



# Is gene editing natural and does it matter? A qualitative analysis of citizen-consumers' and farmers' views on the use of new genomic techniques in plants

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## Abstract

This study examines the notions of ‘naturalness’ in Finnish citizen-consumers’ and farmers’ perspectives, through ten focus group discussions, on genetic modification (GM) and new genomic techniques (NGTs) in plant breeding, amidst the current European Union (EU) legislative changes. In this context, the study shows that citizen-consumers’ views on GM plants and NGTs are significantly associated with different notions of ‘naturalness’ that are closely entangled with each other. Some citizen-consumers consider any human intervention as unnatural and unacceptable, while others are open to NGTs if they resemble natural processes or traditional breeding methods. Those who do not explicitly make use of the notion of naturalness are the most open towards all genetic techniques. However, consideration of the use purpose of NGTs can shift views of citizen-consumers. Farmers, in contrast, focus less on naturalness and more on the practical and economic implications of NGTs. Organic farmers expressed concerns about being excluded from the benefits of NGTs. Despite some caution towards transgenesis, most farmers were open to using NGTs due to the pressing challenges they face, such as climate change and economic pressures. The study concludes that different understandings of (un)naturalness are inextricably linked and continuously shape each other, rather than existing independently. This dynamic interdependence, in turn, underlie shifting views of NGTs in different contexts.

**Keywords** Naturalness · Focus groups · Public perception · Genetic modification

## Introduction

In the European Union (EU), the issue of potential deregulation of the use of new genomic techniques (NGTs) in plants is again gaining traction. After the Court of Justice of the European Union decision in 2018 that NGTs are regulated under the genetically modified organism (GMO) legislation from 2001, the European Commission (EC) published a new proposal for differentiating between genetic techniques on the regulatory level in 2023. In the new proposal, the

legislation governing NGTs is transitioning away from being regulated under the framework of GMOs, reflecting a shift towards a more tailored approach to these techniques. While debates regarding GMOs and their regulation have been quite heated for decades and there are also certain lines of division regarding NGTs – scientists and commercial actors typically promoting deregulation and activist organisations opposing it (Helliwell et al. 2019) – there is limited research regarding public perceptions of NGTs and their regulation. As these new policies affect citizens (as food consumers) and farmers (as food producers), it is crucial to gain a better understanding of how NGTs and their regulation are viewed by these groups.

This study analyses through focus group discussions the views of Finnish citizen-consumers and farmers on NGTs when used in plants, and the new regulation proposal. We focus on how these views are formed in conjunction with the research participants’ understandings of what constitutes

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naturalness and natural enough food production. Naturalness has been a central theme in the debates around genetic techniques and GMOs. Opponents have viewed genetic techniques as (too) unnatural, disrupting ecological balance and potentially generating novel environmental and health risks (Van Haperen et al. 2012). Too strong human intervention on the genetic level and the insertion of genes from other species are viewed particularly critically (Van Haperen et al. 2012). In contrast, proponents consider genetic techniques as just another step in the development of technologies enhancing agricultural production, necessary to respond to the nutritional needs of the growing human population (Zwart 2009). Interestingly, NGTs are suggested to shift, even solve, certain aspects of this naturalness debate, as the products generated with these new techniques can be identical to those developing in nature or through conventional breeding methods (Pirscher et al. 2018).

The core idea in the proposal is to differentiate between techniques resembling natural processes of genetic change and inheritance – ones that could happen either in nature or via traditional breeding methods – and techniques that would either not be possible in nature or were developed after the 2001 GMO legislation that has remained unchanged (European Commission 2023): The latter means techniques based on transgenesis, which enables gene transfer across species that could not otherwise mix, that is, cross-pollinate. In the proposal, plant breeding based on transgenesis would remain under the current EU regulation on GMOs. The former, that is, techniques that resemble natural plant reproduction or traditional breeding, would be regulated in a lighter manner. According to the proposal, instead of the current GMO regulatory process, there would be the following:

verification procedure for plants obtained by targeted mutagenesis or cisgenesis<sup>1</sup> that could also occur naturally or be produced by conventional breeding. Such plants would be treated similarly to conventional plants and would not require authorisation, risk assessment, traceability and labelling as GMOs. (EC 2023, p. 10)

Particular NGT plants are likened to naturally occurring or conventionally bred plants as opposed to those that could not occur in nature. A key difference is also a change in focus from method or process to product: according to the proposal, it is not the new techniques as such but the products they generate that are regulated and would go through the above-mentioned verification process. It has been suggested that this shift promotes an idea of naturalness that focuses on the end product and its similarity with nature

instead of the process through which it has been developed (Pirscher et al. 2018). As the proposal states,

... in some cases, products containing or consisting of plants with genetic modifications introduced by NGTs cannot be differentiated from products containing or consisting of plants bred with conventional breeding methods by analytical methods, whereas this is always possible for established genomic techniques. (EC 2023, p. 1)

In February 2024, the European Parliament (EP) accepted the proposal but suggested certain major amendments. These amendments were regarding the requirement to label NGT products as well as a prohibition to patent NGT products (EP 2024). Next steps are a Council of Ministers version, a trilogue negotiation between the EP, the Council of the European Union and the EC, and a final vote by the EP. As the legislation is still in process, a better understanding of citizens' and plant producers' views is urgently needed. Decision-makers should consider the views of the residents of their respective countries when formulating their stand on the issue.

The public understanding of NGTs and their regulation has been studied in some countries (Basinskiene and Seinauskiene 2021; Busch et al. 2022), while such research is still scarce in others. Previous studies have shown that attitudes towards NGTs tend to be less negative in comparison to older genetic modification techniques (Vasquez et al. 2022; Bearth et al. 2022; Basinskiene and Seinauskiene 2021; Shew et al. 2018) but support for all genetic techniques is relatively low (Basinskiene and Seinauskiene 2021). Previous studies have also indicated that the perceived benefits (Bearth et al. 2022) and knowledge are associated with more positive attitudes towards NGTs among the public (Strobbe et al. 2023; Basinskiene and Seinauskiene 2021). Research has also examined the different logics used by lay people and scientists in categorising new breeding methods such as NGTs (Debuquet et al. 2020).

The views of farmers have been mainly neglected in the studies concerning NGTs (but see, e.g., Ferrari 2022; Müller et al. 2021). There is some evidence that farmers are rather open to NGTs and perceive them as potentially useful (Ferrari 2022) and that their choices would ultimately depend on the public perception of the issue (Müller et al. 2021). It is crucial to better understand farmers' views as their choices are pushed by climate change and biodiversity loss adaptation and policies on one side and uncertain demand for their produce on the other. As such, their decisions matter not only to the food system but also in many cases to their communities and societies.

