Food Ethics (2026) 11:23
https://doi.org/10.1007/s41055-026-00205-4

RESEARCH

Attitudes towards Genome Editing in Farmed Animals – a Cross-Cultural Study

Leon Borgdorf[1] · Elsa Delanoue[2] · Meta Candek-Potokar[3] · Valentin P. Haas[4] · Koen Kramer[1] · Franck L.B. Meijboom[1]

Received: 13 November 2025 / Accepted: 28 January 2026
© The Author(s) 2026

Abstract
Animal agriculture faces increasing moral and societal scrutiny. The GEroNIMO project aims to address challenges such as sustainability, welfare, and genetic diversity through genomic innovations. The ongoing debate about genome editing is mostly driven by experts from few disciplines with an emphasis on technical and science-based arguments resembling consequentialist reasoning without making systematic comparisons. To increase the range of arguments and stakeholders, we conducted eight focus groups ($n=70$) in Germany, the Netherlands, France, and Slovenia, representing rural and urban groups. Furthermore, we discussed alternative or complementary technologies to genome editing such as cultivated meat to both allow for systematic comparisons and to scrutinise the extent to which attitudes towards specific food technologies rely on general attitudes towards food technology. Guided by Critical Applied Ethics and Moral Foundation Theory, we identified underlying moral intuitions of the participants without uncritically adopting their arguments. Across all groups, benefits for animal welfare, fairness and transparency in economic motives, and trust in institutions emerged as key conditions for responsible use of genome editing in animal agriculture. While these concerns were broadly shared, participants from the Netherlands and Germany expressed relatively more openness towards technological food innovation, compared to those from France and Slovenia, within the scope of this qualitative study. Our findings highlight the need to understand the cultural and intuitive dimensions of moral reasoning for effective public engagement and responsible development of emerging food and breeding technologies. In particular, concerns rooted in feelings of disgust deserve deeper scrutiny rather than being addressed with harm-based arguments, which fail to address the moral roots of disgust.

Keywords Focus groups · Genome editing · Moral foundations · Public attitudes · Cross-cultural research · Farmed animals · Animal breeding

Extended author information available on the last page of the article

Published online: 11 March 2026

Introduction

Recent advancements in genome editing technologies, such as CRISPR-Cas9, have provided opportunities to reconsider animal breeding by enabling more precise, efficient, flexible, and cheaper breeding compared to previous technologies. On the one hand, since animal agriculture faces public criticism (see Schütz et al. 2023, p. 2), proponents of genome editing highlight its potential to alleviate moral issues related to animal agriculture. They argue that such technologies can improve animal welfare by increasing tolerance towards diseases, such as Porcine Reproductive and Respiratory Syndrome (PRRS) (Whitworth and Prather 2017) or heat stress (de Almeida Camargo and Pereira 2022). Moreover, harmful procedures such as dehorning can be made superfluous by breeding hornless cattle (Carlson et al. 2016). Breeding animals who need less feed (Kim et al. 2020) or reducing the amount of emissions in animals' excrements (Ruan et al. 2017) can tackle environmental issues associated with animal farming. On the other hand, genome editing technologies raise societal and ethical concerns (Nuffield Council on Bioethics 2021). Opponents of genome editing cite negative effects on animal welfare, which could occur directly or indirectly. Direct effects refer to, for example, Caesarean sections, mobility complications, and respiratory issues as consequences of increased muscle growth to increase productivity (Ishii 2017). Indirect effects describe an intensification of animal farming resulting from adapting animals to existing farming systems among others (Devolder 2021). Furthermore, there are concerns beyond welfare related to animal dignity or integrity (Nuffield Council on Bioethics 2021). This is in line with earlier discussions on biotechnology (e.g. Bovenkerk et al. 2002).

Although research on the social and ethical dimensions of genome editing is still relatively new, our study builds on previous work (Borgdorf and Meijboom 2024; de Graeff et al. 2019; Eriksson et al. 2018; Middelveld et al. 2022; Naab et al. 2021; Nuffield Council on Bioethics 2021; Yunes et al. 2021). A review of the existing literature (de Graeff et al. 2019, pp. 9–10) revealed four weaknesses in the current approach of addressing the societal and ethical dimensions. First, the public is underrepresented, while experts take the lead in the discussion. Second, literature includes little reasons for or against genome editing related to nonhuman animals. Third, in the current debate, primarily veterinary or biomedical scientists are involved, resulting in a lack of disciplinary diversity. Finally, there is a tendency towards consequentialist reasoning, which offers valuable insights, but there are other relevant ethical perspectives. In addition to improving these aspects, Kramer and Meijboom (2022) pose three scoping questions to broaden the ethical debate on genomic selection, which we believe are also applicable to genome editing. These questions relate to the inclusion of a broader philosophical vocabulary, the awareness that ethical concerns are not limited to novel dimensions of a technology but include existing issues that can be amplified or locked in by emerging technology, and the importance of the broader social and technological context in which the technology is emerging.

To address the lack of diversity in arguments and stakeholders in the existing analyses of the social and ethical dimensions of genome editing, this study aims to broaden the debate to (1) explore arguments beyond those reflected in the existing literature, (2) include the perspective of the general public, and (3) identify country-specific issues in the public evaluation of the use of genome editing in pig and poultry breeding. The latter aim starts from the hypothesis that, despite the fact that the science underlying genome editing is a global practice and legislation is often formulated at an international level, public perception also

depends on national and culture-specific considerations. Therefore, we hypothesize that further insights and grip on the national concerns and discussions are essential to deal with the societal dimensions and for answering whether – if at all – genome editing can be responsibly introduced in pig and poultry breeding.

With regard to the first aim, broadening the debate to explore lines of reasoning beyond the mainstream arguments, we deliberately paid attention to people's intuitive responses. The observed tendency towards consequentialist or risk-based reasoning reflects the characteristics of traditional ethics that have been criticized for merely considering rational arguments (Donovan 1990; Donovan and Adams 2007; Hursthouse 2011). In practice, however, there are strong reasons to assume that moral decision making happens intuitively to a relevant degree (Haidt 2001). Ethical intuitionists have argued that moral judgments that are based on intuition or emotion should not just be dismissed as 'irrational' or 'biased', but express what people value and thus present a starting point for ethical reflection (Roeser 2006).

A number of intuitive arguments from debates on other biotechnologies, such as cloning or the use of genetic modification of plants, often inform ethical views on genome editing. The European Group on Ethics in Science and New Technologies (2021, p. 43) concluded that their ethical considerations on cloning for food supply are equally applicable to genome editing of farmed animals. They reject cloning not in principle, but based on concerns for food safety, animal welfare and health, the need for traceability and labelling, moral unease with a new dimension of breeding, and the need for more research and public engagement (EGE 2008). European citizens are also critical of genetically modified food and cloning, especially when applied to food production (Frewer et al. 2013). In particular, they raise concerns about unnaturalness or playing God (Frewer et al. 2013; Gaskell et al. 2013). In these previous debates regarding the genetic modification of animals, intuitive arguments related to naturalness or "playing God" were quickly dismissed by rationalists as fallacies (Moldovan 2018). However, arguments such as "playing God" might also be read as a legitimate concern about humans overestimating their understanding of nature and responsibilities, which could lead to side effects, while naturalness could refer to legitimate concerns about food safety (Bovenkerk 2020; Sandøe et al. 1999; Schroten 2001). Indeed, psychological research confirms that the perceived importance of naturalness is related to the emotion of disgust, which is argued to function as behavioral immune system, protecting humans from eating potentially harmful food (Siegrist and Hartmann 2020). Although genome editing differs from other GMOs as it does not require the insertion of external DNA (Svingen and Jahren 2023), it is salient how little attention intuitive arguments received in the ethical debates revolving around genome editing.

In line with our second aim, fostering public engagement, we organized eight focus group discussions with citizens from four EU member states – France, Germany, the Netherlands, and Slovenia – who had little or no connection to animal breeding technology and the future of agriculture. While we acknowledge that the mere public endorsement of a certain practice or technology is insufficient for it to be morally acceptable, an exclusion of the public would violate values of equality and fairness in a democratic society. Furthermore, we aimed to contribute to public engagement in the debate on genome editing of farmed animals by conducting focus groups among members of the general public in these countries from both rural and urban areas and used these focus groups to explore relevant arguments and considerations.

Concerning the third aim, getting a grasp on country-specific differences, our assumption that public views on using genome editing in pig and poultry breeding might well differ across the selected countries aligns with previous research on values and farming systems in these countries[1]. While Germany and the Netherlands have a stronger background in Protestant traditions, France and Slovenia are primarily shaped by Roman Catholicism. In general, Protestant countries score higher on secular-rational and self-expression values than the Roman Catholic countries (Inglehart 2006). Schwartz (2014) maps countries via three dimensions, autonomy/embeddedness, hierarchy/egalitarianism, and harmony/mastery and concludes that Western Europe including France, Germany, and the Netherlands scores the highest on autonomy, egalitarianism, and harmony. East-Central Europe including Slovenia scores high on harmony and egalitarianism, but rather in the center of autonomy/embeddedness (Schwartz 2014). Furthermore, farming systems differ between these countries. Again, in Germany and the Netherlands, specialist livestock farm is the dominant model of farming, while France and Slovenia have mostly mixed farms producing both livestock and crops (Eurostat 2022). In countries where specialist livestock farming is dominant, farm animal welfare is considered more important and the percentages of vegetarians and vegans are higher than elsewhere in Europe (de Boer and Aiking 2026). Since technologies imply certain values and invite users to use them in certain ways and contexts (Verbeek 2012), the predominant values and farming system in the countries where genome editing is applied have to be taken into account.

