their effectiveness and range of applications to the point where they can be used to stop all of the negative impacts of the farming on climate change.

Another aspect of efficiency that may make it insignificant or negative as a part of the ethical debate on farm animal genome editing is that the current economic system is based upon growth. Efficiency gains could lead to more adverse environmental impacts from farming as the whole industry is focused on producing more value and selling more products, thus making higher efficiency irrelevant in combating the negative impacts of the animal agriculture sector. A clear example of this would be Dutch government regulations after WW2 leading to innovations like the development of compounded feed, thus resulting in the advent of factory farms. This development significantly increased the output of farming businesses and the negative impacts on animal health and well-being and environmental pollution. Furthermore, previous efforts to improve the efficiency of breeding are known to have increased the suffering of domesticated animals from a welfare perspective. This could also happen with the viability of genetic engineering as a breeding and selection technology for farming businesses; the main consideration is that more yield will be desired by farms and thus more animals will be born, resulting in more diseases and injuries for the farm animals, hence more suffering and issues with the health and well-being of the stock (de Graeff et al., 2019; Borgdorf & Meijboom, 2022).

On the other hand, the bioengineering of farm animals could also have a positive impact on the interests of animals. Improvements to animal health and well-being could happen through the genetic engineering of the animals to be more resistant towards

disease or environmental conditions. The genome editing of the stock for these aspects would allow farmers to make less use of antibiotics, thus lowering the risk of zoonotic infections and improving the hardiness of the farm animals as well. Another positive impact of bioengineering on animal welfare would be the avoidance of painful procedures by ensuring animals do not have the characteristics that necessitate these practices, thus improving the health and well-being of the stock significantly. An example of such a potential advance is in the welfare of poultry, where culling could be avoided by making gender checks in eggs easier, thus allowing for gender change in the chicks or the culling of male chicks before hatching, hence reducing the suffering of poultry. Finally, genome editing of farm animals can go so far as to 'downgrade' farm animals to ensure they feel less or no pain. This would involve the genetic engineering of animals to do things like blinding chickens to stop adverse behaviours. If the definition of welfare as pleasure and absence of pain is used it is possible to justify this point of view. However, something to contemplate would be whether there is more to animal health and well-being than only pleasure and the absence of pain; there may be a dignity factor to consider when it comes to animal welfare. Finally, there are risks to the integrity of farm animals via the presence of unwanted mutations, however, the modern technology available for genetic engineering is rather precise and there are many experts available to guide the use of the tech, thus the risks are low (de Graeff et al., 2019; Borgdorf & Meijboom, 2022).

A clear and concise criticism of farm animal genome editing is that it can be labelled as a 'technofix', meaning that the technology does not help in tackling the moral issues present in the systems used by farming businesses. However, some of the obstacles can be fixed with the use of this tech, though more fundamental concerns can arise as a result of genetic engineering as well. Alternative solutions that could help tackle the structural problems in the animal agriculture sector include plant-based diets for humanity and the culturing of meat in laboratories. These alternatives would help in avoiding lots of complications with the current structures of the farm animal industry. On the other hand, this would mean that humanity would need to move away from animal agriculture completely. What is important to acknowledge is that the bioengineering of domesticated animals works within the confines of the animal farming system for this type of application. Therefore, shunning farming businesses and their procedures is not exactly possible when considering the ethical debate around the genome editing of farm animals. This is because these alternative solutions tackle an overarching predicament, but this current ethical debate around the bioengineering of farming stock takes place within the animal agriculture sector that the alternatives seek to forgo completely (de Graeff et al., 2019; Borgdorf & Meijboom, 2022).

Recognising that in this ethical debate it is necessary to see how things can be done within the systems involved in the farm animal industry, a very valid point would be that improved farming conditions could reduce the need for some of the solutions offered by the genetic engineering of animals. Examples include ensuring that less overcrowding occurs in farms to reduce disease and adverse behaviour from the stock. Another consideration which the structures of the poultry industry could do with thinking about would be tackling the culling of male chicks. Their culling is an economic choice that causes great suffering and violates their animal welfare, however, it is worthwhile to contemplate whether raising the chicks to later kill them is a better alternative. A third example when it comes to addressing animal agriculture problems without bioengineering farm animals would be the handling of horned cattle. They are mainly dangerous to other cows or farmers and are generally only dangerous when they are provoked in some way, such as being subjected to overcrowded farms or when feeding from the same place as other cattle. It would thus be easy to fix some of the headaches surrounding horned bovines by allowing for better farm conditions for the livestock, and thus genetically engineering them might be unnecessary. A final example would be anaesthesia not being

used when castrating pigs or debeaking chickens, which is something that could be done for the health and well-being of animals but is not done in the current system. However, it is regarded as an area where the bioengineering of animals can help (de Graeff et al., 2019; Borgdorf & Meijboom, 2022).