<sup>1</sup> In the proposal, techniques called targeted mutagenesis and cisgenesis are defined as NGTs.

However, it is not yet known in which contexts citizen-consumers and farmers apply the logic of naturalness and when not, and how the different logics of naturalness are related to each other as well as to the views of NGTs. This study contributes to filling these gaps, contributing to both empirical understanding regarding perceptions on NGTs and the need to better understand the questions related to NGTs and the issue of naturalness that is at the core of the debate. The aim of this study is to analyse and compare the views of citizen-consumers and farmers on their notions of naturalness. Hence, our research questions are: How do the study participants understand and use notions of naturalness and nature in regard to the use of NGTs and GM in plants? How do these understandings shape their views on the use of NGTs and GM in plants?

Our key findings suggest that, while for many of the consumer-citizens the notions of nature and naturalness were significant in the sense-making process regarding NGTs, for the farmers, these categories appeared less relevant. Our argument is that people's understandings and experienced significance of naturalness are clearly connected to how they view NGTs, but not in a unilinear manner – a particular understanding of naturalness does not simply determine a person's view of NGTs. Instead, different understandings of naturalness appear as entangled and knowledge about and descriptions of NGTs may mold even profound ideas of naturalness and what is viewed as natural enough.

## The ideas of naturalness underlying public perceptions of NGTs

Questions of naturalness have been highlighted as a significant aspect around what kind of food is valued in general (Román et al. 2017) and genetically modified foods in particular (Winther 2024; Nawaz and Satterfield 2022; Otsuka 2021; Mielby et al. 2013; Scott et al. 2018; Ditlevsen et al. 2020). Agriculture is a unique mix of natural and unnatural: agriculture would not exist without human intervention, but, at the same time, completely artificial agriculture does not exist (Van Haperen et al. 2012). Zwart (2009) suggests that the concepts of naturalness and biotechnology tend to be differently understood by the proponents and opponents of biotechnological innovations such as genetic techniques. Yet, these concepts are usually not explicitly defined: proponents consider genetic techniques to be just another chapter in the history of agricultural technologies, beginning in the neolithic era and thereby resembling a 'natural' development of which human innovations are a part. Contrarily, opponents consider biotechnology, beginning in the 1970s when the first genetic techniques were innovated, in a narrower sense. For them, these techniques thus represent a deviation from

the more natural ways of cultivating plants, with the view that human intervention is going 'too far'. Regarding plant biotechnologies and ethical questions surrounding them, arguments of naturalness always include cultural, technological, and ecological aspects, and their intertwinements need to be analysed (Van Haperen et al. 2012). We have based our approach on the above in our attempt to not seek an 'objective' or even most justified definition of naturalness but to focus instead on how these different layers are present in meaning-making.

Recently, Nawaz and Satterfield (2022) have provided three definitions of naturalness regarding NGTs, based on the work done by Siipi (2008) and Dussault (2016). Their framework is founded on a comprehensive synthesis of different theoretical and empirical approaches. Their three-part model suggests that naturalness could be defined (1) in opposition to artificiality, (2) in opposition to abnormality, and (3) as relational. In brief, artificiality refers to human influence, while abnormality refers to the disruption of the natural order of things. Then, viewing naturalness relationally means understanding naturalness "not in opposition to something else, but rather in relation to entities or people" (Nawaz and Satterfield 2022, p. 293). Further, Nawaz and Satterfield (2022) have divided these three categories of naturalness into three to five subcategories. We discuss these subcategories in the following analysis as they appear relevant. For the purposes of our study, we have extracted from their analysis the type of logic, affects, and values that may be embedded in ideas of naturalness.

Our research approach aims to understand research participants' views and definitions of naturalness of NGTs by using Nawaz and Satterfield's framework as a tool to identify the participants' logic and meaning-making and to pay attention to how seemingly contradictory rationales may coexist.

## Methodology

We conducted 10 focus group discussions between October 2023 and February 2024, with Finnish citizen-consumers and farmers (Table 1). All focus group discussions were led by the same facilitator from the research group to ensure consistency. The participants received a gift card of 60 (online) to 80 (on-site) euros for their participation.

### Focus-group discussions with citizen-consumers

Citizen-consumers were recruited for three focus groups. Each group had two discussions, with approximately one week between the sessions. All participants were aged between 18 and 65 years, and the ratio of men and women

**Table 1** Characteristics of citizen-consumer and farmer groups: number of participants and discussion rounds, meeting format, and key features

Group	No. of Participants	No. of Discussion Rounds	Meeting format	Key Features
Citizen-consumer Group 1	6	2	Online (Zoom)	Higher education degree, equal gender ratio; aged 18–65 years
Citizen-consumer Group 2	6	2	Online (Zoom)	No higher education degree; equal gender ratio; aged 18–65
Citizen-consumer Group 3	8	2	Live	High interest in food production (based on preview question); equal gender ratio; aged 18–65
Farmer Group 1	4	1	Online (Teams)	Young farmers (under 41, starting their first farm), organic farmer included
Farmer Group 2	6	1	Online (Teams)	Mixed ages, organic farmer included
Farmer Group 3	3	1	Online (Teams)	Mixed ages, organic farmer included
Farmer Group 4	2	1	Online (Teams)	Mixed ages

was equal. All participants in the first group had a tertiary degree of education, while those in the second group had a secondary or lower degree of education. The third group consisted of individuals with a high level of interest in issues related to food production, and a preview question was used to define this. To ensure nationwide participation, two groups took part in the discussions online via Zoom and one group through face-to-face discussions. Recruitment for the focus groups was undertaken by Inspirans, a market research company. Data collection was done according to the guidelines of the Finnish National Board on Research Integrity (2019). Prior to the discussions, the participants received an information letter regarding the study, the use purposes of the data, and consent was implied through their voluntary participation in the discussion.

The original design was that the focus group discussions of citizen-consumers and farmers would overlap so that we could inform the citizen-consumers about the farmers' views during the second round, making it a topic for discussion. Even though the timing of the focus groups in autumn proved to be impossible for the farmers' participation due to their work, this design provided the opportunity to deepen the discussions on the topic that might have been unfamiliar for the citizen-consumers.