Although cross-cultural studies on the ethical and societal implications of genome editing are scarce, some empirical studies involving general public exist. Overall, many Europeans have little grasp on genome editing: a 2025 Eurobarometer survey revealed that 37% of the Europeans previously heard about genome editing, which is a slight increase compared to 20% in 2022 (European Food Safety Authority 2025). Middelveld et al. (2022) conducted focus groups in the Netherlands with the general public, resulting in five narratives: (1) fixing social problems technologically creates new problems, (2) rich people will use the technology to maximize profit, (3) genome editing makes humans strive for perfection in animals and humans, (4) human endeavors to "play God" or dominate nature via genome editing might cause undesired long-term effects, and (5) genome editing should be developed carefully by experts with good intentions rather than industrial stakeholders. Borgdorf and Meijboom (2024) interviewed stakeholders involved in the fields of animal breeding, animal advocacy, and animal farming from different countries. They corroborated the results of Middelveld et al. (2022) by also identifying the first four above-mentioned narratives. In addition, they found two additional lines of reasoning, which are (a) genome editing being a morally neutral technology and (b) genome editing not being morally different from other breeding technologies. Similarly, Winther et al. (2023) mostly identified concerns about naturalness and the risks and benefits of genome editing.

Finally, to address the lack of animal-related arguments and systematic comparisons identified by de Graeff et al. (2019), we included cultivated meat as a complementary context of using genome editing. Cultivated meat is not only a potential alternative to genome editing, but can also rely on it since stem cell quality differs among animal breeds (Melzener et al. 2022). Public perceptions of this technological overlap have received little empirical attention to date. Including cultivated meat in the discussion allows us to examine whether

[1] We thank an anonymous reviewer for raising this point and for directing us to literature on values and farming systems in the countries considered.

public intuitions, such as disgust towards 'unnatural' food or the 'technofix' argument, are directed at specific technologies or at the broader idea of food innovations.

Based on the review of the literature, we formulated the research question for this study as: *Which societal and ethical issues related to genome editing in farmed animals are identified by the general public in France*, *Germany*, *the Netherlands*, *and Slovenia?* In this article we present four steps. First, we introduce the theoretical background that forms the basis for the design of the focus group discussions and the analysis of the result. Second, we elaborate on the methodology used. Next, we present the results in three clusters of fragments followed by a section with the discussion and concluding remarks.

Background

Our study has a theoretical background in Critical Applied Ethics (Leget et al. 2009) and Moral Foundations Theory (Graham et al. 2013). Critical Applied Ethics helps to relate the empirical to the normative. By relating both dimensions to each other, we can critically assess the focus group discussions to derive the normative implications of genome editing of farmed animals. Moral Foundations Theory can explain disagreements between participants and make sense of certain intuitions that do not appear rational. Combining both approaches can thus explain certain moral intuitions and taking them seriously without blindly committing to the arguments made by the respective participant.

Moral Foundations Theory

The discussion of our results is influenced by Moral Foundations Theory (MFT) which emphasizes the importance of intuitions in moral decision making. MFT distinguishes between six[2] different moral foundations that shape moral agents' intuitive moral judgements (Graham et al. 2013). According to Graham et al. (2013), foundations are rooted in humans' evolutionary psychology and evolved, inter alia, culturally, to adapt to specific challenges in the past, but are predictive of moral intuitions today. This interplay between evolutionary and cultural influences is illustrated by the metaphor of moral taste receptors as taste receptors differ per individual, are culturally shaped and rooted in evolution (Graham et al. 2013, p. 60).

First, the Care/Harm foundation is triggered by cuteness or suffering in others and might elicit compassion with the victim and anger towards perpetrators (Graham et al. 2013, p. 69; Haidt 2012, p. 155). In the context of food technologies, an argument related to the reduction of animal suffering appeals to the Care/Harm foundation. Second, the Fairness/Cheating foundation is concerned with proportionality and triggered if someone takes an unfair advantage. Possible emotions could be pleasure, liking, anger, and contempt (Haidt 2012, p. 159). Arguments related to food technologies based on this foundation could be related to companies benefiting from the respective technologies, while animals or hard-working

[2] Originally, Graham et al. (2013) suggested five moral foundations, care/harm, fairness/cheating, loyalty/betrayal, authority/subversion, and sanctity/degradation. Later, Haidt (2012, pp.196–211) argued that the fairness/cheating foundations originally covered both fairness in the sense of proportionality and in the sense of liberty/oppression. For this reason, we treated fairness/cheating in the sense of proportionality and liberty/oppression as two distinct moral foundations.

farmers could be disadvantaged. Third, Liberty/Oppression is closely linked with equality and is activated when someone's liberty is threatened by others. Arguments related to this foundation could refer to governments or companies forcing technologies onto people. These three foundations are called individualizing foundations because they relate to individuals. Fourth, Loyalty/Betrayal is about loyalty towards the ingroup and elicits hatred towards traitors (Haidt 2012, p. 164). A loyalty-based argument against modern food technologies could be that international companies might benefit rather than regional farmers. Fifth, Authority/Subversion is concerned with respect for hierarchical relationships and traditions. The worry that technologies such as genome editing might destroy traditional practices is related to this domain. Finally, Sanctity/Degradation relates to purity and violations evoke disgust. Some disgusted reactions towards food technologies are likely based on these foundations. These three foundations are called binding foundations because they are related to a collective rather than towards individuals. While most people agree on the importance of the individualizing foundations, the binding foundations are primarily found in conservative people.

The binding foundations traditionally receive little attention from Western public institutions. For example, a study found that the EU appeals to the individualizing foundations in its communication (Grosfeld et al. 2024). The authors also found that people who prioritize the binding foundations distrusted the EU more, although this could be counteracted by adjusting one's communication towards the binding foundations (Grosfeld et al. 2024). Therefore, identifying people's moral foundations and taking them seriously is key to effective communication and building trust in institutions. As stated earlier, we believe that public acceptance, which involves at least some degree of trust, is a necessary condition for an ethical implementation of genome editing.

Critical Applied Ethics

Methodologically, we follow the approach of Critical Applied Ethics (Leget et al. 2009), which aims at an iterative process in which empirical and normative approaches condition each other. On the one hand, our empirical research and its instruments are informed by philosophical theorizing. The topic guide (supplementary file) for the focus groups is based on the scoping questions provided by Kramer and Meijboom (2022), existing concepts in animal ethics, moral psychological research on moral foundations, but also previous empirical work done (Middelveld et al. 2022). On the other hand, the ethical reflections offered later in this paper are informed by empirical data derived from the focus groups. The empirical component of this research consists of focus group discussions. Since it is impossible to derive a normative conclusion solely from descriptive facts, we critically discuss the narratives provided by participants. In this discussion, we use MFT to identify underlying intuitions behind people's concerns. We discuss to what extent these intuitions can be justified by indeed relating to ethically relevant concepts and concerns. An example is disgust felt towards novel foods as an expression of one's concern towards food safety (Siegrist and Hartmann 2020). Whether this concern is justified depends on whether the respective food is actually safe. In cases where concerns are justified, we advise taking them into account, while we advise to pick a suited communication strategy addressing the corresponding underlying moral foundations in case they are not justified.

In line with this approach, this study draws on previous qualitative research on the public perception of genome editing in farmed animals by reoccurring narratives by the participants (Middelveld et al. 2022). Narratives can be defined as "stories to which we always return" and are "emotionally felt, without footnotes, without explanation or interpretation" (Heller 2006, p. 257). This corresponds with the idea of MFT highlighting the importance of intuitions in moral decision-making. Moreover, this approach is useful to classify and categorize arguments of the general public without any specific background in ethics or philosophy.

Methods

Context and Countries

This study is part of the GEroNIMO project, a Horizon 2020 EU project focused on developing innovative genome- and epigenome-enabled selection methods for sustainable breeding of chickens and pigs. This project includes research on societal challenges such as human population growth, farming sustainability, and changing socio-cultural values of animal breeding. In this particular research, we focus on genome editing using CRISPR-Cas9 technique as a breeding innovation gaining public and scientific attention. This Project consortium involves partners from various EU member states, including France, Germany, Slovenia and the Netherlands, which were selected to represent the diversity of cultural differences (i.e. language, history), size, geographical location in Europe, and the position of agriculture in their history and economy.

The project received approval of the Geosciences Ethics Review Board (SG ERB) of Utrecht University (reference: subject ERB Review DGK S-23894).

Participants

We organized 8 focus group discussions. In each of the four participating countries, there was one focus group among participants from an urban area and one from a rural area. We aimed for 7–9 participants in each group. In France and the Netherlands, all participants were recruited via professional recruitment agencies. In Germany and Slovenia, we used both professional recruitment agencies and convenience sampling based on the wider network of local partners, to obtain a sample that met our criteria. Although we aimed for diversity within the focus groups, we tried to avoid situations in which people felt alone with their opinion and perhaps might not have had the courage to speak up. Previous research showed that demographic variables matter in so far that people, who are male, young, wealthier, associated with livestock productions, and consuming meat are more likely to accept genome editing in farmed animals (Yunes et al. 2021). Hence, the desired criteria for the composition of each focus group were the following ones.