It is thus unclear whether the genome editing of farming stock will help fix complications in the modern animal agriculture sector or simply help to exacerbate them; this is unknown and would be speculative, making it hard to judge what the right approach might be. An ethical factor to scrutinise would be the level of complicity in foundational concerns that one could experience when one supports the genetic engineering of farm animals. Seeing how many of the troubles in farming business practices can be mitigated with simpler steps it may be prudent to support the transition to improved mechanisms to tackle some of the negative aspects of the current structures. Once some of these issues have been tackled it would seem that the genome editing of farming stock is one of the best options available when operating within the confines of the current systems in place in the animal agriculture sector (Devolder, 2021; Borgdorf & Meijboom, 2022).

Other factors to ponder in the ethical debate surrounding farm animal genetic engineering include animal dignity and public perception. Animal dignity is an important factor due to the potential increase of the power imbalance between humans and animals by making use of bioengineering in farming stock. The major concern when considering animal rights is that the technology can harm the integrity of farm animals. The positive aspects could be that with the genome editing of domesticated animals there may be fewer violations of the rights of the animals as fewer acts like debeaking, castration and dehorning would be needed, thus potentially resulting in a reduction of awful acts. However, from an animal dignity perspective, any tech operating within the current system is still problematic, as the mechanisms remain those of exploitation and wrongdoing, especially when envisaging the conditions that the farming stock is subjected to. Public perception is important to recognise as well, as for many factions in the population genetic engineering is unnatural. Most of the arguments against the use of bioengineering are rooted in emotion for the laypeople who oppose it. These kinds of resistance against technology are hard to overcome and will take a lot of time, effort and education to tackle, and will require a lot of directed efforts to discuss the palatability of genome editing amongst those in opposition (de Graeff et al., 2019; Borgdorf & Meijboom, 2022).

<u>How to expand the current ethical debate</u>

With the public perception in mind, it is important to understand the shortcomings of the current ethical debate around farm animal genetic engineering when it comes to the types of individuals that are participating in the ethical debate at this time. The main people currently present in the ethical debate are primarily professionals, such as veterinarians and biomedical scientists. Farmers and the public are seldom consulted in the modern ethical debate (Meijboom & Stafleu, 2016). They are important stakeholders in this debate because they are the producers and consumers of animal agriculture products that could potentially come from genome editing, thus they should have a voice and be consulted about the use of new technologies that will change how current systems work in a democratic society. An aspect that is not being addressed due to the lack of public presence in the ethical debate are considerations relating to the imbalances between the profiteering of the farm animal industry against the interests of society. A good example of this is the farmer protests that have been taking place in the Netherlands in 2022, with the farmers in staunch opposition to government policy while the government is making attempts to tackle nitrogen emissions limits by trying to buy up, repurpose or shut down farms in areas of the Netherlands. The Dutch government is

trying to enact policies that it believes are for the public good, while the farmers are highly opposed to these policies because they would have a great impact on their business and profits. Finally, another aspect to contemplate in the ethical debate around animal bioengineering is that the population generally opposes the systems of intensive farming used in animal agriculture due to health and well-being concerns, as the people have a lot of sympathy for the welfare of animals nowadays (de Graeff et al., 2019; Borgdorf & Meijboom, 2022).

Considering all of this, it is important to think about the framework within which the ethical debate surrounding the bioengineering of farming stock is taking place and to identify the areas in which the ethical debate can be expanded. First of all, there is a lack of thought about animal well-being in the current ethical debate. Most of the arguments within the debate are centred around how genome editing would be beneficial to the structures of the animal agriculture sector and to humanity as a whole from efficiency and health gains rather than recognising the impact on the animals. While the impact on farm animals is examined, it is not a part of the debate that is given as much weight as the impact of this technology on humanity and the farm animal industry's economic considerations. This gives rise to a lot of questions about how to see animal agriculture in the debate. Questions surrounding the systems of the farm animal industry include the following: Should the current exploitative framework continue? Is it morally justifiable? Do we need to revisit the underlying assumptions of such structures and reevaluate our way of treating animals?