Discussions took place during October and November 2023. The duration of each discussion was sixty minutes. A facilitator moderated each discussion, steering the conversation and posing questions in accordance with the structured discussion outline (Annex 1A and 1B). The discussions aimed to explore participants' awareness, perceptions, and acceptance of plant breeding and genetic technologies. Initially, participants shared their engagement with food production issues, discussed associations with terms like plant breeding, genetic modification, and gene editing and reviewed informational material on breeding methods (Annex 2A). Conversations included ethical considerations, public concerns (e.g. health, environment, corporate power, etc.), transparency, trust in experts, and consumer rights. Participants assessed their willingness

to consume gene-edited food and reflected on changes in their views. In the second round, participants recalled the previous session, considered new thoughts, and discussed examples and applications of genetic methods, focusing on acceptable contexts for their use. Regulatory aspects were addressed with information on the EU's legislative proposal (Annex 2B). Participants shared their views on regulating genetic technologies and whether decisions should be left to experts and authorities.

### Focus group discussions with farmers

Altogether four groups of farmers were formed for focus group discussions which took place in January and February 2024. No external agency was used in the recruitment process. We aimed to ensure diversity in participants' geographic locations, types of agricultural production, and involvement in either conventional or organic farming. To find suitable participants, we used the snowballing technique. This influenced the composition of the groups, and some of the participants knew each other from before. The region of South Ostrobothnia, where a significant share of Finnish plant production is located, was emphasised in the focus groups. However, there were participants from the eastern and northern parts of Finland as well. Most of the farmers produced a variety of crops, but a few mainly produced feed crops for their livestock. Four of the participants were organic farmers, and they were divided into the first three groups. The first group with four participants consisted of young farmers, defined in Finland by the Finnish Food Authority as being below the age of 41 years and having started their first farm (Finnish Food Authority 2025). Characterising factors, such as age, were not used to define the other groups, which included participants ranging from just having started as farm owners to one participant who had recently retired. The first group comprised four participants, the second group six participants, the third group three participants, and the fourth group only two participants due to scheduling challenges. Considering time constraints, these

groups had only one round of discussions and, because of the long distances involved, all discussions were arranged online. As with the citizen-consumers, the participants were informed about the study and the use purposes of the data prior to the discussions and consent was implied through their voluntary participation in the discussion.

The duration of the farmers' focus group discussions varied from 40 to 90 min. The facilitator led the group discussions, ensuring the conversation followed the outlined topics. The focus group discussions with farmers were structured into three main thematic sections: general views on genetic modification technologies, regulation, and personal readiness to cultivate varieties developed through new breeding methods (Annex 1C). The discussion began with participants' farming practices and attitudes towards plant breeding and genetic techniques, including gene editing. Next, farmers were presented with informational materials (Annex 2C). After reflections on the material, the discussion moved to the perceptions regarding current and proposed regulation and concluded with reflections on personal willingness to use gene-edited food varieties.

In the information materials shown to the focus groups, genetic techniques were divided into mutagenesis, cisgenesis, and transgenesis; these were explained in textual format as well as in a table. In the table, the techniques were additionally divided into random (older) and targeted (newer) approaches. In our informational materials, NGTs were described as more targeted than older techniques and as similar to naturally or conventionally bred plants. We also briefly described the key changes to the current legislation of the proposal of the EC.

## Analysis

The focus groups' discussion materials were transcribed, and the analysis was conducted with the help of the ATLAS.ti program. Our analytical approach followed the principles of thematic analysis, as we started by first coding the data and then proceeded to combine the codes into themes and sub-themes (Braun and Clarke, 2021). However, even before the coding process, we identified the theme of naturalness as a significant one, and our research questions guided the analysis process. During the phase of organising and combining the codes, we further considered previous analyses and theorisations of naturalness, and found Nawaz and Satterfield's (2022) categorisation, discussed above, interestingly resonating with our tentative analysis. Therefore, we made use of their categorisation of definitions of naturalness when finalising the analysis. Rather than the data neatly fitting into the pre-existing categories, our approach of developing on the work done by Nawaz and Satterfield (2022) helped us in highlighting the complexity and even contradictions in the data.

## Results and discussion

### Citizen-consumers

In this section, we present the citizen-consumers' views of genetic techniques, ideas of naturalness and the ways these intertwine (Table 2). The views form three subcategories (1a–1c) wherein the first category (1a) includes those who most strongly oppose all genetic techniques and the last category (1c) who are the most open towards all techniques yet particularly accepting of NGTs. We want to emphasise that the views were highly diverse and that the participants

**Table 2** The logic of naturalness and views of different groups on GM and NGTs

Logic of Naturalness	Description	Group (CC = citizen-consumer, F = Farmers)	Views on GM	Views on NGTs
In opposition to artificiality	(Intentional) human intervention	CC	Critical	Critical (1a)
	Human intervention in the genome	CC	Critical	Critical, but shifting towards openness (1b)
In opposition to abnormal	Humanity's correct place	CC	Critical	Critical (1a)
	Biological function	CC	Critical	Critical (1a)
	Ecological balance	F		Critical of transgenesis, open towards other NGTs (2b)
Through relationality	Satisfying moderate needs	CC	Critical	Critical of NGTs (1a); shifting towards openness to NGTs (1b)
	Familiarity/similarity to natural processes	CC, F	Openness	Shifting towards openness to NGTs (1b); open to all genetic techniques but NGTs easier to accept (1c); openness to NGTs, critical of exclusion of organic products (2a); transgenesis viewed as risky but NGTs positively (2b)
	Political-economic-environmental context	CC, F	Critical	Openness and willingness to use NGT crops (2a, 2b); Shift towards openness to NGTs (1b)

1a, 1b, 1c, 2a, and 2b refer to the different views of NGTs

clearly found it challenging to formulate a clear stand on GMs or NGTs. The difficulty of understanding such complex issues and the need for more information was emphasised particularly in categories 1b and 1c.

### Human intervention as unnatural and genetic techniques disrupting the natural order (1a)

The issue of naturalness arose among citizen-consumers spontaneously. It did not, however, seem to be a relevant category for all the participants – some did not use the concept at all and did not comment on the discussions around naturalness. Those who approached NGTs and GMOs together through the notion of naturalness could either have a somewhat fixed idea of nature or view nature as dynamic in and of itself. These views could also mix, generating a sense of tension or complexity that the participants discussed.