- gender (at least 3 male and 3 female),
- age (at least 1 < 30; at least 1 between 30 and 55, at least 1 > 55),
- educational level (non-academic/academic; at least 3 per group), and.
- eating behavior (at least 2 plant-based, vegetarians, or flexitarians).

- level of urbanity (1 rural and 1 urban focus group per country).

In total, 70 people participated in the focus groups and the recruitment criteria were met in most of the groups (Table 1). Still, there were some differences between groups as the participants in Germany and Slovenia had a saliently different age distribution. To grant confidentiality, we replaced the names of the participants with codes resembling their demographics.

Materials

The topic guide used for the focus group consisted of five sections, which were an introduction, three main discussions about human-animal relations, the future of farming, and genetic innovations, and a concluding section. The introduction session highlighted some basic principles of focus group discussions, including inviting the respondents to ask questions first rather than immediately criticizing the other in the case of disagreements and to see the process of a focus group discussion more as a process of collaboration than as a competition (Barbour and Morgan 2017). Furthermore, the participants were asked to introduce themselves shortly and they were asked to name their favorite dish and favorite animal.

This paper focuses on the main topic of the focus group discussions, genetic innovations in animal breeding. First, the respondents were introduced to the technology of genome editing. For this purpose, we used an update of the information according to the study of Middelveld et al. (2022; see Online Resource 1). Our material highlights that genome editing involves targeted modification of existing genes rather than inserting external genetic material, a distinction that scientists consider important for fostering public acceptance (Svingen and Jahren 2023). Subsequently, we asked them to state what they know about genome editing technology and express their first impressions. After having a general discussion about this technology, we presented four different breeding goals. Based on previous research, which identified human health, productivity, animal health, and improving animal welfare as a possible categorization of breeding goals (Ishii 2017, p. 29), we conceived four different, but related categories, which were human purposes, animal welfare, environment, and shift to alternative proteins. The reason was that we regard the distinction

Table 1 Demographic data

Gender	Ger *R*	Ger U	Slo *R*	Slo U	F *R*	F U	Nl *R*	Nl U	Total
Male (M)	5	5	6	3	3	3	4	5	34
Female (F)	2	3	5	8	5	5	6	2	36
Age	4	6	2	1	2	1	5	2	23
<30 (Y)	3	1	5	5	5	3	3	4	29
30–55 (M)	0	1	4	5	1	4	2	1	18
>55 (O)									
Education	5	6	5	8	5	3	5	3	40
Academic	2	2	6	3	3	5	5	4	30
Non-Academic									
Diet	0	2	2	0	0	0	0	0	4
Plant-Based (P)	2	0	0	2	1	0	1	4	10
Vegetarian (V)	0	0	0	0	2	3	0	1	6
Flexitarian (F)	5	6	9	9	5	5	9	2	50
Omnivore (O)									

Ger Germany, *Slo* Slovenia, *F* France, *Nl* Netherlands, *R* Rural, *U* Urban

between animal welfare and animal health as redundant since we claim that, in line with most approaches to animal welfare, health is an essential constituent of welfare (Berthe et al. 2012). Furthermore, we aimed to broaden the discussion by including environmental purposes as well as a potential transition away from animal-based proteins. Under human-related goals, we listed allergen-free dairy and eggs, productivity, and meat quality. For animal welfare, we proposed robustness against circumstances such as heat stress or diseases, but also the replacement of potentially harmful procedures such as dehorning by breeding hornless cows as breeding goals. Environmental breeding goals were a reduction of emissions and feed efficiency, while a breeding goal related to a shift towards alternative protein was to increase the quality of stem cells for cultured meat. Per discussion, one breeding goal of each category was selected and the participants were asked to rank them in terms of desirability and to propose their own breeding goals.

Finally, the respondents were presented three visions of genome editing (see Online Resource 2), which were in line with the study by Middelveld et al. (2022). The first scenario was a positive one, which identifies genome editing as a revolution improving animal welfare, meat quality, productivity, and sustainability, as it is frequently envisioned by companies or scientists (Ruan et al. 2017). Although this idea of a revolution was stated seven years ago, similar ideas are still expressed today. For example, Winther et al. (2023, p. 477) call genome editing a game-changer which they define as "newly introduced element that significantly alters established perceptions and practices". Second, we presented a negative scenario as it is portrayed by Non-Governmental Organizations (NGOs), who state that editing animals leads to a further intensification of animal agriculture and diminishes the motivation to properly address animal welfare issues (Cotter and Perls 2019). Until today, ethicists argue that genome editing might allow for the "perpetuation of a morally highly problematic practice" (Hiekel and Ach 2025, p. 15). Third, there was a pragmatic vision claiming that genome editing is a less ideal solution than a shift towards plant-based diets or towards cultured meat, but more likely to lead to actual improvements in the short term (Shriver and McConnachie 2018). More recently, Hiekel and Ach (2025) argued that genome editing should be applied if it is morally tolerable, politically feasible, and likely effective because morally preferable solutions are considered unlikely. Participants were asked to indicate any salient features and which scenario resonated with them the most.

The discussion was concluded by inviting participants to provide an opinion about the discussion and highlight any aspects that might have been missed. Subsequently, they were asked to state their take-home message and ask any remaining questions. After all questions were answered, the participants were thanked for their time and contributions.

Data Analysis

In this study, we followed the six steps of thematic analysis as proposed by (Braun and Clarke 2006), which are (1) familiarizing yourself with your data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, and (6) producing the report. To familiarize with the data, LB transcribed the German and Dutch groups via Amberscript and manually corrected for accuracy. Slovenian transcripts were translated into English by native Slovenian local researchers associated with the GEroNIMO project and their collaborators. After familiarizing with the data, LB generated initial codes based on the Dutch, German, and Slovenian transcripts using NVivo 14. This broad

codebook was subsequently reviewed and refined through critical discussions between LB and FM. This deliberative process led to several iterations until consensus was reached, and the more than 150 initial codes were refined and grouped into 13 overarching themes containing more exact codes to facilitate the data analysis. The finalized codebook was then applied by ED to code the French focus groups. In our final analysis, we made use of verbatim quotes to portray the underlying emotions as adequately as possible. This is key for the following discussion based on MFT. As the aim of this study is to portray the range of arguments existing, we group the arguments by topic and discuss them through the lens of MFT afterwards.

Results

In general, genome editing was perceived more positively in the focus group discussions in Germany and the Netherlands, while the majority of Slovenian and French participants rejected the technology. An exception for Slovenian participants was using genome editing for medical issues which they generally found acceptable. Overall, eleven clusters of fragments could be identified in the focus group discussion, which are structured across the three main topics of the focus group discussions, (1) the role of technology; (2) the role of animals; and (3) the future of animal farming (Table 2).

In this section, we discuss these eleven clusters of fragments across the three main topics of the focus group discussions, in more detail.

The role of technology

Trust and Responsibility

Participants mentioned trust and responsibility as central topics in the evaluation of genome editing. Especially the intentions behind certain applications of genome editing technologies were questioned and leads to issues of trust.

> *GerRFMO: Personally, I would […] have no trust in humans using CRISPR Cas… That's an incredibly great story in itself. But I don't trust people to […] use it with common sense, as with many other discoveries and findings.*

The lack of trust in human competence to use this technology responsibly was associated with the role of financial incentives, in particular to greed. Some of the participants related this greed to the current financial system. Participants drew a comparison to the situation regarding genome editing in plants, in which it was argued that economic factors and in particular, patents do not create the incentive to make the most ethical, but the most economical decision. Based on this, they argue that it will be similar with genome editing of farmed animals given that the economic circumstances are comparable. Ultimately, they worried that the focus on economic incentives might lead to a decrease in animal welfare.

Table 2 Identified categories of fragments

Topic	Narrative	Example Quote
Technology	Trust and responsibility	GerRFMO: Personally, I would […] have no trust in humans using CRISPR Cas…That's an incredibly great story in itself. But I don't trust people to […] use it with common sense, as with many other discoveries and findings.
	Risks & benefits	GerRMYV: […] At that point, I see greater potential in CRISPR, because you can at least make targeted adjustments without causing collateral damage.
	Genome editing is a morally neutral technology	SloRMOO: […] the technology itself is not bad; it's how you use it.
	The moral issues of genome editing already exist	NlRMYO: Basically, we […] mess around with animals for hundreds of thousands of years. […] From a wolf we made a kind of chihuahua.
Animals	Animal welfare is an important breeding goal	SloUMMO: […] try to use modern technology in a positive way, to improve the health of animals […]
	Animas are different from plants	GerUFYP: […] I don't know about animals, that's another topic, but now with plant-based products, even if something goes wrong, it's just a plant […]. As soon as […] an animal suffers, it would just be stupid [to use it].
	Animal disenhancement	NlUFMV2: [when] you start making all cows pain-free, then that provokes something else […] Then it just becomes even easier to just treat the animals badly, because they don't feel anything anyway.
Future	The technological fix	NlRMYO2: You're just postponing the problem. If you look […] at problems we are facing, [such as] climate change [and] you [use] genome editing [to reduce] emissions, then you're still perpetuating the system so you're going to run into the problem again later, only then […] you hope you can do the trick again. And if you can't, you are facing an even hotter fire.
	Genome Editing is a good short-term solution	NlUMYO: [Genome editing is] a very nice technique, but I think plant-based diets […], maybe in-vitro meat might be even better, as there would be no need for animals at all. […] [B]ut I think it would be a very, very nice model in the transition.
	Society gets used to technology	FraRMMO1: today we use drugs. These are chemicals and nobody mentions this and everything's fine. It has become an accepted practice. I think that genetic modification is becoming commonplace. If we show that there's an interest in everything, the animal won't suffer.
	Using CRISPR-Cas9 for cultivated meat	GerRMMO: The farmer is not only a livestock farmer, but also a crop farmer, and I see that as a great addition, and then you could significantly reduce the number of animals, and I think the farmers will still manage, or some will certainly stop, but I'm not so afraid of that now.