When tackling these questions it is important to look at the root causes of these questions and the perspectives that these questions might take. The assumptions surrounding the processes used by the animal agriculture sector are guided by a perspective where farm animals are products that can yield food and nonfood products that consumers generate demand for. This view is one in which animal health and well-being are barely acknowledged, but rather where what animals can do for humanity in the form of products is what is considered of greatest importance. This is characterised by the farm animal industry and the ethical debates moving in a direction that asks for the further efficiency of structures with a lack of regard for animal welfare; the main goal that the animal agriculture sector is working for seems to be that of getting products to consumers as cheaply and efficiently as possible while maintaining high-quality standards (de Graeff et al., 2019; Borgdorf & Meijboom, 2022).

Government regulation seems like the only force stopping the system from increasing the imbalance in priorities further than they already are, as it is the only force that may be capable of using regulation to alter how the farm animal industry and its mechanisms function. Many of the technologies developed over the years in animal agriculture have exacerbated the levels of exploitation, with animals being skewed further and further towards a position in which they are purely products for the consumption needs and wants of humanity rather than living as beings with their way of living and natural behaviours. Genome editing seems to be the next advance in a line of technologies that have skewed the balance between humans and farming stock and how farm animals are used within the context of animal agriculture. A philosophical approach that has proven useful in looking at the relations between multiple entities and the power structures within such relations is that of Foucault's 'biopower' and related 'biopolitics' framework. This approach is often used to look at the balance of relationships between entities and thus could inform the ethical debate around the bioengineering of farming stock significantly, however, it is important to understand the approach first before its application.

On ‘biopower’ and ‘biopolitics’

The first step towards exploring whether the Foucauldian approach has value to add to the ethical debate around livestock genome editing is understanding the concepts behind the approach. This section introduces the concepts of ‘biopower’ and ‘biopolitics’. These concepts are fundamental to the Foucauldian account.

Understanding ‘biopower’ and ‘biopolitics’

Foucauldian ‘biopower’ and ‘biopolitics’ are concepts that can be applied to analyse many phenomena experienced in society that tend to be related to demographics and the management thereof (Foucault & Rabinow, 2000). The main characteristics of these two concepts relate to how society engages with ‘power’ and the perceptions thereof. The idea of ‘power relations’ is central to the foundations of these concepts. ‘Power relations’ as an idea works with the consideration that ‘power’ as a thing does not exist, but that it is derived from how entities interact with each other. How Foucault underpins this idea has to do with examining the relationship between the state and the subject. The major point in state-subject relations is acknowledging that conflicts are fought between different entities to impose perspectival and strategic truth. The Foucauldian strategic truth consists of rationalisations that function as the basis of truth instead of absolute facts. These conflicts surrounding a subjective form of truth lead to an historico-political discourse where a perspectival truth is used to obtain victory for one side. This implies that when ‘power relations’ are at play that it is about one of the parties involved in the relationship fighting to have their reality seen as the true reality, where the other parties participating in the relationship have alternate views of what the true situation is. The example of the relation between the state and the subject is an intriguing study, in the sense that there are rights given up by the subjects to gain the protection given by the government, and in turn, the government has responsibilities that it must fulfil and ensure it delivers to its subjects. This relationship is what underpins the Foucauldian view of society, in which societies are composed of intricate relations between the state and the subject. The conflicts fought between entities are about shifting the relations into a more beneficial arrangement for one of the parties via the imposition of perspectival and strategic truth from one side. These shifts in ‘power relations’ can happen gradually with many small conflicts and pushes or quickly with large conflicts. The current state of ‘power relations’ is thus based upon rationalisations as compared to facts and rationality because the truth that is imposed by an entity is subjective rather than objective. ‘Power relations’ thus tend to be skewed by one entity that wins and then gets to impose its perspectival and strategic truth on the other (Foucault & Rabinow, 2000).