While in much of the discussions, the question of ‘natural’ was described as complex, for some, the idea of nature as something quite harmonious, intact, and devoid of human intervention served to make sense of NGTs and GMOs as well. In Finland, as in various other countries, public attitudes towards GMOs have been sceptical (Annala 2020). In the focus groups, there were a few who described having critical views towards GMOs in the 1990s and early 2000s when the issue was topical, and these individuals expressed the strongest views against NGTs too (Shew et al. 2018). They said that they mainly use organic products which they saw as being of better quality: “organically farmed strawberries simply are better”. Among these most critical participants, the idea that human intervention into nature is questionable or simply not needed was presented. The statement made by one participant is as follows:

Citizen-consumer participant (CP) 15: This thought was haunting me already the previous time, that *why*. Why should this be done. And this came into my mind immediately as I read this [description of NGTs], that *why*. I mean why do we even need to do this, if nature can do it too, why do humans/people need to go and do it as well.[...] It sounds scary to me that these final products can’t be distinguished from plants produced through traditional breeding methods. So, as a customer in a grocery store, I wouldn’t be able to recognise them. Or when eating them, would you still be able to tell the difference? (Citizen-consumer Focus Group C)

This comment was a reaction to the material we presented on the proposal of the Commission for NGTs. In the material, the idea of the similarity of the technique to nature was described in a similar manner as in the proposal itself. While

the proposal itself can be said to be based on the idea of naturalness, the logic presented does not appear to justify the technology. Instead, similarity to nature is viewed as rendering the technology irrelevant. The participant also viewed similarity with naturally occurring plants as a worrisome rather than a positive feature.

Among all the citizen-consumer participants a preference of ‘clean’ food was emphasised. When asked whether food products produced by NGTs could be considered clean food, one participant opposed strongly:

CP15: I at least don’t consider it clean. I feel that, somehow, the nutritional values are not good anymore. If you compare bilberry bred by nature to blueberry bred by humans, I don’t know how [much] that is bred, but I would think that nature always knows better than the human. Even though [the human] is part of nature but separate from nature like this. (Citizen-consumer Focus Group C)

Here, hesitancy towards human intervention *and* the idea that “nature can do it too” or that “nature always knows better” are emphasised. The concept of naturalness is understood in opposition to being “artificial” but also in opposition to being “abnormal” (Nawaz and Satterfield 2022), and these two are entangled. Within the category of natural in opposition to “abnormal”, Nawaz and Satterfield further differentiate between a logic of the natural order where humans should occupy their correct place and a logic of an organism’s essence or biological functionality (2022, p. 293). In the discussion above, participant CP 15 describes how the use of NGTs would put humans out of their place, that being separate enough from nature. The problem of human intervention seems to originate in disrupting this order – the two categories of naturalness in opposition to being “artificial” and “abnormal” seem to be profoundly entangled. Furthermore, Nawaz and Satterfield (2022) suggest one subcategory of naturalness stemming from relationality, the third category, to be the ability of an entity to satisfy moderate nutritional needs. This logic too seems, in part, to animate the last excerpt as the ability of NGT food to satisfy nutritional needs is questioned. Our aim here is to emphasise how the different understandings of (un)naturalness are, or may be, mutually constitutive. How these understandings entangle one another may be consequential, we argue, in determining the type of regulatory frameworks and justifications that will be viewed as acceptable.

Among the critical ones, alongside or mixed with more essentialist ideas that “nature always knows better”, criticism towards big corporations such as Monsanto, a company that has been at the centre of GM debates, was brought up. The interest of the industry in profit generation, combined

with intensive human intervention into delicate ecological processes could be seen as the origin of the problem. This excerpt (CP 18) exemplifies that the critique of corporate control or the political-economic systems that NGTs are seen to underpin may also apply to the language of 'naturalness' (Nawaz and Satterfield 2022):

CP18: Humans try to do similar mutations that happen in nature. To go back to Monsanto and maize, in practice the regulation would concern for example pest-resistant potatoes, the same situation as with maize. They attempted to produce pest-resistant maize and it kills the bees around it. [...] I did not change my view. (Citizen-consumer Focus Group C)

As the above excerpts show, a combination of ideas of nature as a self-competent system and separate from human influence were expressed mainly by those most critical of GM and NGTs, even though to varying extents. The rather stark critical views concerned GM and NGTs and their use in plants in general; the NGTs were not viewed more positively than older techniques. What stands out is that the logic of the proposal of the Commission based on the idea of similarity to nature as a justification to the changes in GMO legislation was not appealing to these participants. We suggest that this may be due to a specific combination of the different concepts of (un)naturalness. There is a connection between what is understood to constitute naturalness and how NGTs are perceived, even though this connection is rather complex.

#### Human intervention to the genome as too much – unless for a good purpose (1b)

For many of the participants, the notion of genetic modification, discussed in the beginning of the focus group discussions, was troublesome, yet as we introduced the informational materials regarding NGTs, views shifted towards a more positive direction. In this subsection, we discuss these perceptions. Here too, the meanings and definitions of what is natural and how it matters in the context of GM and NGTs were brought into the discussion by the participants themselves.

When discussing what kinds of thoughts and feelings the term 'genetic modification' evokes, the issue of constant change in nature was elaborated on in one group:

CP3: [...] as I went and read that thing [about genomic technologies], in that they justified it so that if it is for example a grain variety in Finland, that has been growing here forever, that some kind of variation/modification is happening anyway somehow depending on

the conditions. That everything is kind of, everything anyway changes in some way in the long run. I don't know if that can justify *gene manipulation* as good, in my own head. That in the nature, the change is constantly happening, when it is after all kind of ....

CP1: And then humans try to change it even more, or?

CP3: Yes [...], but there, humans kind of intervene in it. So, it is not nature that changes, but it comes from outside, a change initiated by humans, and that is what makes me a bit disturbed or anxious or something. (Citizen-consumer Focus Group A)

Here, similarly to some accounts in the previous section, human intervention is suggested as what renders GM suspicious or somehow disturbing. Naturalness is understood in opposition to artificiality and, more precisely, as the absence of *intentional* human interference (Nawaz and Satterfield 2022). The commonplaceness of this idea is surprising among focus group participants in that all of them consider traditional breeding acceptable, necessary, or both. Instead of understanding this type of argumentation as simply 'irrational', we suggest that it can be understood as pointing towards the affective dimensions of sense-making and ethical evaluation. Furthermore, it highlights that understandings of naturalness emerge as a continuum rather than fixed and separate categories. Here, the quantity and quality of human intervention seem to be what is of concern to the participants. The issue of interfering with the genome was regarded as problematic in the discussions and was compared to traditional breeding:

CP4: [...] that in genetically modified [food] there is, unlike in [traditional] breeding, in this modification you go to the genome and change something. For myself, that is what starts to feel a little puzzling. I somewhat understand the purposes: of course you want more sustainable, higher-yielding breeds/strains, if we talk about plants ....