> *GerRFMO: "[…] I would have more concerns that animals would then be bred and produced to carry even more meat mass, so that this might actually turn into the opposite—contrary to animal welfare."*

Since trust is relevant in cases of uncertainty and lack of control (Meijboom 2020), the dimension of dependence was also raised in the discussions. Combined with concerns on economic incentives, the dependence on big companies was mentioned in several groups.

This also included ways to become less dependent, e.g. by offering the technology open source.

> *FraRMMO1: But we don't have to be dependent on multinationals, it has to be open source. Because if we're a captive market, the multinationals should reinvent the prices.*

The dimension of dependency was highlighted not only in the context of economic dependency, but also with regard to the protection of local breeds. This was mainly a topic raised in Slovenia. The participants were concerned that genome editing will make farmers more dependent on specific breeds. They argued that genome editing will lead to genetically optimized and more efficient animals that will displace local breeds of farmed animals.

> *SloRFYO: I mean, yes, they teach that it is the future, it will come. But they never say that if it comes it can displace these indigenous varieties. It will make changes in nature, there is not so much of that in Slovenia yet. If we look at America, there is already a lot of this.*

This dependency on specific breeds or even the extinction of local breeds was also considered to be a concern from a consumer perspective. In particular, the price pressure resulting from the consumers' desire for cheap animal products was identified as a problem.

> *SloUFMO: Those black and white [cows] produce the most milk. [They] are now everywhere and have completely taken over all other breeds. […]. There is one breed of Slovenian cows that are adapted to life on the mountain, […] where it is colder and windier, but they give less liters of milk […].*

The issue of trust was raised not only because of concerns regarding financial incentives. The attitude that humans have towards nature was also evaluated critically. Some participants were concerned about the extent to which humans desire to control nature. This was particularly problematic when considered alongside concerns about human competence and the tendency to overestimate our ability to control nature.

> *FraUFYF: I think we can use [GMOs], but we have to be careful. […] The human side of wanting to control everything really bothers me.*

To summarize this first group of arguments, participants formulated concerns with regard to the incentives behind the development and potential use of genome editing and questioned the competence to deal with the responsibilities that come along with this innovation. This resulted in questions of trust and confidence in the current economic and agricultural systems. Furthermore, it leads to concerns that human attitudes of greed or hubris in combination with genome editing may lead to harm to animals or the environment, create further economic imbalance, or foster attitudes towards nature that are considered unhealthy.

Risks & Benefits

A part of the discussion reflected views on the perceived risks and benefits of genome editing and breeding technologies in general. In general, CRISPR-Cas9 was seen as a powerful technology, which provides its users with a range of possibilities and therefore potential benefits.

> *NlRMYO1: You could simply cure all diseases that exist, all abnormalities that exist, with this.*

Moreover, this participant highlighted the advantages and argued that the technology is so accurate and powerful that it can fix the errors it creates. Therefore, he regarded CRISPR-Cas9 as a safer alternative to previous genetic technologies. He concluded that there are no disadvantages, but only small side effects. Another participant argued that the CRISPR-Cas9 minimizes risks because it allows changes of single genes instead of altering entire organisms.

> *GerRMYV: […] At that point, I see greater potential in CRISPR, because you can at least make targeted adjustments without causing collateral damage.*

The risks of this technology were assessed in different ways by the participants. In reply to the previous mentioned view, it was stressed that the technology is risky and that humans should be more careful when editing genes as there might be unforeseen side effects revealed in the future that are yet unknown. One participant worried that disrespecting nature might have unforeseen consequences for humans as well.

> *SloRFYO: In certain cases, it is a good thing to adapt certain things. But certain people use it for the desires of man, which is not suitable for plants or animals or nature. Because nature will one day turn against these changes and there will be no more adaptation to these changes. […] you hope that you get out what you wanted, not that there are mutations that would have even worse consequences in nature.*

This argument was closely associated with a call for caution, more research, and limits to what should be done.

> *SloUFOO: You just have to have some kind of limited environment to be sure that what is changed is fine. But if you try it in nature, you never know what will happen.*

> *SloUFYO: Yes, that you touch nature as little as possible.*

> *SloUFMO: Until you are absolutely sure that what you have is fine.*

Finally, there were mixed voices stating that the technology can be beneficial, but it should be developed slowly and carefully to anticipate the harms, while simultaneously exploiting the benefits.

FraRMMO1: […] produce more and better, and maybe slaughter fewer cows or other [animals], that could be good. I think that this forum (ed. Note: focus group), which is open to everyone and working together, is one of the solutions. [but] there's the ethical side, and there's the control side, there's the side of seeing at first sight the dangers.

Genome Editing is a Morally Neutral Technology

In line with arguments related to risks and benefits and trust and responsibility, participants argue that this technology is neither good nor bad in itself, but its moral implications solely depend on its use. This was most clearly formulated in a focus group in Slovenia:

SloRMOO: […] the technology itself is not bad; it's how you use it.

The idea that the moral evaluation of the technology depends on the choices one made regarding the application relates to the previous arguments in that sense that the question of how to use a technology involves both issues of distrust and risks. This view was also reflected in other groups. For instance, that one can apply it to enhance the interests of animals, but also mainly those of humans or for certain husbandry systems and that this often requires trade-offs.

NlRMYO1: Technology […] can be better for the animals, or it can be chosen for the consumer. [It] can kind of go two ways.

The Moral Issues of genome Editing Already Exist

Regardless of whether participants endorsed genome editing or had a more critical attitude, some of them stressed that many of the arguments made against genome editing also apply to already existing animal breeding technologies.

GerRMYV: We are currently doing the same thing; you have constant manipulation through breeding. As soon as we let two animals mate with each other, we have genetic manipulation, often intentional, but there are also a lot of unintentional effects.

This participant argued that selective breeding is already a kind of manipulation on the genetic level. However, with the primary difference that this sort of manipulation is less accurate. In another group, a similar argument was made.

NlRMYO: Basically, we […] mess around with animals for hundreds of thousands of years. […] From a wolf we made a kind of chihuahua. That's not natural either […] we did that with other techniques. But [genome editing] is just a faster technique to start modifying things.

These types of arguments were also used by participants to argue against the claim that genome editing is an unethical breeding method because it is unnatural, because this technology does not differ from existing breeding methods. However, a participant in one of

the Netherlands discussions argued, the fact that a specific act has been performed for a long time, does not make this act ethical. In a French group, this argument was also used to counter worries about genetically modified food being unhealthy. In particular, people were strongly worried about the food safety and quality of cultivated meat. A reply was that the food which is currently available is not natural either.

FraUFYF: You already eat fruit [that is] modified. I don't understand why you say it's rubbish. […] I don't understand why it's a bad thing according to you.

The role of animals

Animal Welfare Is an Important Breeding Goal

Most participants agreed that farmed animals should benefit from genome editing. In all German and Dutch groups, animal welfare-related breeding goals and facilitating the transition towards cultivated meat were considered the most important breeding goals. In France and Slovenia, although being skeptical of cultivated meat, all groups still rated animal welfare goals among the top two most important ones out of the four options. This is in line with the above-mentioned concerns regarding prioritizing economic profit over human and animal interests, which were directly addressing animal welfare. As some participants put it:

> *SloUMMO: […] try to use modern technology in a positive way, to improve the health of animals, to enable these things that have a positive effect on animal husbandry as we know it today.*

Additionally, one group in Germany discussed the idea to use the technology to breed animals in a way that poor treatment of animals becomes directly visible.

> *GerUFOO: If the animal would turn blue when it's treated badly. […] it would be measurable if the animal wasn't well.*

In line with this idea, it was proposed that it would be interesting when poor treatment would influence the quality of the animal products:

> *GerUFYP: Maybe inedible meat, because then you kind of have leverage.*

Although this was discussed as future scenarios, it showed animal welfare was evaluated as an essential breeding goal.

Animals Are Different from Plants

In line with the overall endorsement of animal welfare, some participants argued that editing animals significantly differs from editing plants.

> *GerUFYP: […] I think [genome editing] is super cool, especially right now. […] I don't know about animals, that's another topic, but now with plant-based products,*

even if something goes wrong, it's just a plant […]. As soon as […] an animal suffers, it would just be stupid [to use it].

In line with this quote, concerns about animals stemmed from their ability to suffer, while plants do not have that capacity. Interestingly, some participants, who were worried about using genome editing for breeding animals, were strongly endorsing genome editing in plants.