With all of the information above the buildup towards ‘biopower’ and ‘biopolitics’ can be described. Over time the needs of the state as an entity shifted as other states also changed and improved and new dilemmas arose for the state to tackle. These new problems necessitated the development of new techniques, approaches and technologies to serve as solutions for the obstacles faced by the state. This stimulated the development of new political structures, springing from the new economic and social relations that have come about from the fixes to the new disputes the state needed to solve. Finally, the birth of these new political frameworks contributed to the shifting of ‘power relations’ and the way they work between the state and the subject and the interactions between states. In turn, this led to the creation of the idea of the ‘reason of state’, in which the state employs a matrix of rationality that allows the state to exercise its sovereignty. The biggest shift in the way in which states interacted with their environment and the ‘power relations’ involved was in the base they used from which to

look at the ‘power relations’ they were party to; a move was made from a base of abilities and virtues to a base supported by the rationality of principles and application.

The move is of great importance to the concepts of ‘biopolitics’ and ‘biopower’ because with these concepts the power of the state became tied to subjective and relative strength within a rationalisation framework in contrast to the more absolute strength of the state in the structure of values and capability that was there previously. This was characterised by increased competition amongst states, the necessity of the brokering of alliances to accumulate more forces and the strengthening of the state by working on internal and external factors mainly measured by population and wealth. It is hard to measure the relative contribution of population and wealth to the strength of the state, and thus the term ‘political economy’ helps to combine these two main measures of the ‘reason of state’, however, the balancing of resources and population with regulation and the adaptation of resources to handle the needs of the population is a difficult balance to strike. In turn, the population in the ‘reason of state’ is not governed by just the number of subjects, but rather by many factors that influence the well-being of the population and the subjects that constitute it. The factors that govern the health of the population are then regulated by the framework that props up the ‘reason of state’, and these systems can be modulated by rules and laws that serve as the foundations of such structures. With this, we have the birth of ‘biopower’ and ‘biopolitics’, where ‘biopower’ refers to the techniques that are used to regulate the factors that influence the population, and ‘biopolitics’ is the blueprint within which the ‘population’ is treated as a mass of related living beings that have biological and pathological traits and thus needs the use of ‘biopower’ to be controlled and modulated (Foucault & Rabinow, 2000).

How to apply the Foucauldian approach

The ‘biopower’ concept and the ‘biopolitics’ framework are best applied when tackling factors that have great demographic importance, and thus have to do with the characteristics of a population. Examples of such factors include health, sanitation, birthrate, longevity and race, with many other factors involved that are relevant to the demographics of a population. Foucault recognised two main approaches behind the application of ‘biopower’ and ‘biopolitics’. Those approaches are through a lens of ‘liberalism’ and the lens of the ‘reason of state’. The ‘liberalism’ approach has to do with the exercising of government to aim for a maximised economy with minimal governance, and thus as little intervention and regulation as possible; this keeps the government small and minimises the growth of the apparatus of the state. The alternative is the continued use of the ‘reason of state’ approach, where the state takes actions to strengthen itself as much as possible and thus applies whatever laws and regulations it sees fit to make the most use of the population resources it has available and tries to modulate it for its gain. However, the market in its current form serves as a good test of how well each approach functions in specific contexts, as there is an incompatibility between the optimal development of the economic process and the maximisation of governmental procedures, thus each approach must be adapted appropriately or used in tandem so that the state can strengthen itself appropriately and take care of the health of society at the same time. The ‘liberalism’ approach strengthens society, whereas the ‘reason of state’ approach strengthens the state in the context of how the level of laws and regulations affect the health, strength and utility of the population.

This subjectivity in the case of governmental actions helps critique common conceptions of power, with the ‘power relations’ lens allowing us to look at this all from the perspective of regulation being a set of strategic relations, then using techniques and procedures to effect change based on the balance that is needed in terms of the level of intervention at play with regards to laws and regulations applied to factors governing a population. These methods are used to effect changes in the state and how it regulates

its laws, handles its needs and respects the views of society are informed by ‘techniques of the self’, a concept that builds upon civilisational perspectives of what it means to “know oneself” and “govern oneself”. ‘Techniques of the self’ consist of procedures that are suggested or prescribed to individuals to determine, maintain or transform their identity through relations of self-mastery or self-knowledge. This concept applies to any entity at an individual or a state level. For states it describes a state that consistently looks at its needs, the will of society and the regulations that must be put in place for those factors to be satisfied, allowing the state to analyse itself to choose better laws (Foucault & Rabinow, 2000). Now that this philosophical approach and the buildup to its relevance and use have been discussed, it can be used to add to the ethical debate around the bioengineering of farming stock.