CP2: Yes, and something similar precisely there, that [traditional] breeding, that you try to combine natural varieties to get the best possible version, but then modification, so it sounds a little like that naturalness has already been demolished in some way. But indeed, I don't really know what it means. But also, as I said in the beginning, I'd like to eat food that is as clean as possible, then this word sounds like it is not natural or clean anymore. (Citizen-consumer Focus Group A)

In these excerpts, modifying genetic material is described as too unnatural. Such modification is seen to destroy the naturalness and cleanliness of food. This highlights the significance of what is being modified and how food is being rendered unnatural. These views appear to come out as gut feelings or ideas because the participants often reflected upon not necessarily knowing about the topic but basing their views on affective reactions. We regard such reflexivity as indicative of the openness towards new information and potentially rethinking one's position towards genetic techniques. This is a clean break from the views introduced in the previous subsection.

After we shared information material about GM techniques, where also random mutagenesis using radiation or chemical agents was briefly explained and introduced as being the only technology accepted in the current EU regulation, many participants were surprised about the current situation. In the focus groups with citizen-consumers, random mutagenesis was generally viewed as a rather haphazard and aggressive form of intervention. In one group, this notion spurred a discussion on whether mutations should be understood as 'good' or 'bad':

CP2: Yes, a bit the same, I understand CP5's perspective that often of you have a genetic mutation, it maybe is not the most positive thing. But then... Yes, I would see that it could have positive effects on different things. I can't think of any examples now. But I'm not panicking, if we talk about genetic mutations.

CP4: Yes, and somehow, I think that these mutations have been occurring for thousands of years, one could say naturally, as different kinds of organisms, including humans, have lived on this planet.

CP3: Well, that is true. It's interesting how you don't think of those [mutations] which happen over time, over thousands of years. Those you consider as normal development; so, only in your head you create a kind of a difference. (Citizen-consumer Focus Group A)

In this discussion, mutations occurring constantly in nature are considered 'normal development'. The focus group participants discuss in terms of 'what could happen in nature', resembling the 'similarity logic' in the proposal of the Commission. While Nawaz and Satterfield's (2022) framework does not seem to properly catch this logic, it resembles the logic of familiarity that Nawaz and Satterfield (2022) consider a relational logic of naturalness. Mielby et al. (2013) have, even more aptly, described precisely this 'similarity logic' in their analysis, showing that cisgenesis tends to be

seen as more natural than transgenesis (see also Hudson et al. 2015).

Interestingly, the participants who regarded naturalness as something untouched by intentional human intervention could perceive NGTs as potentially acceptable, even necessary. This is a key difference from the previous subsection, where NGTs were seen as unacceptable as older GM techniques. During the second round of focus group discussions, one participant described her thoughts as follows:

CP1: Yeah, maybe something more positive, and the fact that product development is happening anyway, so maybe this isn't all about touching some sacred naturalness [*laughing*], the way I perhaps saw it.

Q: Okay, so your view on this fundamental issue changed a bit?

CP1: Yeah, maybe it's not as black and white as I thought. And indeed, with climate change and drought and all that, if we can use technology to develop and improve the world's conditions in general, then it's not necessarily just a purely bad thing. (Citizen-consumer Focus Group A)

This participant said that she had started to rethink her views, especially due to a discussion with a family member after the first focus group discussion. When provided with an example of NGT rice with improved qualities regarding pest tolerance and nutritional values, the participants continued in a similar vein:

CP1: Well, [...] while we have climate change, and even though we here have more than enough to eat, not everyone in the world does. So, if it [the crops] could withstand better without – because I'm not exactly in favour of all those pesticides either—if it could resist things that destroy the leaves, for example, or withstand drought better, then I'm quite sympathetic to those kinds of things.... But yeah, something needs to be developed so that our land can continue producing crops in the future. Whether it's pests that destroy them, or drought, I could really be quite sympathetic to those kinds of solutions, or maybe it's even necessary.

CP3: It's interesting because, when we started this conversation last week, I was really against it and didn't like the idea. But now that it's presented this way, it sounds reasonable and good. Like the previous speaker said, in many places there's drought and diseases affecting plants, so it feels like a good idea. I

don't know yet where my thoughts on this will develop from here. (Citizen-consumer Focus Group A)

Here, the reason *why* NGTs could or should be utilised is emphasised, with climate change and lack of access to proper nutrition described as acceptable motivations. Before the rice example, we had provided an example of an NGT-tomato that could reduce anxiety and promote relaxation in humans. In this group, this type of modification was viewed suspiciously and as unnecessary, which compares interestingly to how the rice example was perceived. We argue that a key question in how these participants viewed NGTs is a *relational logic* of what constitutes naturalness (Nawaz and Satterfield 2022). According to Nawaz and Satterfield (2022), naturalness may be defined not only in relation to a satisfied need but also in terms of being supportive of people's social, cultural, and spiritual relationships. In the previous example, a need to maintain 'our land' as fertile is discussed. The examples further show how considerations of the impacts of climate change and global food insecurity become crucial as the participants rethink their views regarding NGTs – and, we argue, regarding naturalness. How the notion of naturalness is defined and made use of shifts from naturalness in opposition to artificiality to naturalness understood through relationality. The different logics of naturalness overlap and are used in a flexible manner. Additionally, we argue that viewing naturalness primarily through the logic of relationality also renders the views of NGTs more flexible and dynamic than viewing naturalness in opposition to artificiality.

### **New genomic techniques as assisted natural evolution or as speeded conventional breeding (1c)**

A common idea among those who were the most open towards NGTs was that they are practically the same as traditional breeding but faster:

CP8: I also think in a way that if it is a gene transfer within the same species, it just helps the process a little bit, but it could happen anyway, if it is between such varieties that could naturally hybridise. In that case, it just helps and targets a specific trait that is desired. It could certainly be achieved with traditional plant breeding as well, but this method is just much faster and, precisely, it does not involve randomness but is carefully targeted. But also, if a gene segment was transferred from an orange to a mandarin, I would eat that too. I wouldn't be directly opposed to that either, but it's somehow easier to accept when it is within the same species since it could happen naturally, but

now it is just being targeted to a specific part of the genome. (Citizen-consumer Focus Group B)

This view is well aligned with the proposal of the Commission, emphasising similarity to natural processes and traditional breeding, as well as preciseness and speed, all seen as positive features. Here, in comparison to the previous subsection, the reasons for applying NGTs – be it food security, climate change, or better tasting food – as significant in terms of acceptability were not brought up. We suggest, however, that here too, a logic of relationality frames how naturalness and, thereby, NGTs are viewed. Unlike in the previous section, the aspect of familiarity as a form of relationality, also described by Nawaz and Satterfield (2022), is emphasised as NGTs are compared to conventional breeding methods, and they are considered to be fundamentally similar.