Animal Disenhancement

Another animal-related topic was disenhancement of an animal's capacities as a potential breeding goal. Although the participants were not actively primed to talk about disenhancement, this topic came up in two focus groups in the Netherlands and in Slovenia. In one group, a participant mentioned the idea to breed animals who do not feel pain. The underlying idea is that pain is bad and should be avoided. However, the majority of the participants in the group found this morally problematic. One participant stated to feel "uncomfortable" (NlUMOO), while another one found it a "a scary thought" (NlUMYF). Simultaneously, the question came up to what extent an animal, who cannot experience any pain, is still an animal?

NlUMMO: That is a little philosophical question of: when is it still a cow? If you put it with cultured meat. Is that still an animal?

Finally, there was a worry that breeding animals, who do not feel pain is problematic because it is the wrong solution to animal welfare issues and might even lead to other long-term problems.

NlUFMV2: [When] you start making all cows pain-free, then that provokes something else […]. Then it just becomes even easier to just treat the animals badly, because they don't feel anything anyway.

The concern that creating non-sentient animals might change the attitudes of humans towards these animals was not only raised as a problem because it may result in treating animals poorly and therefore is bad for the animals. It was also put forward as problematic to the moral agent, who has an unethical attitude towards animals: when humans know that certain animals do not feel pain, they might treat them with less respect. Another discussion on disenhancement arose after being presented with the future scenario that presented further industrialization of animal farming as a result of the application of genome editing. Here, participants worried about the perceived risk of breeding chickens with physical disenhancements, for instance, without legs, so they would better fit in a housing system. In line with the presented future vision, this scenario was perceived as rather negative.

SloUFYO: I am very worried about [further industrialization of animal farming] […]. If this chicken can […] be changed so that it no longer has legs and just sits there and after three weeks it's over and it only has breasts […].

The future of farming

The Technological Fix

In discussing the relevance and desirability of the genome editing of animals, it was often mentioned that apart from potential benefits or risks, this technology starts at the wrong end of the problem. Instead of changing the farming system fundamentally (e.g. by de-intensifying or abolishing animal farming), genome editing runs the risk of leaving that system intact and approaches challenges of future farming only as technical challenges (Devolder 2021, pp. 15–16). This resembles the technological fix argument.

> *NlRMYO2: You're just postponing the problem. If you look […] at problems we are facing, [such as] climate change [and] you [use] genome editing [to reduce] emissions, then you're still perpetuating the system so you're going to run into the problem again later, only then […] you hope you can do the trick again. And if you can't, you are facing an even hotter fire.*

Besides being the wrong solution for the problem, there is a concern that genome editing as a short-term solution might inhibit a more holistic solution and therefore leads to more harm in the long run. In this context, it was mentioned that one has to consider the development and application of technology much more carefully from the start.

> *SloUFYO: I have a problem that scientists are so excited that they often don't think about what will happen next. We're going to make this hornless cow, which they think is great. But the question for me is why we need a cow without horns at all. The answer would be to cram more cows into a pile, so that they don't get hurt. Why do we need more cows in the pile?*

Genome Editing is a Good Short-Term Solution

In the final part of the focus group discussions, we presented three future scenarios of what the implementation of genome editing might lead to. Aside from a scenario based on scientists and the industry labelling genome editing as a revolution and a scenario sketched by NGOs of further industrialization, there was a pragmatic scenario claiming that dietary shifts or the implementation of cultivated meat are morally preferable compared to genome editing, but it is uncertain whether these developments will ultimately happen. Therefore, genome editing presents a good short-term solution for the existing animal welfare problems. This line of reasoning was endorsed and followed in the focus groups in different ways.

> *NlUMYO: I think I would go for the pragmatic view. [Genome editing is] a very nice technique, but I think plant-based diets […], maybe in-vitro meat might be even better, as there would be no need for animals at all. […] [B]ut I think it would be a very, very nice model in the transition.*

Next to this pragmatic positive view on genome editing, the pragmatism was also put forward as part of being disillusioned or skeptical that the ideal situation seems unreachable.

> *SloRMOO: I don't think that anything significant will change in the next 20 years, except that the living conditions for animals will change for the better. Already now, it has been noticed that farmers […] know that animals are intelligent. […]. Unfortunately, we do not yet know how to make meat in the laboratory, although there have been attempts, this also holds for milk. The problem is the diet of the people […] every day there is a steak or two in the diet.*

Based on the assessment that the consumption of animal products is on a high level and cellular agriculture is not available yet, this participant argued for using genome editing as a pragmatic approach given the unlikeliness of more holistic approaches.

Society Gets Used to Technology

Finally, the participants mentioned societal change, which could be the result of technological change. One participant in France argued that technologies can become accepted by being normalized.

> *FraRMMO1: Today we use drugs. These are chemicals and nobody mentions this and everything's fine. It has become an accepted practice. I think that genetic modification is becoming commonplace. If we show that there's an interest in everything, the animal won't suffer.*

For this participant, the process of normalization was a positive development. Once the technology is normalized, it is not seen as morally problematic anymore. However, for other participants, this normalization was perceived as a danger, and they constructed a slippery slope argument that also resembles the arguments of control at the start of this part of the paper.

> *FraRMMO2: If one cow is created like that, other […] cows or other animals are created, and that leads to excesses. So it's uncontrolled and whether we like it or not, there will be these aberrations. That's the way humans are, as history has shown us. So for me, it's not possible.*

Using CRISPR-Cas9 for Cultivated Meat

When discussing possible breeding goals to use CRISPR-Cas9, we presented the participants a scenario that sketched the use of this technology for optimizing stem cells to enhance the production of cultivated meat. We included this item to explore whether and which cultural differences might play a role with regard to the views on the use of CRISPR-Cas9. In line with their general attitudes towards genome editing, the majority of the participants in Germans and in the Netherlands had a positive attitude towards using animal breeding technology to optimize cultivated meat, in Slovenia and in France, the majority of the participants were against this specific application of CRISPR-Cas9. Across several

groups, younger participants, especially those who were not omnivores, expressed more openness towards this technology. One clear advantage of breeding for cultivated meat that the participants identified, is that it could eliminate the need for animal slaughter.

Interestingly, also omnivores, who previously argued that killing animals for food is morally unproblematic endorsed the use of the technology to enhance the development of cultivated meat.

In one German group, a participant was more skeptical of cultivated meat, which led to a discussion with a proponent about the underlying motives.

> *GerUFOO: […] before I want to eat this meat, I would go vegan. That would be the basic decision. If I […] no longer wanted to eat meat from any living, […] then I don't want anything, so cut and then go through with it.*

> *GerUMYO1: […] I don't understand why, if the alternative is perfect, why would you rather do without it than eat something where no animal had to die for? I mean […] if it was one-to-one identical, you wouldn't notice if you had a piece of meat here now.*

> *GerUFOO: I wouldn't pay a penny for it.*

In this conversation, the idea of cultivated meat also evoked a strong repulsion by one participant, who also argued against the use of genome editing in general. For this participant, applying modern technology to food was unacceptable in general. The feeling was so strong that no argument of other participants could convince her. Instead of replying to the arguments, she stressed how unlikely it is that she would try cultivated meat. A similar feeling was also recognized in a French group when discussing genome editing. Here, worries seemed to relate to the quality of food. A participant argued that even if it is possible to increase quality by genome editing according to official parameters, he will still be repulsed by the end product because it is genetically modified.

> *FraUMOO1: Quality [comes] lasts, because I don't see how you can change quality. […] It's good to have good quality, but by eating what? If you eat shit, it's not worth it […]. I'm not talking about breeding, we're talking about modification, we don't know what we're eating in there.*

In Slovenia, most participants rated enhancing cultivated meat as the least important breeding goal and linked cultivated meat to lower quality food. The feeling of repulsion was accompanied with the idea of cultivated meat being an unavoidable negative future scenario that will replace the more natural slaughter-based meat. The unavoidability was argued to be caused by economic powers and developments that will have socio-economic consequences making slaughter-based meat to a product for rich people only, while less affluent people have to eat cultivated meat, insects, or other types of proteins.

> *SloRMOO: […] that I am glad I was born so much earlier so that I won't have to eat it. But I am sure it will come. Mobile phones have practically taken over the world in the last 20 years, and no one can live without a mobile phone anymore. It is the same*

as this. […] it is an industry. The problem here is not a shortage of food at all. It is just a question of how to earn more money in a more elegant way […].

Also, in Slovenia, where most participants were critical towards cultivated meat, there were some exceptions. One participant highlighted the benefits in terms of animal welfare and sustainability:

SloRFMP: […] you still get the same quality protein that you get from an animal, […]. But then you take the suffering of the animal [and] the death of the animal out of the equation and you can still have access to dairy meat products without having to inseminate the animal first. And environmentally, I suppose it is also more environmentally friendly, it could be.

Simultaneously, some participants raised concerns regarding the use of fetal bovine serum, which is obtained by slaughtering pregnant cows.

GerRMYV: So even in the near future, we still have the problem that even this so-called "meat printing" actually requires a large amount of FBS — that is, fetal bovine serum — meaning that even for printed meat, a lot of animals are still….

In line with the concern about disrespecting nature, a participant worried about replacing something that exists in nature with something artificial which she regarded unnecessary. This worry was raised both regarding cultivated meat replacing slaughter-based meat and genome editing replacing other breeding methods.