Foucauldian ‘biopower’ and ‘biopolitics’ and the ethical debate around the genetic engineering of farm animals

The potential added value of the Foucauldian ‘biopower’ and ‘biopolitics’ concepts to the ethical debate around the bioengineering of domesticated animals is discussed in this section.

Perspectives on the farm animal bioengineering debate

It is important to ask in what ways the ethical debate surrounding farm animal genome editing can be improved in breadth and scope, and thus inform stakeholders better on the ethical dilemmas that are present with the application of genetic engineering technologies in farm animals and the context within which such actions may or may not be acceptable. One way in which this can be done would be the inclusion of scientists from multiple disciplines rather than choosing to concentrate on the veterinary and biomedical fields. This could yield more insights and knowledge for the ethical debate that may not be so apparent at this time. The public should also be drawn into the debate by asking them questions about the ethics of farm animal bioengineering, thus again broadening the debate and incorporating more important stakeholders. Finally, the use of a plethora of ethical approaches and theories present in literature could be beneficial in addressing the breadth and scope of the debate and exploring all of the aspects and perspectives involved in the ethical debate surrounding farm animal genome editing. It is also worthwhile to look at ways in which it is possible to specify how to scope the ethical debate. An article written by Kramer and Meijboom about scoping methods and how they work sheds light on how scoping helps to find different aspects to look at and what importance to assign to parts of the ethical debate (Kramer & Meijboom, 2022). It is good to consider scoping as it helps people involved in the ethical debate make important choices, such as choosing appropriate ethical approaches and thinking about whether genome editing should be regarded as a standalone technology with its impacts or if it should be evaluated in the broader context of the systems of the farm animal industry, with the technology addressed in the context of the issues inherent in the framework (de Graeff et al., 2019; Borgdorf & Meijboom, 2022; Kramer & Meijboom, 2022; Swierstra, 2015).

The concepts of Foucauldian ‘biopower’ and ‘biopolitics’ are the ethical approaches that can be used to give a lens and some different perspectives in the ethical debate around farm animal genome editing. When applying Foucauldian ‘biopolitics’ some of the contexts behind the decisions taken in the farm animal industry become apparent and some of the hitches in the assumptions behind the current ethical debate are laid bare. Examples of the application of Foucauldian ‘biopower’ and ‘biopolitics’

when looking at the use of genomic selection in animal agriculture and the impact of genetic science on farm animals are available and go into great detail on how the concepts can be applied to look at the ethical debate relating to those topics (Twine, 2015; Holloway & Morris, 2012; Holloway et al., 2011; Twine, 2007; Kramer, 2020; Holloway & Bear, 2021). While those examples are of great importance, they address the ethical debate around genomic selection and genetic science use in the farm animal industry, meaning that they are beyond the scope of the current ethical debate surrounding the use of genetic engineering. However, it is important to keep these studies in mind as they have shown how Foucauldian 'biopower' and 'biopolitics' can be applied to technological advances in the animal agriculture sector and why this kind of analysis is important, as will be demonstrated.

Applying the Foucauldian approach to the ethical debate

First of all, the needs of the state arise from modern problems faced by the state, resulting in the development of new technologies and techniques to face whatever issues the state has to handle. This idea applies to the farm animal industry due to headaches states face around food insecurity, environmental impact and the improvement of efficiency in both aspects. Another factor to ponder in the case of the needs of the state is the current systemic economic approach relating to the desire for constant growth and more profits leading to state demands for further efficiency in many fields to be able to sustain growth with fewer or equivalent amounts of resource investment. The farm animal industry is a key example in this aspect when it comes to important factors that influence the strength of the state. The state's desire for efficiency results in the further skewing of already very imbalanced 'power relations' in the case of the farm animal industry that has been facilitated by advances in technology. The current state of the farm animal industry has the whole industry imposing its victorious 'truth' onto farm animals in the context of 'power relations' and the battles fought by the state to meet its needs and strengthen itself. With the current systems, the farm animal industry is trying to maximise its economic potential within governmental regulation frameworks.