Those with the most positive views towards NGTs were also most open towards GM techniques as well; as the above excerpt exemplifies, they did not have anything "directly against" any NGTs or GM techniques, referring also to transgenesis. Instead, they could be critical of the implications of the commercialisation and patenting of GM and NGT products:

CP5: From what I've followed, I've mostly noticed that much of it is quite close to regular breeding. Of course, it's a different approach and done a bit faster. In that sense, I don't have anything against it, especially if they're trying to develop, for example, drought-resistant crop varieties or something like that, which is generally a good thing for food production. What I've read the most about, though, is mainly from these American companies, where they patent a certain soybean variety, and then you can't replant it because it has a gene that makes it sterile, so you must buy the seeds again from the same company that holds the patent. And if it cross-pollinates with another soybean variety in a neighbouring field, this big company can then sue the farmer whose field it pollinated. These are the kinds of unpleasant side effects I'm really against. But yeah, as a technology itself, I don't have anything particularly against it. (Citizen-consumer Focus Group A)

This critique, addressing the power of multinational or US companies, is very similar to that presented in our first category (1a). This exemplifies well how very different approaches to naturalness may however entangle similar critiques towards genetic techniques. Here, the political-economic context instead of perceived unnaturalness is used to question the deregulation of NGTs. While the 'no

opposition in principle' approach is descriptive of this category, the same participants also expressed hesitancy towards transgenesis:

CP8: If these things could also be achieved through traditional breeding methods, but the process is significantly longer and more uncertain, then doing it much faster and more precisely like this would be good. I think it would make sense to distinguish these in legislation because I believe the risks would be smaller compared to when gene transfers are made between different species. In that case, I see it as riskier. There are more risks involved than in something that could also be achieved with traditional breeding methods. (Citizen-consumer Focus Group B)

Acceptance and optimism towards NGTs, (and GM) did not inevitably lead to positive views regarding deregulation:

CP12: Yeah. I didn't get a huge defensive reaction when I read this text the first time. I just thought that this just speeds up the traditional breeding process. On the other hand, it caught my eye that in the European Union there is a bit of this issue because there is so much regulation here. Then you start to think about what is happening elsewhere in these matters and whether things are regulated at all there. I can easily imagine that in some place like India there is no regulation and you can do almost anything, and then it starts to be a bit of a question whether that's still a good thing. (Citizen-consumer Focus Group B)

In this subsection, we have included views that demonstrate openness towards GM techniques in general and NGTs in particular. Interestingly, these participants in category 1c did not so explicitly bring up or rely on the notion of naturalness. This is a clear difference in comparison to the previous sections where we have shown that the term itself was often spontaneously brought up and elaborated on in the focus group discussions. In our interpretation, however, ideas of naturalness, similar to the proposal of the Commission, were operating here, too. Even though these participants precisely expressed that, in principle, they do not have anything against genomic techniques, they demonstrated hesitation towards transgenesis. New genomic techniques were seen positively precisely due to their similarity with traditional breeding methods. This, again, is close to the logic of naturalness in opposition to abnormality (Nawaz and Satterfield 2022). The logic of 'similarity to natural processes' is in our data as well as in the proposal of the Commission, discussed through descriptions of similar and (too) different species. In addition to the significance

of familiarity and thereby relationality (Nawaz and Satterfield 2022), we argue that this is significant and based on the idea of clear boundaries between species. That is, these boundaries are mostly not questioned even when ideas of naturalness are not explicitly utilised to justify one's views on genomic techniques.

## Farmers

### Organic farming and NGTs as natural enough or necessary for staying in the game? (2a)

The concept of (un)naturalness was rarely mentioned in the focus group discussions with the farmers. Silences are often considered meaningful in qualitative analysis, but interpreting silences is, of course, not straightforward. Here, we suggest that silence in this context may inform about the comparative irrelevance of the concept of naturalness in relation to GM and NGTs for the farmers. One explanation for this could be that farmers do not perceive GM and NGTs as an ethical issue that often evokes arguments about naturalness (Rozin et al. 2004; Haidt and Rozin 2017; Mäkinen et al. 2011) but as a pragmatic one. While the issue of naturalness was not explicitly discussed, ideas around it surfaced in certain aspects of the discussions. For the farmers, naturalness manifests through very concrete practices and problems, not merely as an abstract value – this being a significant difference in comparison to the citizen-consumers. A similar spectrum descriptive of the citizen-consumers' views could not be formed to describe the farmers' views, but we have discussed below two themes that we consider the most significant, feeding into how farmers approach genetic techniques and naturalness: the issue of organic farming and the situational aspect of farmers' needs.

In three of the four focus groups with farmers, there was at least one organic farmer participating, and the potential impacts of the new proposal on NGTs on organic farming were brought up in all groups. Even though the Finnish word for 'organic' means 'nature-like' ('luonnonmukainen'), the farmers focused instead of naturalness on how NGTs and GM are regulated in organic farming, which was one of the most striking differences between farmers and citizen-consumers. In the EU, organic farming is strictly regulated, and in the proposal of the Commission, the use of NGT products would be prohibited in organic farming. This stance has been promoted by organic farmers' organisations in Europe, many of which have taken a critical approach towards the approval of the use of NGTs in plants in the EU. In the US and Canada, the question of NGTs or 'gene editing' has similarly deepened the boundaries between organic production and biotechnology rather than bridged them (Nawaz et al. 2020). Considering this, the views of the organic farmers

who participated in the focus group discussions were surprising. All the organic farmers expressed concerns about the impacts of exclusion from organic farming. One of the organic farmers vocalised on the issue as follows:

Farmer participant (FP) 1: I can't really take a strong stance on it, but from the perspective of organic farming, where I grow organic crops, it's a clear no-no that no GMOs can be involved in any way. Whether there could be something lighter in terms of genetic modification, based on what I've heard about the new possible legislation, well, at least the organic organisations in Europe have strongly opposed it, even in Finland. But it should not lead to a situation where the breeding of organic varieties is completely prevented. If all breeders switch to newer techniques and organic is blocked, organic varieties will never develop. They will remain where they are now, and that's a bit concerning as an active organic producer. But I'm sure some compromise will be found that makes sense. Let's hope the authorities are proactive. (Farmers Focus Group 1)

As this quote shows, a key concern was the impact of the prohibition on the future interest of breeders to focus on organic varieties. The idea that organic varieties could be excluded was brought up in other focus groups too, especially by the organic farmers. They also brought up the issue that one needs to constantly consider whether it is reasonable and financially feasible to stay in organic farming. Organic farming in Finland has been challenged by changes in agricultural subsidies and market conditions (Pro Luomu 2023).