GerRFMO: If I didn't eat the natural product, why should I make something artificial? Then I'll just leave it alone. People find that it makes sense, but somehow, I have something against it, I don't know….

In general, those participants, who were generally opposed to genome editing, were also skeptical about cultivated meat. The worry of recreating something perceived as natural with something artificial is often accompanied by the idea that natural products are always better and healthier than artificial ones, which are perceived as dangerous. Overall, the argument is thus that humans should be more modest about what they know and what they can change. Finally, in one group it was argued that the development of cultivated meat and the improvement of slaughter-based meat are two parallel processes.

GerRMMO: Yes, for me these (ed. Note: cultivated meat and sustainability) are two different breeding directions, because we have a few animals for stem cells, which can be trimmed to this breeding goal and then of course in place one. But that's something that runs in parallel.

In this argument, cultivated meat is regarded as a supplement to slaughter-based meat, which can help to reduce the consumption of traditional animal products, while maintaining a sustainable animal agriculture on a smaller scale. As the participant put it:

GerRMMO: The farmer is not only a livestock farmer, but also a crop farmer, and I see that as a great addition, and then you could significantly reduce the number of animals, and I think the farmers will still manage, or some will certainly stop, but I'm not so afraid of that now.

Discussion

This study examined the societal and ethical issues related to genome editing in farmed animals in France, Germany, the Netherlands, and Slovenia by conducting focus groups in these countries. Within this overall aim, we (1) explored arguments beyond the mainstream arguments reflected in the literature to broaden the debate, (2) included the perspective of the general public, as a relevant stakeholder that remained underrepresented in the debate about the ethical implications of genome editing in farmed animals, (de Graeff et al. 2019), and (3) we identified country-specific aspects to how the public evaluates the use of genome editing in pig and poultry breeding. Within the scope of our qualitative study, we did thus not measure the prevalence of specific attitudes, but mapped, interpreted, and reflected on arguments and moral concerns concerning genome editing of farmed animals.

Country-Specific Issues

In general, we saw tendencies of people being more critical of both genome editing and cultivated meat in France and Slovenia compared to Germany and the Netherlands. Moreover, there were some themes that were specific or exclusive to the focus group in one country. For instance, the protection of local breeds and the related attention to biodiversity were themes that only emerged in Slovenia, while attention to food quality was an argument that was more often mentioned in France than in other countries. Although large-scale, quantitative follow-up research is necessary to draw more sophisticated conclusions about national or cultural differences, the results show that attention to the diversity of arguments is important for the public debate on innovations in farm animal breeding. Aside from country-related cultural issues, other demographic and cultural factors, such as age, wealth, gender, affinity with animal farming, and eating behavior are related to attitudes towards genome editing in farmed animals (Yunes et al. 2021). In our qualitative study, we saw a light tendency of female and older participants being more opposed tendency to genome editing, but our study was not designed to draw conclusions about the influence of such factors.

Arguments beyond Welfare

In line with previous research (Naab et al. 2021; Yunes et al. 2021), we found that genome editing was considered more acceptable when it was applied to enhance animal welfare. Furthermore, in line with a survey on genetic modification in general (Frewer et al. 2013), we found that genome editing more acceptable when applied to plants rather than animals. An exception for that was the topic of animal disenhancement that came up in two focus group and was perceived as uncanny, which is in line with the study by Naab et al. (2021). Despite the consensus on animal welfare as a relevant or even acceptable aim to apply novel breeding technologies, such as genome editing, this study also showed that the debate can-

not be reduced to an animal welfare-only perspective. Next to welfare-related concerns, the results showed a wide variety of arguments, such as worries of playing God, dominating nature, a wrong attitude of humans when interacting with animals, and a general concern about unnaturalness. Similar arguments were also found in previous research on novel farm animal breeding technologies (Borgdorf and Meijboom 2024; Middelveld et al. 2022; Nuffield Council on Bioethics 2021; Yunes et al. 2021).

This broader vocabulary is reflected in several sets of arguments resembling narratives already described in literature (Borgdorf and Meijboom 2024; Middelveld et al. 2022). These include narratives with regard to the context of the market and consumer capitalism within which genome editing is developed and implemented. This was put forward to stress participants' problems of trust related to genome editing, its advocates, and companies involved in the process of development and implementation. Furthermore, there was a set of more pragmatist arguments including the views that genome editing will become socially accepted once it is applied and normalized because people will get used to it. Similarly, participants argued that genome editing can serve as a good short-term solution to animal welfare and sustainability issues because other, morally preferable, solutions such as the consumption of cultivated meat or a shift towards plant-based diets are less likely to occur in the near future. Finally, more in line with arguments resembling utilitarianism, some participants discussed genome editing in terms of a morally neutral technology and that consider genome editing as not significantly different from existing breeding technologies. Overall, our results also resemble the discourses on cloning and genetic modification in general, in which similar concerns were raised (EGE 2008; Gaskell et al. 2013).

The Importance of Emotions and Intuitions

So far, we described arguments that participants articulated to support their ethical views on genome editing. However, there were also strong convictions while discussing the moral desirability of genome editing and cultivated meat that were not backed up with clear arguments but rather started in feelings of disgust or unease with the new technology. In these cases, it was hard for the participants to articulate these concerns in the form of logical arguments. For instance, in one situation a participant asked another participant why she would object to cultivated meat even if it had no disadvantages. The opponent to cultivated meat only replied that it was her decision, and she remained with it. In another situation, using genome editing to increase the quality of cultivated meat was called "shit" as it was modified, rather than farmed. When confronted with the argument that almost all food that we eat is already altered, this person just repeated his argument. This phenomenon is called moral dumbfounding and is seen as an indicator that moral decisions are usually made intuitively rather than purely rationally, and that arguments mainly serve to defend such decisions *post hoc* (Haidt et al. 2000). It is important to stress that these intuitions are not just a phenomenon that indicates a knowledge deficit in lay people but play a role in the moral reasoning of scientists and experts as well. Hence, public engagement cannot be reduced to the inclusion of uninformed or irrational voices but rather be understood as the integration of diverse moral perspectives. Following critical empirical ethics (Rehmann-Sutter et al. 2012), it is nevertheless important to distinguish between arguments based on factual misconceptions and those that articulate underlying moral concerns. While the former group of intuitions

may be addressed through reframing or information, the latter requires genuine scrutiny and dialogue.

Whether the intuitive response can be justified or not is thus highly context-dependent. For instance, the above-mentioned argument about playing God refers to a genuine concern about human hubris leading to unintended, but not (yet) foreseeable consequences. By contrast, the above-mentioned cases of moral dumbfounding are difficult to reformulate in underlying arguments. Nonetheless, they can be an important moral signal, for instance as an expression of disgust as a part of our behavioral immune system warning for unsafe food. The ethical value of this response depends on whether the food is indeed unsafe. The examples of this study, genome editing and cultivated meat, give no concrete reason for such worries, which leaves the intuitive disgust reaction unfounded.

Since Moral Foundations Theory (Graham et al. 2013; Haidt 2012) differentiates between different intuitions leading to different moral judgements, it provides a potential explanation why reason-based arguments highlighting the potential reduction of harm due to novel food technologies did not convince participants who felt repulsed or disgusted by such technologies. The participant who asked his co-respondent why she would not eat cultivated meat when all things considered equal except for the fact that animals do not have to die, refers to the care/harm foundation. However, the disgust-based repulsion of cultivated meat originated in the sanctity/degradation foundation. To properly address these concerns, arguments based on the same foundation might have more effect. Previous psychological research indicated that embracing the naturalness of novel foods such as cultivated meat by explaining that many normalized foods are equally unnatural might mitigate such repulsion both in the short and in the long term (Macdonald and Vivalt 2017). In both focus group discussions, such arguments were made. GerUMYO1 referred to bananas being selectively bred and thereby unnatural, but GerUFOO stated to prefer 'natural' bananas. In the French group, as stated earlier, the opponent of cultivated meat repeated his argument. Similarly, research found that familiarity with certain types of meat, including meat from genetically modified animals, can reduce the disgust felt even if the perceived naturalness does not increase (Gagliardi et al. 2025). In the case of genome editing, addressing the sanctity foundation by increasing familiarity or highlighting the unnaturalness of already accepted food items might increase public acceptance as well.

Limitations and Strengths

This study has some limitations. First, due to issues with recruitment agencies and last-minute cancellation, some convenience sampling had to be done with the help of the project consortium. This led to several focus groups in which the recruitment criteria were not fulfilled. Still, we believe that this sampling bias does not significantly affect our qualitative study due to its explorative character. Second, when the participants were asked to rank different breeding goals, we had to work with broader categories of breeding goals for reasons of feasibility. For instance, removing horns and improving disease resistance were both presented as examples of animal welfare. Nonetheless, we can differentiate between them if we analyze the moral implications.

Despite its limitations, this study is the first cross-cultural qualitative study about attitudes towards genome editing. Furthermore, it encourages public engagement since the study design was inclusive towards people who do not speak English, as all focus groups

were conducted in the native language of the corresponding country. Also, by conducting focus groups in rural and urban areas, it was possible to identify more regional and cultural differences. Finally, this is the first study that not only discussed genome editing in animal breeding in terms of refining animal farming, but also explored its potential for a replacement using cultured meat (Melzener et al. 2022) and how this relates to human moral intuitions and the future of farming.