The main issue with this approach by the state is that this point of view is only possible with the view of farm animals as products, however, it is important to note that there are factions within the state and animal agriculture that regard animal health and well-being as a high priority. The view of farm animals as products leads to a denial of the dignity of the farm animal, which is enabled to occur due to the 'power relations' at play throughout the process of the establishment of the farm animal industry, the roots of which can be traced to the development of domestication itself many thousands of years ago. It is the process of domestication and the needs of the state-like entities to address human food security problems that serve as the main drivers of the gradual subjugation of wild animals to domesticated animals. The domesticated animals have then over time been subjected to the further skewing of 'power relations' giving rise to the idea of farm animals as farmed products. The 'power relations' at play between humans and farm animals are currently showing humans and the farm animal industry as controllers of the fate of farm animals.

When viewed through the Foucauldian 'biopolitics' lens it seems like there was a sense of inevitability when it comes to the development of new techniques and technologies to skew the 'power relations' between humans and farm animals further. The socio-political context showing the need for the domestication of farm animals to supply humanity with food and nonfood products has slowly but surely gathered steam and shown more of its relevance with the further development of human civilisation and the resulting states that have come from this forward progress. The human ability to alter the 'power relations' between humans and farm animals via improved techniques and technologies used to meet the needs of the state that have arisen from the developing

socio-political context has resulted in farm animals being forced further and further away from their initial wild telos, to the point where techs like genome editing can even completely remove the initial wild telos of the farm animal for good. The animal telos is of huge importance when scrutinising the 'power relations' between humanity and domesticated animals, as the skewing of this relationship to an extent where it is debatable whether the animals are animals anymore would be an intriguing perspective to research further.

Genome editing is simply the newest in the line of technological advances involved in domestication, a process that has gradually turned into the extreme exploitation of farm animals. In the end, the same principles used to justify previous advances that have altered the 'power relations' between humanity and farm animals are the ones that can be used to support the bioengineering of farming stock. The principles involved in this justification of the use of genome editing in domesticated animals stem from the needs of the state and the key position of food security in the priorities of the state. As a result, the management of the farm animal population by the state is seen by the state as a resource that must be exploited as much as possible and to the fullest extent of the state's ability. This is because food security is recognised as being amongst the main factors that give states strength.

The rationalisations that are present in the 'power relations' of Foucauldian 'biopolitics' permeate most aspects of the modern farm animal industry, with justifications for the further subjugation of farm animals easy to come by. The state has extensive experience in justifying the use of new technology to meet the needs of the state when it comes to managing the human population, and this comes about by using the farm animal population as a resource and a lack of regard for animal welfare or dignity. The adjustment of farm animal demographics to favour humanity as much as possible is already occurring. The use of genome editing technology in farm animals gives more tools to the farm animal industry by which they can manipulate key aspects of farm animal demographics to favour the state's food security and humanity as a whole.

The 'reason of state' matrix of rationality that is based upon the rationality of principles and application rather than abilities and virtues is a key proponent by which this treatment of farm animals is justified. The rationalisations in favour of genome editing are thus informed by the skewed 'power relations' between humans and farm animals, allowing for the justification of many acts by humanity to subjugate farm animals and push them into a lowered state, thus making the commodification of farm animals the norm. The lack of emphasis on abilities and virtues that was present before the use of the 'reason of state' matrix of rationality means that states have an easier time ignoring moral or ethical concerns in favour of farm animal welfare. The state simply focuses on the needs of the state and the rationality required to forget or ignore the dignity of the animal as that is what is in the state's interest according to the 'reason of state'. However, 'liberalism' is no saviour either. When it comes to regulations in the farm animal industry, the liberal and neoliberal ideas of how to govern less result in the government not trying to protect the welfare of farm animals. The government does this by choosing not to intervene against the line of reasoning used to justify the domestication and further exploitation of animals, as an intervention in this regard does not benefit the government or society in any way according to the 'power relations' involved between humans and farm animals. Therefore, both the 'reason of state' state perspective and the 'liberalism' society perspective work towards justifying the use of genome editing on farm animals from the commodification of animals being justified and a lack of will to regulate the livestock industry.