The concerns regarding the future of organic farming if the use of NGTs is prohibited were not the only sources of criticism towards such prohibition. Resembling the last category of citizen-consumers, the organic farmers did not feel that there could be any 'principled reason' that would make the use of NGTs unfit for organic farming:

FP 1: Well, I don't see any reason why, if we are able to use genetic techniques like mutagenesis or cisgenesis to breed traits that are similar to those found naturally or in nature, we couldn't also make good use of those varieties in organic farming because then we would have the same breeding techniques available in both, except for the GMOs, which are considered GMOs. Otherwise, we'll end up not doing any organic breeding at all at this rate, and organic breeding will either stop or become very weak. (Farmers' Focus Group 1)

In another focus group discussion, one organic farmer also viewed that dogmatism is an unsuitable approach towards genomic techniques:

FP 8: I believe that we should always make use of any possibilities; the silliest attitude, in my opinion, is to completely reject something without even considering it. It kind of wastes the human ability that science has achieved in various ways. It shouldn't just be a strict orthodoxy rule that we don't do this or that. When people buy things, for example, in organic production, it must be considered that if the customer base is strongly opposed for some reason, it will slow down its adoption. But if it could be utilised elsewhere, it would be a good thing. I, at least, would hope that we could also gain some benefits from this in organic production. (Farmers' Focus Group 2)

For the organic farmers, naturalness is not primarily an issue of philosophical-ethical contemplation. The logic of the proposal, however, functions as a basis for arguing that NGTs should be allowed in organic farming too, and thereby similarity to nature becomes significant. Political and economic conditions that determine organic farming, rather than contemplation around what is natural enough, are emphasised in the organic farmer's views. This, we argue, does not mean that the category of naturalness is completely irrelevant but rather that other issues are, and they need to be prioritised when discussing NGTs. Here, naturalness becomes meaningful through relational logic, even though not merely according to Nawaz and Satterfield's (2022) description of it. While the idea of similarity and thereby familiarity is significant, it is the material-political relations that matter the most in organic farmers' understanding of naturalness.

#### **Naturalness as relational and relative: transgenesis is too much, but some aids are needed (2b)**

Many of the farmer participants were open towards NGTs, but critical views regarding transgenesis were rather common, even though not as thoroughly discussed as among the citizen-consumers. The issue of (un)naturalness arose among the farmers too, and the potential hazards and assumed uncontrollability were viewed as the gravest risks:

FP 2: In theory, if we start combining the best traits of weeds with crops, we could suddenly end up with a mix that spreads like wildfire, which no one can control. With my understanding, it's specifically transgenesis that most likely causes this risk of creating something uncontrollable. And I would especially emphasise that if it doesn't happen naturally, it doesn't belong there,

and then we're testing the resilience of the natural ecosystem against it. (Farmers' Focus Group 1)

This view resembles the logic of nature understood in opposition to artificial, primarily human intervention, even though it is not specified what is meant by 'if it does not happen naturally'. Moreover, the issue of the resilience of an ecosystem was brought up, with a farmer suggesting that transgenic varieties may pose a threat to such resilience. A similar idea of ecological balance or harmony and its vulnerability was raised by other farmers as well in their contemplations on GM and NGTs. Based on Nawaz and Satterfield's (2022) framework, this approach could be categorised in terms of naturalness in opposition to abnormality, as they suggest the idea of ecological harmony as a subcategory.

Despite the expressed hesitations towards transgenesis and GMOs, many of the farmers, both conventional and organic, viewed NGTs as a welcome asset in attempting to succeed as a farmer in Finland. Nearly all the farmers were open to farming NGT varieties themselves, and many also saw a more accepting legislation as necessary:

FP 7: [...] Basically, when we talk about the whole GMO issue, I approach it with quite a bit of caution, but this gene-editing part, or genome editing, is a completely different matter. I view it very positively if a variety can be given certain traits that improve cultivation techniques or quality, such as drought resistance or resilience to extreme weather conditions, so that the varieties can better withstand extreme weather events or diseases.

If we could, for example, reduce the risk of lodging with these methods, then I would view these very positively. However, the boundaries need to be very clear regarding what can and cannot be done. That is perhaps the most important thing here. (Farmers' Focus Group 2)

Many of the farmers described the difficulties that they are either currently facing or expecting in the future, such as climate crisis, changing political climate, EU policies, and the challenging economic situation. While NGTs were seen as a more natural option than genetic modification techniques, it was primarily the extremely complex situation of the farmers (Kuhmonen 2023) that ultimately rendered these techniques as a viable and interesting option for them. This situational account, we argue, mixed with ideas of naturalness as ecological harmony and a natural (enough) breeding process that excludes transgenesis, is what renders NGTs a potentially interesting tool for the farmers.

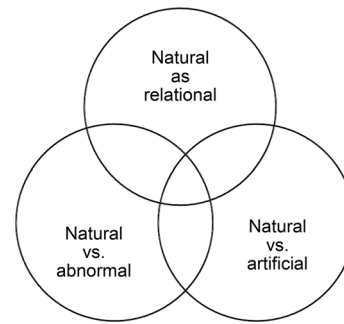


Fig. 1 The different logics of naturalness are entangled with each other

## Conclusions

In our analysis, we have shown how Finnish citizen-consumers and farmers spontaneously articulate their views regarding GM and NGTs through their notions of naturalness. These reflections resemble the new proposal of the EU regulation regarding NGTs where natural processes of genetic change and inheritance are raised as important criteria. The analysis also indicated that the views were complex and many participants could not clearly articulate their views on GM and NGTs.