Conclusion

The research question for this study was: *Which societal and ethical issues related to genome editing in farmed animals are identified by members of the general public in France*, *Germany*, *the Netherlands*, *and Slovenia?* We corroborated several concerns and arguments from previous studies, such as playing God, dominating nature, a wrong attitude of humans when interacting with animals, a general concern about unnaturalness, distrust in profit-driven companies, and pragmatic arguments about societies getting used to genome editing and a lack of better realistic alternatives. Overall, benefits for animal welfare, fairness and transparency in economic motives, and trust in institutions are key conditions for responsible use of genome editing in animal agriculture. In addition to broadly shared attitudes, we found country-specific issues. The general attitudes towards food technology differ between countries. In the discussions with participants from the Netherlands and Germany we observed a general tendency towards more open attitudes to both genome editing and cultivated meat compared to participants in France and Slovenia. In addition, participants from France explicitly formulated concerns about food quality and participants in Slovenia, stressed the value of local breeds when discussing the future of agriculture. These more country-specific concerns are important input for the public and political debate about genome editing. Given the nature of our relatively small qualitative study, these conclusions have to be interpreted with care and large-scale quantitative follow-up research should be done to confirm our results.

Finally, we analyzed how concerns depend on underlying moral foundations and how understanding these foundations can help to respond to concerns. For instance, if a concern is based on disgust, scientists should investigate whether this is due to implausible health concerns or deeper moral considerations. Subsequently, communication should address this feeling accordingly rather than arguing with a potential reduction of harm due to the disgust-evoking technology. Finally, in discussions about more ethical and sustainable diets and the potential role of cultivated meat, technologies such as genome editing in animal breeding should contribute not only to the refinement of livestock farming, but also to the reduction and replacement of animal products, particularly in countries open to new technologies such as Germany and the Netherlands.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s41055-026-00205-4.

Acknowledgements We would like to thank Margaux Pigot for transcribing the French rural focus group discussions and Martina Kovačič for transcribing the Slovenian focus group discussions.

Author Contributions F.M. proposed the idea to conduct focus group in the four corresponding countries to study the ethical and societal implications of genomic innovations in animal farming. The study design

and topic guide were drafted in correspondence between L.B. and F.M.L.B. moderated the focus groups in Germany and the Netherlands, coded the results from focus groups in Germany, Slovenia, and the Netherlands, and attended all focus group discussion. E.D. moderated the French focus groups, coded the French focus groups, and organized the recruitment of the participants. M.C. moderated the Slovenian focus groups, translated the Slovenian transcripts, supported the recruitment of participants, and gave critical comments on the final draft. V.H. supported the recruitment of the participants in Germany and gave critical comments on the final draft.L.B. had the initial idea for the theoretical lens of this paper and drafted the work in regular correspondence with F.M. and K.K., who gave critical comments and made substantive revisions to the work.

Funding This paper is embedded in the GEroNIMO project that has received funding from European Union's Horizon 2020 research and innovation program under Grant Agreement No 101000236. This publication reflects the views only of the authors, and not the European Commission (EC). The EC is not liable for any use that may be made of the information contained herein.

Data Availability Our data are stored via the university's own data storage system that complies with modern scientific standards. Our dataset is not publicly available to preserve individuals' privacy under the European General Data Protection Regulation.

Declarations

Ethical Approval We obtained ethical approval by the Geosciences Ethics Review Board (SG ERB) of Utrecht University (reference: subject ERB Review DGK S-23894) on February 25th, 2023.

Informed Consent and Privacy This research was conducted, and written informed consent of each participant obtained, according to the principles expressed in the Declaration of Helsinki.

Competing Interests The authors declare no competing interests.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

References

Barbour, Rosaline S., and David L. Morgan. 2017. *A new era in focus group research: Challenges, innovation and practice*. London: Palgrave Macmillan. https://doi.org/10.1057/978-1-137-58614-8.

Berthe, Franck, Philippe Vannier, Per Have, Jordi Serratosa, Eleonora Bastino, Donald Maurice Broom, Jörg. Hartung, and James Michael Sharp. 2012. The role of EFSA in assessing and promoting animal health and welfare. *EFSA Journal* 10: s1002. https://doi.org/10.2903/j.efsa.2012.s1002.

Borgdorf, Leon. 2024. and Franck Meijboom Attitudes towards genome editing in farmed animals. In An interview study, 285–291: Brill | Nijhoff. https://doi.org/10.1163/9789004715509_047

Bovenkerk, Bernice. 2020. Ethical perspectives on modifying animals: Beyond welfare arguments. *Animal Frontiers* 10: 45–50. https://doi.org/10.1093/af/vfz055.

Bovenkerk, Bernice, W.A. Brom Frans, and Babs J.. van den Bergh. 2002. Brave New Birds: The Use of "Animal Integrity" in Animal Ethics. *Hastings Center Report* 32: 16–22. https://doi.org/10.2307/3528292.

Braun, Virginia, and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology* 3: 77–101. https://doi.org/10.1191/1478088706qp063oa.

Carlson, Daniel F.., Cheryl A.. Lancto, Bin Zang, Eui-Soo. Kim, Mark Walton, David Oldeschulte, Christopher Seabury, Tad S.. Sonstegard, and Scott C.. Fahrenkrug. 2016. Production of hornless dairy cattle from genome-edited cell lines. *Nature Biotechnology* 34: 479–481. https://doi.org/10.1038/nbt.3560.

Cotter, J. D Perls. 2019. Genetically engineered animals: From lab to factory farm. In *Genetically engineered animals: From lab to factory farm*, FRIENDS OF THE EARTH.

de Boer, Joop, and Harry Aiking. 2026. Vegetarianism and gender identity: Parallels and contrasts between gender- and diet-choices in the EU. *British Food Journal* 128: 70–83. https://doi.org/10.1108/bfj-09-2025-1205.

de Almeida Camargo, Luiz Sergio, and Jorge Fernando Pereira. 2022. Genome-editing opportunities to enhance cattle productivity in the tropics. *CABI Agriculture and Bioscience* 3: 8. https://doi.org/10.1186/s43170-022-00075-w.

de Graeff, N., K.R. Jongsma, J. Johnston, S. Hartley, and A.L. Bredenoord. 2019. The ethics of genome editing in non-human animals: A systematic review of reasons reported in the academic literature. *Philosophical Transactions of the Royal Society B: Biological Sciences* 374: 25. https://doi.org/10.1098/rstb.2018.0106.

Devolder, Katrien. 2021. Genome Editing in Livestock, Complicity, and the Technological Fix Objection. *Journal of Agricultural and Environmental Ethics* 34: 16. https://doi.org/10.1007/s10806-021-09858-z.

Donovan, Josephine. 1990. Animal rights and feminist theory. *Signs* 15:350–375. https://doi.org/10.1086/494588

Donovan, Josephine, and Carol J.. Adams. 2007. *The Feminist Care Tradition in Animal Ethics: A Reader*. Cambridge University Press.

EGE: European Group on Ethics in Science and New Technologies. 2008. Ethical aspects of animal cloning for food supply. In *Ethical aspects of animal cloning for food supply*, European Commisison.

EGE: European Group on Ethics in Science and New Technologies. 2021. European group on ethics in science and new technologies opinion on the ethics of genome editing. In *European group on ethics in science and new technologies opinion on the ethics of genome editing*, Eruopean Commission. https://doi.org/10.2777/659034

Eriksson, S., E. Jonas, L. Rydhmer, and H. Röcklinsberg. 2018. Invited review: Breeding and ethical perspectives on genetically modified and genome edited cattle. *Journal of Dairy Science* 101:1–17. https://doi.org/10.3168/jds.2017-12962

European Food Safety Authority. 2025. Food safety in the EU – Eurobarometer report. In *Food safety in the EU – Eurobarometer report*, Publications Office of the European Union. https://doi.org/10.2805/7315555

Eurostat. 2022. *Key figures on the European food chain – 2022 edition*. Publications Office of the European Union. https://doi.org/10.2785/500223.

Frewer, Lynn J.., Ivo A.. van der Lans, Arnout R. H.. Fischer, Machiel J.. Reinders, Davide Menozzi, Xiaoyong Zhang, Isabelle van den Berg, and Karin L.. Zimmermann. 2013. Public perceptions of agri-food applications of genetic modification – A systematic review and meta-analysis. *Trends in Food Science & Technology* 30: 142–152. https://doi.org/10.1016/j.tifs.2013.01.003.

Gagliardi, Laura, Damien Foinant, and Andrea Borghini and Jérémie Lafraire. 2025. Disgust reactions and their justifications: the case of meat. In *Disgust reactions and their justifications: the case of meat*, Proceedings of the Annual Meeting of the Cognitive Science Society.

Gaskell, George, Sally Stares, Agnes Allansdottir, Nick Allum, Cristina Corchero, Claude Fischler, Juergen Hampel, Jonathan Jackson, and Nicole Kronberger. *Niels Mejlgaard, Gema Revuelta and Camilla Schreiner 2013. Europeans and biotechnology in 2010: Winds of Change? - A report to the European* Commission's Directorate-General for Research.