It can thus be said that there is a movement towards the optimal development of the farm animal industry due to a lack of intervention from the state, or sometimes even the intervention of the state in favour of the further exploitation of animals using the same

line of reasoning as humans have used in history to justify the domestication of animals. This further exploitation is mainly facilitated by the technological advances that are driven by the needs of the state. However, societal views on the farm animal industry are shifting, and thus in turn some states are starting to intervene against the farm animal industry to protect some of the dignity of the farm animals. Examples of these include regulations against some harmful practices conducted against farm animals such as the banning of forced moulting in poultry farming in the EU. Societal shifts in the attitudes towards the farm animal industry are thus a potential threat of opposition against farm animal genome editing entering widespread use. Public consumers are now more aware of what they are buying and the treatment of the farm animal products that they wish to consume, and this influences the consumer's choices and thus works against the acceptance of genetic engineering in farm animals. The increasing popularity of plant-based diets and the purchase of farm animal products that are produced with more consideration for the dignity of the farm animal are factors that may cause the governments operating from both the 'reason of state' and 'liberalism' perspectives to be able to justify a higher level of importance for animal welfare and health concerns in the farm animal industry.

Changes in the market prove that this shift in mentality is reflected on a societal level. This may result in regulations that question arguments justifying the domestication and further exploitation of farm animals. A way to look at this shift in view by states may be related to the application of 'techniques of the self' spreading from the individual level to a societal level considering the gradual shift in society's attitude against the strengthening of the imbalance in 'power relations' between humans and farm animals. It may be possible that there is a will within society to transform its identity relating to how states and humanity as a whole treat farm animals, though this change is happening slowly. The use of the 'techniques of the self' by humanity to combat the rationalisation matrix surrounding the farm animal industry already seems to be happening due to the societal trends seen in recent times.

Conclusion

The questioning of the fundamental principles behind how technologies such as genome editing have come into being is a double-edged sword. It is possible to use the bioengineering of farm animals to alter the frameworks at play and the farm animal industry. However, it is also possible for genetic engineering to make the current systems and the modern animal agriculture sector more efficient for production and welfare. Thus, the main concern is whether it is possible to accept the ethical faults in the set of skewed 'power relations' between humanity and farm animals. The Foucauldian 'biopolitics' approach has clarified where the underlying assumptions lie in the ethical debate surrounding farm animal genome editing.

According to the Foucauldian 'biopolitics' approach, there are fundamental issues in the justifications that support the domestication of animals, and then excuse the increasing exploitation of farm animals over thousands of years. Recent technologies have accelerated the pace of this exploitation via a line of reasoning embedded into our society relating to domestication, the process functioning as the backbone of modern societies and states globally. However, the societal application of 'techniques of the self' at a large scale may be able to combat this line of reasoning, though it could also be used to justify using farm animal genome editing to effect changes in the 'power relations' between humans and farm animals. The 'techniques of the self' can thus cause governments to move towards a vision and set of 'power relations' between humanity

and farm animals that society is more comfortable with during and after applying the techniques to change its identity. When thinking of this, governments could take different decisions and actions on how to regulate the farm animal industry with its current ingrained assumptions and reasoning. Such a change is liable to happen with a Foucauldian approach, for the current decisions taken are informed by justifications that society is sceptical of at this time.

There can be a plethora of further studies based upon the insights of Foucauldian concepts in farm animal genome editing that could be of great relevance. Firstly, a deep focus on how the 'liberalism' and 'reason of state' frameworks within the Foucauldian approach impact the ethical debate would certainly be very informative in understanding the current regulatory steps taken by governments in this field. An account regarding the effect of technologies on animal dignity and telos from the Foucauldian perspective would also be of great interest, especially when inquiring about the skewed 'power relations' between humans and animals and the capabilities of both parties to modulate these relations. Finally, discovering more about how society is starting to apply 'techniques of the self' in the context of farm animal bioengineering and how this is occurring can be another intriguing topic of study. Overall, the application of the Foucauldian 'biopower' and 'biopolitics' concepts to the ethical debate surrounding livestock genetic engineering has yielded some new perspectives and new questions that have added value to the debate, with a lot of this value coming from views on technology use and its exacerbation of power dynamics problems in the context of the animal agriculture sector.

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