Our findings show how the different definitions of naturalness are intertwined with different views of NGTs and GM techniques in actual group discussions. We could identify all three definitions of naturalness identified by Nawaz and Satterfield (2022): natural in opposition to artificial, natural in opposition to abnormal, and natural as relational. However, our results also highlight that understandings of naturalness were closely entangled with each other (Fig. 1). More specifically, some citizen-consumer participants viewed nature as detached from human intervention, and as “always knowing better” – the logic of naturalness in opposition to *artificiality* and in opposition to *abnormality* (Nawaz and Satterfield 2022) being firmly entangled. The participants who approached naturalness in these terms were the most critical towards both older and newer genomic techniques, and they did not change or reconsider their views during the discussions. The analysis further showed that there indeed seems to be a connection between the citizen-consumers' and farmers' views regarding genetic techniques and the extent to which human interference is perceived as (un) natural. In Nawaz and Satterfield's (2022) approach, this refers to the idea of understanding naturalness in opposition to *artificiality*, an aspect that our analysis shows to gain the most weight. This resembles earlier research, suggesting that those who consider human intervention particularly into the genes more unnatural, too intense, or both also more strongly oppose genetic techniques or food-related biotechnology, more broadly (Van Haperen et al. 2012; Zwart 2009; Pirscher et al. 2018). This suggests that the approach of the

EC proposal to naturalness – described, for example, by Pirscher et al. (2018) as an entity-based approach – does not sufficiently solve the dilemma of un/naturalness. If different stakeholders (here, citizen-consumers and farmers) consider a process-based approach to naturalness more compelling, there needs to be space for ongoing discussion on whether the new techniques are natural and thereby acceptable enough. Furthermore, our analysis shows that even though the aspect of human interference is significant, sense-making around naturalness and genetic techniques is more complex. As we have discussed, varying rationales were operating and intertwined, and the participants' ideas of naturalness cannot be simplified to resemble only one logic.

At the other end of the spectrum were citizen-consumer participants, who were open to both GM and NGTs and did not have any moral opposition against them, but who still viewed NGTs as easier to accept than GM techniques (and particularly transgenesis). While they did not discuss the issue of naturalness as explicitly as many other participants, they, however, justified their views with the logic of similarity to nature and traditional breeding methods, resembling the approach of the proposal of the Commission. In between were those who were critical of GM and NGTs precisely because they viewed them as not being natural enough. These participants pondered the issue of naturalness explicitly yet self-reflexively noted the dynamic nature of nature and their own affective attachments to what they viewed as natural. These participants were critical of older GM techniques but shifted their views towards being more open to NGTs. Significantly, for these participants, the use purpose of NGTs affected the acceptability of the techniques. In this sense, views of what is natural enough also seemed to shift dynamically depending on the use purpose: naturalness became *relational*.

For the interviewed farmers, the notion of naturalness as such was less relevant when compared to consumers-citizens. Most farmers viewed NGTs as natural enough for organic farming. The organic farmers were concerned about their interests suffering if NGTs are excluded from organic farming. Additionally, the farmers described NGTs as a welcome and even a needed aid in the complex situation the farmers face, yet they were simultaneously rather cautious and described various risks that some techniques may bring. In the farmers' views, a relational view of not only naturalness but also of NGTs was more prominent than in those of the citizen-consumers: whether NGTs are a 'good' or a 'bad' thing or useful or not is ultimately defined by the social-material-political context in which they are applied.

The comparison of citizen-consumers and farmers shows many similarities but also several differences. Citizen-consumers discussed the notion of naturalness more than the farmers. Previous research suggests that even if naturalness

and ethicalness are distinct concepts, naturalness is sometimes used to justify questions that are perceived as ethical dilemmas (see Rozin et al. 2004; Haidt and Rozin, 2017; Mäkineniemi et al. 2011). Therefore, one possibility is that citizen-consumers may perceive NGTs and GM as involving ethical dilemmas whereas for the farmers the focus was mostly pragmatic.

To conclude, we argue that ideas of naturalness animate how both citizen-consumers and farmers view genomic techniques and NGTs specifically, even though it is not always explicitly articulated. This shows especially in the ways the logic of the proposal of the Commission, based on the similarity of NGTs with nature and traditional breeding, appeared compelling to the participants. Similarly to the proposal – and perhaps unsurprisingly – NGTs used for targeted mutagenesis and cisgenesis more specifically were viewed as acceptable by most, while GM techniques and transgenesis were approached with hesitance or straightforward rejection. This could be interpreted as tentative support for the proposal – apart from the organic farmers' views regarding their exclusion from using breeds developed with NGTs. We want to highlight, however, also the argument above: that as the sense-making around naturalness in regard of genetic technologies is not based on one logic only, the EC proposals approach cannot solve the issue of naturalness. As this is closely connected with the question of acceptability, there needs to be more space for engaged critical public debate. As this is a qualitative study based on focus group discussions, no generalisations regarding citizen-consumers' or farmers' views can be made. Another possible limitation of the study is that the information provided to the participants was rather complicated and probably very new to many participants. We designed the information to be as impartial as possible, but we are aware that all information given to research participants does affect the discussions. This study does, however, elucidate the rationales and logic behind views on genomic techniques. More research on the topic is needed as the NGT proposal, despite the current stagnation, will proceed in the EU. Both in-depth qualitative analyses and quantitative analyses of people's perceptions of NGTs are important as they provide complementary understanding on the potential reception of these methods and their products. Another important topic for further research and theory development would be to investigate when the issue of naturalness becomes relevant and when irrelevant. In addition to empirical studies, we call for further analysis and theorisations on the issue of natural (enough) breeding. It would be worthwhile to consider the 'politics' regarding what is seen as natural genetic processes and what is not (Subramaniam and Bartlett 2023), how and why such views may shift, and what implications the rather straightforward rejection of transgenesis shown also in our analysis may

entail. Questions regarding species boundaries, their flexibility, and similarity versus difference are implicitly present in our analysis but would require more careful attention. For example, Subramaniam (2014) has shown how key ideas such as that of variation travel across disciplines and may have surprising consequences. These questions are significant as they involve conviviality – the possibilities and ways of living with similar, different, and other species, regardless of whether they are mediated by new technologies or not (Antonsen et al. 2019).

Finally, despite various aspects of relationality being present in the material, it is surprising how little NGTs are discussed in relation to and as part of broader food production systems. This is, we suggest, a larger problem describing debates around NGTs and their regulation: new techniques cannot be viewed as good or bad or needed or unnecessary as such but need to be comprehended as adjusting to particular types of socio-technical and economic structures, thereby generating outcomes that those structures allow or disallow (e.g. Montenegro de Wit 2020).

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## Declarations

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