Graham, Jesse, Jonathan Haidt, Sena Koleva, Matt Motyl, Ravi Iyer, Sean P.. Wojcik, and Peter H.. Ditto. 2013. Chapter Two - Moral Foundations Theory: The Pragmatic Validity of Moral Pluralism. In *Advances in Experimental Social Psychology*, ed. Patricia Devine and Ashby Plant, 55–130. Academic Press. https://doi.org/10.1016/B978-0-12-407236-7.00002-4.

Grosfeld, Eva, Daan Scheepers, and Armin Cuyvers. 2024. Mapping the moral foundations of the European Union: Why a lack of moral diversity may undermine perceived EU legitimacy. *PNAS Nexus*. https://doi.org/10.1093/pnasnexus/pgae282.

Haidt, J. 2001. The emotional dog and its rational tail: A social intuitionist approach to moral judgment. *Psychological Review* 108:814–834. https://doi.org/10.1037/0033-295x.108.4.814

Haidt, Jonathan. 2012. *The righteous mind: Why good people are divided by politics and religion*. New York, NY, US: Pantheon/Random House. https://doi.org/10.1080/15426432.2015.1038148.

Haidt, Jonathan, and Fredrik Bjorklund and Scott Murphy. 2000. Moral dumbfounding: When intuition finds no reason. *Unpublished Manuscript University of Virginia* 191:221.

Heller, Agnes. 2006. European master narratives about freedom. In *Handbook of contemporary European social theory*, 257–265. Routledge. https://doi.org/10.4324/9780203086476.

Hiekel, Susanne, and Johann Ach. 2025. Genome editing for farm animal welfare in a non-ideal world. *Etica & Politica* 27: 13–24. https://doi.org/10.13137/1825-5167/37498.

Hursthouse, Rosalind. 2011. Virtue Ethics and the Treatment of Animals. In *The Oxford Handbook of Animal Ethics*, ed. Tom L.. Beauchamp and R.G. Frey, 119–143. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780195371963.013.0005.

Inglehart, Ronald. 2006. Mapping global values. *Comparative Sociology* 5: 115–136. https://doi.org/10.1163/156913306778667401.

Ishii, Tetsuya. 2017. Genome-edited livestock: Ethics and social acceptance. *Animal Frontiers* 7: 24–32. https://doi.org/10.2527/af.2017.0115.

Kim, Gap-Don., Jeong Hyo Lee, Sumin Song, Seo Woo Kim, Ji Seon Han, Seung Pyo Shin, Byung-Chul. Park, and Tae Sub Park. 2020. Generation of myostatin-knockout chickens mediated by D10A-Cas9 nickase. *The FASEB Journal* 34: 5688–5696. https://doi.org/10.1096/fj.201903035R.

Kramer, K., and F.L.B. Meijboom. 2022. The ethics of innovations in genomic selection: On how to broaden the scope of discussion. *Journal of Agricultural and Environmental Ethics* 35: 7. https://doi.org/10.1007/s10806-022-09883-6.

Leget, Carlo, Pascal Borry, and Raymond De Vries. 2009. 'Nobody tosses a dwarf!' The relation between the empirical and the normative reexamined. *Bioethics* 23: 226–235. https://doi.org/10.1111/j.1467-8519.2009.01711.x.

Macdonald, Bobbie. 2017. and Eva Vivalt Effective strategies for overcoming the naturalistic heuristic: Experimental evidence on consumer acceptance of clean meat. https://doi.org/10.31219/osf.io/ndtr2

Meijboom, F.L. 2020. Trust and Food Biotechnology. In *The Routledge Handbook of Trust and Philosophy*, ed. Judith Simon, 378–390. London: Routledge. https://doi.org/10.4324/9781315542294-29.

Melzener, Lea, Shijie Ding, Rui Hueber, Tobias Messmer, Guanghong Zhou, Mark J. Post, and Joshua E. Flack. 2022. Comparative analysis of cattle breeds as satellite cell donors for cultured beef. *bioRxiv*. https://doi.org/10.1101/2022.01.14.476358.

Middelveld, Senna, Phil Macnaghten, and Franck Meijboom. 2022. Imagined futures for livestock gene editing: Public engagement in the Netherlands. *Public Understanding of Science* 32: 143–158. https://doi.org/10.1177/09636625221111900.

Moldovan, Andrei. 2018. On appeals to nature and their use in the public controversy over genetically modified organisms. *Informal Logic* 38: 409–437. https://doi.org/10.22329/il.v38i3.5050.

Naab, Francis Z.., David Coles, Ellen Goddard, and Lynn J.. Frewer. 2021. Public perceptions regarding genomic technologies applied to breeding farm animals: A qualitative study. *BioTech* 10: 28. https://doi.org/10.3390/biotech10040028.

Nuffield Council on Bioethics. 2021. Genome Editing and Farmed Animal Breeding: Social and Ethical Issues: Key Themes, Findings, and Recommendations. In *Genome Editing and Farmed Animal Breeding: Social and Ethical Issues: Key Themes, Findings, and Recommendations*. London.

Rehmann-Sutter, Christoph, Rouven Porz, and Jackie Leach Scully. 2012. How to relate the empirical to the normative: Toward a phenomenologically informed hermeneutic approach to bioethics. *Cambridge Quarterly of Healthcare Ethics* 21: 436–447. https://doi.org/10.1017/S0963180112000217.

Roeser, Sabine. 2006. The role of emotions in judging the moral acceptability of risks. *Safety Science* 44: 689–700. https://doi.org/10.1016/j.ssci.2006.02.001.

Ruan, J., J. Xu, R.Y. Chen-Tsai, and K. Li. 2017. Genome editing in livestock: Are we ready for a revolution in animal breeding industry? *Transgenic Research* 26: 715–726. https://doi.org/10.1007/s11248-017-0049-7.

Sandøe, P., B.L. Nielsen, L.G. Christensen, and P. Sørensen. 1999. Staying good while playing God - The ethics of breeding farm animals. *Animal Welfare* 8: 313–328. https://doi.org/10.1017/S0962728600021953.

Schroten, Egbert. 2001. Xenotransplantation and moral theology. *Veterinary Sciences Tomorrow*.

Schütz, Aurelia, Winnie Isabel Sonntag, Inken Christoph-Schulz, and Ivica Faletar. 2023. Assessing citizens' views on the importance of animal welfare and other sustainability aspects in livestock farming using best–worst scaling. *Frontiers in Animal Science*. https://doi.org/10.3389/fanim.2023.1201685.

Schwartz, Shalom H.. 2014. National Culture as Value Orientations: Consequences of Value Differences and Cultural Distance. In *Handbook of the Economics of Art and Culture*, ed. Victor A.. Ginsburgh and David Throsby, 547–586. Elsevier. https://doi.org/10.1016/B978-0-444-53776-8.00020-9.

Shriver, Adam, and Emilie McConnachie. 2018. Genetically modifying livestock for improved welfare: A path forward. *Journal of Agricultural and Environmental Ethics* 31: 161–180. https://doi.org/10.1007/s10806-018-9719-6.

Siegrist, Michael, and Christina Hartmann. 2020. Perceived naturalness, disgust, trust and food neophobia as predictors of cultured meat acceptance in ten countries. *Appetite* 155: 104814. https://doi.org/10.1016/j.appet.2020.104814.

Svingen, Marit, and Lisbeth Jahren. 2023. Making space for CRISPR: Scientists' translation work to make gene editing a legitimate technology. *Science and Public Policy* 51: 15–27. https://doi.org/10.1093/scipol/scad050.

Verbeek, Peter-Paul. 2012. Expanding mediation theory. *Foundations of Science* 17: 391–395. https://doi.org/10.1007/s10699-011-9253-8.

Whitworth, Kristin M.., and Randall S.. Prather. 2017. Gene editing as applied to prevention of reproductive porcine reproductive and respiratory syndrome. *Molecular Reproduction and Development* 84: 926–933. https://doi.org/10.1002/mrd.22811.

Winther, Hannah, Torill Blix, Lotte Holm, Anne Ingeborg Myhr, and Bjørn. Myskja. 2023. A social and ethical game-changer? An empirical ethics study of CRISPR in the salmon farming industry. *Environmental Values* 33: 476–494. https://doi.org/10.1177/09632719231196543.

Yunes, Maria Cristina, Zimbábwe Osório-Santos, Marina A. G.. von Keyserlingk, and Maria José Hötzel. 2021. Gene editing for improved animal welfare and production traits in cattle: Will this technology be embraced or rejected by the public? *Sustainability* 13: 4966. https://doi.org/10.3390/su13094966.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Authors and Affiliations

Leon Borgdorf[1] · Elsa Delanoue[2] · Meta Candek-Potokar[3] · Valentin P. Haas[4] · Koen Kramer[1] · Franck L.B. Meijboom[1]

✉ Leon Borgdorf
leonborgdorf@gmail.com

Elsa Delanoue
Elsa.Delanoue@idele.fr

Meta Candek-Potokar
meta.candek-potokar@kis.si

Valentin P. Haas
valentin.haas@uni-hohenheim.de

Koen Kramer
k.kramer@uu.nl

Franck L.B. Meijboom
f.l.b.meijboom@uu.nl

1 Veterinary Medicine, Utrecht University, Utrecht, Netherlands

2 Institut de l'Elevage, Paris, France

3 Agricultural institute of Slovenia, Ljubljana, Slovenia

4 Institute of Animal Science, University of Hohenheim, Stuttgart, Germany